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A Measure of Underlying Inflation in the United States

by
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Abstract

A monetary authority with the primary objective of price stability has to distinguish between temporary price shocks and persistent shocks to the rate of inflation. A measure of underlying inflation, therefore, has an important role to play as a guideline for monetary policy. In this paper, a measure of underlying inflation in the United States is obtained using a structural vector autoregressive (SVAR) methodology. The assumption that movements in measured inflation are the result of (a) one-time shocks to prices arising from supply-side developments and (b) persistent shocks to the inflation rate arising from demand-side developments provides a set of long-run restrictions to identify the structural innovations to the consumer price inflation rate.

The model is estimated with monthly data and includes consumer prices (CPI), capacity utilization (CAPUT), producer prices of finished consumer goods (PPI), and import prices (IMP). The evidence reported in this paper suggests that measured inflation in the United States was below its underlying trend rate in 1994 and 1995, a period when inflationary pressures remained subdued, despite above-potential growth and labour market tightness. The evidence also supports the view that temporary factors have helped to contain inflationary tendencies in recent years. Past shocks should exert some further downward pressure on the inflation rate. Moreover, we find that the tightening in 1994–95 coincided with an upward trend in the underlying inflation rate, while measured inflation was still trending downward. The finding supports the view that the Federal Reserve reacts to movements in the underlying trend inflation rate.

Résumé

Une banque centrale ayant pour objectif premier de préserver la stabilité des prix doit pouvoir distinguer les chocs temporaires qui frappent les prix et les chocs persistants qui touchent le taux d’inflation. Il importe donc qu’elle dispose d’une mesure de l’inflation sous-jacente susceptible de la guider dans la conduite de la politique monétaire. L’auteure de l’étude mesure l’inflation sous-jacente aux États-Unis au moyen d’un vecteur autorégressif structurel (SVAR). Elle prend pour hypothèse que les variations de l’inflation mesurée résultent a) de chocs d’offre ponctuels que subissent les prix et b) de chocs de demande persistants qui touchent le taux d’inflation. Elle obtient ainsi un ensemble de restrictions à long terme permettant d’isoler les chocs structurels auxquels est soumis le taux d’accroissement des prix à la consommation.

Le modèle, qui est estimé à l’aide de données mensuelles, englobe l’indice des prix à la consommation (IPC), le taux d’utilisation des capacités (CAPUT), les prix à la production des biens de consommation finis (PPI) et les prix à l’importation (IMP). Les résultats présentés par l’auteure donnent à penser que l’inflation mesurée aux États-Unis est restée au-dessous du taux de l’inflation tendancielle en 1994 et 1995, années au cours desquelles les tensions inflationnistes sont demeurées faibles, en dépit d’une croissance économique supérieure à celle de la production potentielle et de tensions sur le marché du travail. Il semble également que des facteurs

temporaires aient contribué à contenir les tendances inflationnistes ces dernières années. Les chocs passés devraient exercer de nouvelles pressions à la baisse sur le taux d'inflation. De plus, l'auteure constate que le resserrement monétaire opéré en 1994 et en 1995 coïncidait avec une tendance à la hausse du taux d'inflation sous-jacent, à un moment où l'inflation mesurée s'orientait toujours à la baisse. Ce résultat vient appuyer la thèse que la Réserve fédérale réagit aux mouvements du taux de l'inflation tendancielle.

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1. Introduction

The ultimate objective of monetary policy in the United States is to promote economic growth by achieving and maintaining price stability (see Federal Reserve Bulletin July 1988). Price stability contributes to economic growth by reducing the uncertainty economic decision makers face. Greater certainty, in turn, will enhance the efficient and effective allocation of resources.

A key challenge facing monetary authorities with the primary objective of price stability is distinguishing between temporary price shocks and persistent shocks to the rate of inflation. Roger (1995) notes that, as long as shocks to the general level of prices are perceived as one-time events, they should not have a lasting effect on the inflation rate. In such cases, it would be inappropriate for a monetary authority that is targeting the inflation rate to respond.[1] There are two main arguments for "accommodating" a one-time shock to the price level. The first argument is that it may be beyond the scope of the monetary authority to prevent a shift in the price level, a shift that will be reflected in a temporary change in the measured inflation rate. Nevertheless, this does not preclude the monetary authority from reacting to second-round effects that could feed into inflation. The second argument is that, the more clearly a price movement is perceived as a one-time event, the weaker the case for incurring the short-term output or employment costs of trying to offset the price level effect of a temporary shock.

Transitory events appear to have had an important impact on measured inflation in the United States in recent years. Federal Reserve Board Chairman Alan Greenspan noted in his *Monetary Policy Testimony and Report to the Congress* in July 1996 that "powerful forces have evolved in the past few years to help contain inflationary tendencies." These forces include a slowing in the growth of labour compensation costs, largely due to reduced benefits that put downward pressure on inflation, and job insecurity that has contributed to containing wage demands. Indeed, inflation remained subdued and actually declined, although above-potential growth and tight labour markets were pointing to the possibility of upward pressure on prices and wages in the United States. Although these temporary downward pressures on prices have helped contain and even lower measured inflation, they should not have any lasting effect on the inflation rate. Indeed, Greenspan noted in his July 1996 testimony that "these forces, to the extent that they are operative, exert a transitory, not permanent, effect in reducing price and wage inflation."

The purpose of this paper is to obtain a measure of underlying inflation in the United States based on the assumption that movements in measured inflation are the result of one-time shocks to prices arising from supply-side developments and of persistent shocks to the inflation rate arising from demand-side developments due to monetary policy shocks. The innovation

1. Note, however, that if the target is instead a price level, then even a price level shift would require a change in monetary policy to restore the target price level.

introduced in this paper to the existing empirical work on measuring underlying inflation is the methodology that is applied. Recent studies have tried to measure the underlying inflation rate using various statistical approaches to construct alternative measures of the consumer price index. Laflèche (1997) constructs measures of the trend inflation rate in Canada, while Roger (1995) investigates several alternative measures for New Zealand. Bryan and Cecchetti (1993) examine methods of removing noise from monthly price data in the United States. These studies propose measuring inflation in any month by the *median* of monthly changes in prices rather than by the average change. An alternative to the median, proposed in the literature, is to compute a *trimmed mean*, in which a chosen proportion of unusually large and small price changes is excluded before the average is computed. Another approach is based on structural time-series modelling that assumes a functional form for the underlying process, often a random walk, and then processes the observed price series through a filter. However, the assumption that changes in the underlying inflation rate follow a random walk, or that underlying inflation is the product of some arbitrary smoothing procedure is not very intuitive.

In this paper, an alternative estimation technique is used to obtain a measure of underlying inflation in the United States, namely the structural vector autoregressive methodology (SVAR) proposed by Shapiro and Watson (1988) and Blanchard and Quah (1989). The SVAR methodology imposes restrictions that provide a decomposition of a particular time series into its transitory and trend components. More specifically, it allows us to decompose shocks to the inflation rate into temporary price shocks and persistent shocks to the rate of inflation.

The SVAR methodology involves estimating a vector autoregressive (VAR) model and identifying different types of shocks on the basis of assumptions about the inflation process. Quah and Vahey (1995) propose a technique for measuring “core inflation” that is closely related to the Blanchard and Quah (1989) method. Quah and Vahey impose a restriction that is consistent with a long-run vertical Phillips-curve hypothesis and define “core inflation” as the component of measured inflation that has no medium- to long-run impact on output. “Non-core inflation” is defined as the component of measured inflation that has a medium- to long-run impact on output. Under the assumption that observed changes in measured inflation are affected by these two types of disturbances, Quah and Vahey obtain an estimate of core inflation by using a transformed vector autoregressive system.

This paper builds on Quah and Vahey’s definition of core inflation. A measure of underlying U.S. inflation is obtained by means of a four-variable structural vector autoregressive model. The model uses monthly data and includes consumer prices, capacity utilization, producer prices of finished consumer goods, and import prices. We assume that observed changes in measured inflation are driven by two types of disturbances, each uncorrelated with the other. Long-run restrictions are imposed to identify the structural innovations to the consumer price inflation rate, defining underlying inflation as the component of measured inflation on which only shocks to the inflation rate have a long-term impact. Shocks to the other three variables arise from supply-side developments and change the path of inflation only temporarily. Impulse response analysis and variance decomposition are used to capture the dynamics of the model and to measure the relative contribution to inflation of transitory shocks.

Applying the structural VAR approach, we find that consumer prices grew at above trend during three of the past four U.S. economic downturns, likely the result of the lagged response of inflation to supply shocks. In contrast, measured inflation was about in line with the underlying trend rate during the 1981–82 recession suggesting that this downturn may have been demand-led, i.e., tight monetary policy, rather than the result of supply shocks. The fact that both measured and trend inflation were declining sharply at the beginning of the 1980s supports the view that the Fed had raised interest rates in order to lower the trend rate of inflation. In 1994, the Fed also began tightening although measured consumer price inflation was still trending downward. The tightening coincided with an upward trend in the underlying inflation rate and supports the view that the monetary authority uses underlying inflation as a guideline for monetary policy.

Evidence is provided that U.S. consumer price inflation was below trend in 1994 and 1995. Furthermore, measured inflation has been about in line with underlying inflation since 1996. The small deviation of measured inflation from its underlying trend could indicate that the temporary factors to which Greenspan alluded in his July 1996 testimony may be becoming less important in containing inflationary pressures although past shocks should exert some further downward pressure.

The paper has three further sections. Section 2 outlines the structural VAR approach and presents the model that is estimated. Section 3 describes and analyses the data and presents the empirical results, while Section 4 draws some conclusions.

2. The structural VAR model

The estimated model is based on the vector autoregressive approach proposed by Shapiro and Watson (1988) and Blanchard and Quah (1989). Structural VAR models impose restrictions on the movements of the variables in the model that allow the identification of the parameters and the structural shocks. To identify the structural model and to decompose the forecast variance, one common approach is to impose an arbitrary Choleski decomposition (Christiano and Eichenbaum 1991; Gordon and Leeper 1994). However, Bernanke (1986) proposes an alternative methodology. This technique imposes short-run restrictions that are exclusion restrictions on the matrix of structural coefficients to identify the structural model. Shapiro and Watson (1988), Blanchard and Quah (1989) and St-Amant (1996) impose long-run restrictions on the variance-covariance matrix of the vector of structural innovations, while Galí (1992) imposes both short-run and long-run restrictions on the structure of the economy to identify exactly the structural innovations. In this paper we follow the approach of imposing long-run restrictions to provide a decomposition of the U.S. inflation rate into its temporary and permanent components. This technique is implied by the finding that the monthly U.S. consumer inflation rate contains a unit root, i.e., that the inflation process contains a permanent component.

Let $X_t = [\Delta^2 CPI_t,\ CAPUT_t,\ \Delta^2 PPI_t,\ \Delta^2 IMP_t]'$ be a covariance stationary vector process (for a discussion of the variables contained in X_t, see Sections 3.1 and 3.2). To identify the structural model, the VAR is first estimated in its unrestricted form, i.e.,

$$X_t = \Phi(L)X_{t-1} + \varepsilon_t \tag{1}$$

where $\Phi(L) = (I - \Phi_1 L - \ldots - \Phi_p L^p)$ and ε_t is the vector of serially uncorrelated innovations.

As all equations in the system share the same matrix of regressors, estimation of (1) amounts to applying ordinary least squares (OLS) separately to each equation, after including the optimal number of lags, p, to eliminate serial correlation from the residuals. The estimated unrestricted model can then be inverted to the Wold moving-average representation, i. e.,

$$X_t = C(L)\varepsilon_t \tag{2}$$

where $C(0) = I$. In the moving-average representation, each element of X_t is expressed as a linear combination of current and past structural shocks, i.e.,

$$X_t = S(L)\upsilon_t \tag{3}$$

where $S(L) \equiv [S_{ij}(L)]$ for $i, j = 1,...,4$, and $S(L)$ is invertible.

Under the assumption that the innovations in ε_t are a linear combination of the structural disturbances in υ_t, the structural shocks can be related to the disturbances of the reduced-form model as follows:

$$\varepsilon_t = S(0)\upsilon_t \tag{4}$$

and

$$E(\varepsilon_t \varepsilon'_t) = S(0)(E\upsilon_t \upsilon'_t)S'(0) = \sum \tag{5}$$

where $\sum$ denotes the variance-covariance matrix of the vector of reduced-form innovations.

The vector autoregressive representation of X_t in terms of the structural disturbances is given by

$$A(L)X_t = \upsilon_t \tag{6}$$

where $A((L) \equiv [A_{ij}(L)])$, for *i, j = 1,...,4,* and $A(0) \equiv S(0)^{-1}$.

To identify the structural shocks to the inflation rate, three identifying restrictions are needed, as three additional variables are included in the model. From equations (2) and (3), it follows that the matrix of long-run effects of the reduced-form shocks is related to the equivalent matrix of structural shocks through

$$S(1) = C(1)S(0). \tag{7}$$

Implementing the restriction that only shocks to the inflation rate have a long-run impact on inflation and transforming the price variables from second-differences to first-differences imply the following structural decomposition of the inflation rate:

$$\Delta CPI_t = C(1)\varepsilon_{perm,\,t} + C^{\tau}(L)\varepsilon_{perm,\,t} + C^{\tau}(L)\varepsilon_{trans,\,t}. \tag{8}$$

The right-hand side of equation (8) is composed of the moving-average component of the different types of shocks, where C(1) represents the permanent component and $C^{\tau}(L)$ represents the transitory components of the shocks to the inflation rate. The first two components of equation (8) represent the underlying trend component of inflation, while the last component captures movements due to transitory shocks.

3. Empirical results

This section discusses the data and analyses their time-series properties. The results from decomposing the shocks to the inflation rate into temporary price shocks and persistent shocks to the rate of inflation are presented.

3.1 The data

U.S. inflation is measured by the total consumer price index. The model uses monthly data from 1969:1 to 1997:4 and also includes capacity utilization, producer prices of finished consumer goods, and import prices.[2] Clark (1997) discusses a number of measures of inflation in final goods and services that are available. The CPI is used in this study as it appears to be the

2. The choice of the sample period is dictated by the availability of data for import prices.

measure on which attention has traditionally focused. Two reasons for the widespread use of the index are that the CPI provides an approximation to the cost of living, and, second, the index is available on a timely basis. Capacity utilization is included in our system of equations to capture energy price shocks. Finn (1996) notes that a rise in energy prices that is not accompanied by a contraction in money growth causes a decline in capacity utilization and a rise in inflation. The negative comovement of inflation and utilization occurs because higher costs of energy usage reduce energy inputs into production and therefore lower output, inducing a decline in capacity utilization and a rise in inflation. Moreover, a pickup in inflation that increases inflation expectations and lowers the real wage reduces the effective return to labour effort. The resulting reduction of labour implies a decline in the marginal productivity of capital utilization that leads to a drop in capacity utilization and a negative comovement of capacity utilization and inflation. Finally, capacity utilization should also capture technology shocks. An increase in technology enhances the productivity of the factors of production, including capital, and thereby increases their usage, leading to higher output and lower inflation. Producer prices are included to reflect cost pressures at the producer level, while import prices should account for the sensitivity of U.S. prices to foreign price factors, which indirectly reflect the exchange rate. All variables are seasonally adjusted and included in second-differences, with the exception of capacity utilization, which is included in levels (see next section). A description and plots of the data can be found in Appendix 1.

3.2 The time-series properties of the data

3.2.1 Test for integration

Phillips (1995) shows that impulse responses and variance decomposition in VAR models with integrated variables give inconsistent estimates and tend to random variables. The time-series properties of the data are examined using the augmented Dickey-Fuller (1979) test to ensure that all variables are included as stationary processes. The augmented Dickey and Fuller (ADF) test allows us to test formally the null hypothesis that a series is I(1) against the alternative that it is I(0). The results from the test of the time-series properties of the data can be found in Appendix 2. ADF critical values are generated by performing Monte Carlo simulations with 5,000 replications for the first-differences of the three price variables.[3] Before conducting the experiment, we accounted for the possibility that these variables follow an autoregressive-moving-average process. Schwert (1987) provides evidence that the presence of moving-average components leads to different critical values than the tabulated Dickey-Fuller critical values reported in Fuller (1976). Evidence was found that the first-differences of the price variables all

3. Corrected critical values were only generated for first-differences due to the time involved in conducting the experiment.

contain a moving-average component.[4] The ADF test suggests that all price variables are non-stationary in levels as well as in first-differences. The null hypothesis of a unit root in the level of capacity utilization is rejected at conventional levels of significance. The ADF test suggests that consumer, producer, and import prices are stationary or I(0) processes in second-differences. The finding that monthly U.S. consumer inflation contains a unit root, suggesting the presence of a permanent component in the inflation process, is also supported by Bonham (1991) and Mishkin (1992, 1995).

3.2.2 Tests for cointegration

The three price variables included in the system appear to be integrated of the highest order, i.e., I(2). To allow for the possibility that the variables included in the system of equations form a cointegrating relationship, i.e., that they share a stochastic trend, the Stock and Watson (1993) and the Engle and Granger (1987) tests for cointegration are applied. The residuals from two regressions are examined: (1) consumer prices are regressed against the other two price variables in levels and capacity utilization; and (2) the consumer price inflation rate is regressed against the first-differences of the other two price variables and the level of capacity utilization. The results of the ADF test from the Engle-Granger and the Stock-Watson procedures are presented in Appendix 3. The results indicate that the ADF test is unable to reject the null hypothesis of no cointegration for both regressions at conventional levels of significance. The finding that there is no evidence of a cointegration relationship between consumer and producer prices is in line with the findings of other empirical work (see Becsi 1994 and Lebow, Roberts, and Stockton 1994). One possible explanation that Becsi (1994) proposes is that the CPI is a broader measure than the PPI.

3.3 Results from the decomposition of the inflation rate

This section presents the results from decomposing the shocks to the inflation rate into temporary price shocks and persistent shocks to the rate of inflation. The four-variable VAR model is estimated including ten lags to eliminate serial correlation from the residuals. A lag length of ten months was chosen based on likelihood ratio tests at the 10 per cent level as proposed by DeSerres and Guay (1995). Structural stability of the VAR model in its unrestricted form (equation 1) is tested using the Sup-F test for parameter constancy proposed by Andrews (1993).[5] The null hypothesis of parameter stability cannot be rejected at conventional levels of significance (Appendix 4).

4. The conclusion was based on the Akaike and Schwartz criteria. Results are not included but are available upon request.
5. The test was performed using Tkacz (1997) RATS procedures for testing structural breaks in linear regression models.

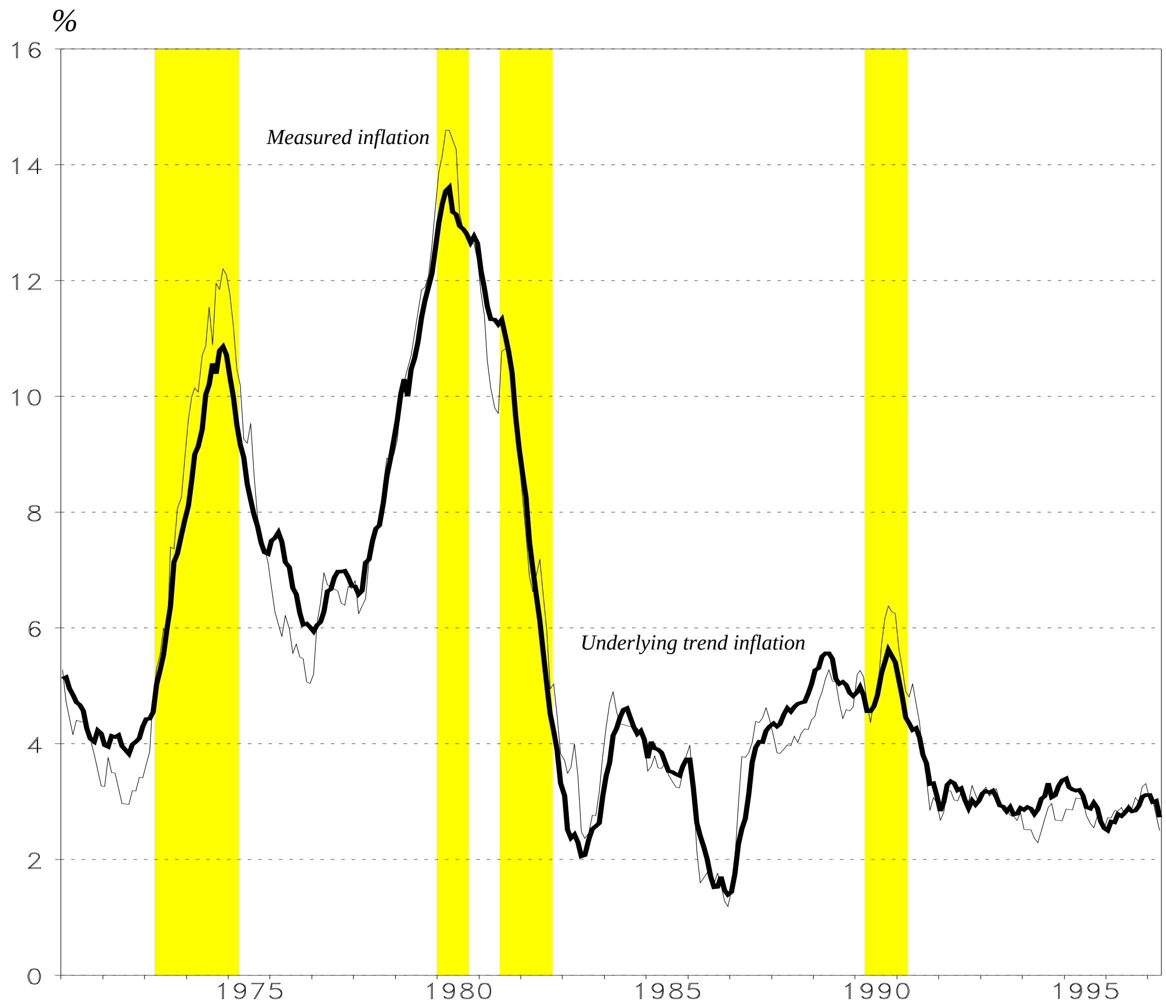
3.3.1 Measured and underlying trend inflation

The implementation of the long-run restriction allows us to decompose the inflation rate into its underlying trend and transitory movements. The four-variable structural VAR model includes CPI, capacity utilization, PPI and import prices.[6] An estimate of the trend inflation rate is obtained by subtracting the cumulative shocks of the transitory component from the actual inflation rate.[7] This ensures that estimation errors are not accumulated over time.

Figure 1 plots the measured inflation rate and its trend component on a year-over-year basis, with recession periods shown by shaded bars.[8] As the model uses monthly data, which are very volatile, the year-over-year changes are plotted. October 1976 was chosen as the level to which the monthly growth rates were applied to obtain an estimate of the underlying trend in levels. The year-over-year change was calculated from this "new" trend level series. In October 1976, consumer prices grew at their estimated trend.[9] Figure 1 suggests that measured inflation exceeded its underlying trend during the 1973–75, 1980, and 1990–91 U.S. recessions, presumably owing to the lagged response of inflation to supply shocks. Interestingly, the measured inflation rate exceeded the trend rate significantly over the 1973–75 recession, probably the result of the oil price shock. In contrast, during the 1981–82 recession, measured inflation was more or less in line with trend inflation and suggests that this economic downturn was the result of demand shocks rather than supply-side developments. Indeed, the view that this recession may have been largely attributable to monetary policy shocks rather than supply-side developments is supported by the sharp tightening in U.S. monetary policy preceding the downturn (Figure 2). The fact that both measured and trend inflation were declining sharply at the beginning of the 1980s supports the view that the Fed had raised interest rates in order to lower the trend rate of inflation.

6. Other variables that were initially considered include M1, M2, Fed Funds rate, industrial production, suppliers delivery index, average hourly earnings, unit labour cost, price of food, price of oil, commodity prices, price of gold, world industrial output, and exchange rate. These variables led to a large deviation of the actual inflation rate and the inflation rate calculated with the estimated structural shocks (equation 8) over part of the sample. This could be because either the deterministic trend is not zero over the entire sample as assumed or that past shocks at the beginning of the estimation, which are not captured, matter. Results are not included but are available upon request. Note that the final choice of variables is in line with earlier work on a forecasting model of U.S. inflation (see Claus 1996).
7. For completeness, the transitory component is plotted in Appendix 5.
8. The peak of the cycle is the first quarter prior to the first quarter of decline in real GDP. The trough is the last quarter of negative growth. Peaks and troughs of real GDP do not always coincide with the official National Bureau of Economic Research (NBER) recession dates.
9. The results do not change with different "starting" dates.

Figure 1:
Measured versus underlying trend inflation (y/y)
1971:2 - 1997:4



Recession periods are shaded.

Figure 2 presents the underlying trend inflation rate together with the change in the Fed Funds target rate. Figure 2 suggests that the U.S. monetary authority responds to shocks in the underlying inflation rate. Starting in February 1994, for instance, the Fed tightened monetary policy substantially to reduce the risk of sustained accelerating inflation. The Fed Funds target rate was increased by 275 basis points, from 3.25 per cent to 6.00 per cent, while the discount rate rose by 225 basis points, from 3.00 per cent to 5.25 per cent, over the period of one year. The Fed tightened although consumer price inflation was still trending downward. The tightening coincided with an upward trend in the underlying inflation rate and suggests that the monetary authority focusses on underlying inflation in conducting monetary policy.

Figure 2:
Underlying trend inflation and the change in the Fed Funds target rate
1971:2 - 1997:4

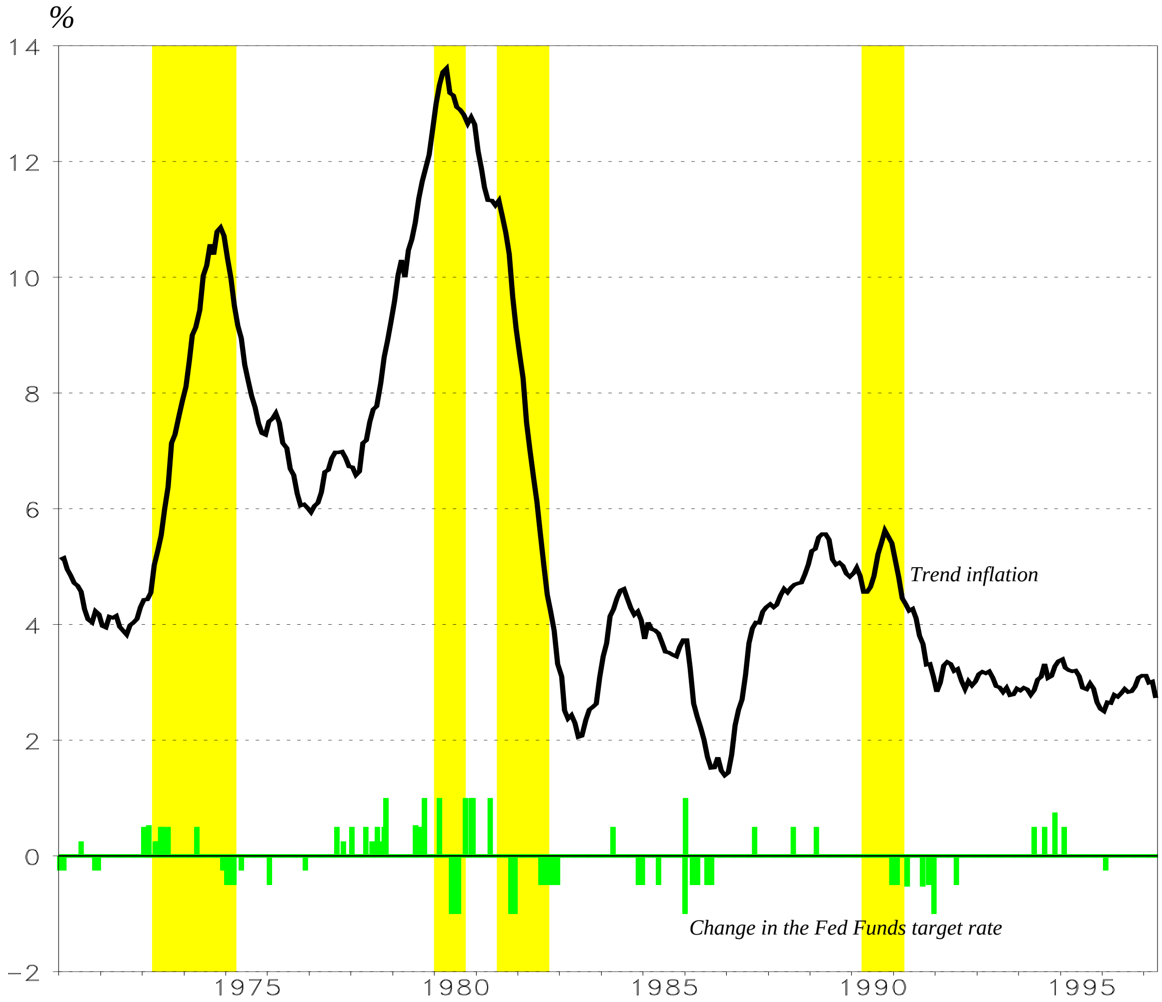
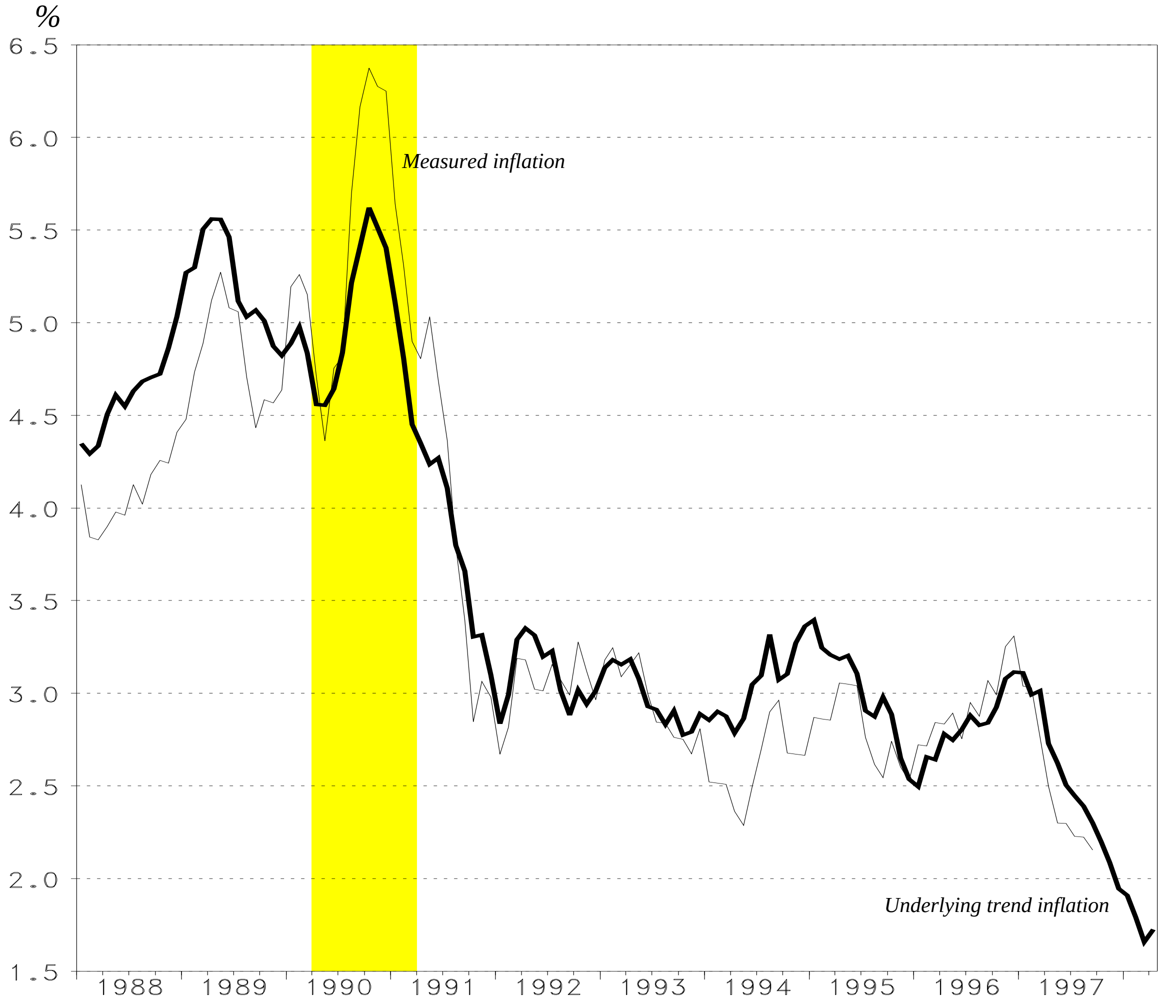


Figure 3 plots the measured inflation rate and its trend component as well as the underlying inflation rate that would prevail if no other shocks to inflation occurred. Figure 3 indicates that measured consumer price inflation was below its trend in 1994 and 1995. Interestingly, many forecasters overestimated inflation during this period. Although above-potential growth and a tight labour market were pointing to upward pressures on prices and wages, inflation remained subdued due to temporary factors, such as the slowing in the growth of labour compensation costs, largely led by declining benefits. One reason for the decline in benefits is that U.S. firms have held down medical costs by switching to managed care and other medical cost-containing programs. Moreover, job insecurity has contributed to containing wage demands despite tight labour markets. Valletta (1996) presents evidence that job insecurity may have actually increased recently in the United States. Another factor that may have contained inflationary pressures is the

Figure 3:
Measured versus underlying trend inflation (y/y)
1988:1 - 1998:4



increasing "globalization" of markets. In his July 1997 *Monetary Policy Testimony and Report to the Congress*, Greenspan noted that "increasing globalization has enabled greater specialization over a wider array of goods and services, in effect allowing comparative advantage to hold down costs and enhance efficiencies." Technological change, increased deregulation of telecommunications, motor and rail transport, utilities, and finance also may have been a factor in restraining prices. Figure 3 also indicates that, since 1996, measured inflation has been about in line with underlying inflation. Furthermore, both rates have been declining sharply over the first half of 1997. The very small deviation of measured inflation from its underlying trend could indicate that temporary factors are becoming less important in containing inflationary pressures. Nevertheless, past shocks should exert further downward pressure on the inflation rate as the underlying inflation rate that would prevail in the absence of any other shocks continues to decline.

3.3.2 Variance decomposition

The decomposition of the variance allows us to measure the relative importance of the shocks to the transitory and the trend components of inflation. Table 1 presents the decomposition over different time horizons. The restriction that shocks to the transitory component have only a temporary impact on the inflation rate implies that these shocks do not contribute to the inflation rate's variance in the long run. Moreover, the two types of shocks are uncorrelated by assumption, such that the sum of the two shocks always equals 100 per cent. Table 1 suggests that both types of shocks are important sources of fluctuations in the inflation rate in the short run. Transitory shocks are relatively more important than an underlying trend inflation rate shock in the very short run; however, their impact is more than halved after two years.

Table 1: Variance decomposition of the inflation rate

Horizon (months)	Consumer price inflation	
	Trend inflation	Transitory movements
1	41.62	58.38
6	56.53	42.47
12	66.43	33.57
24	74.19	25.81
48	79.63	20.37
long-term	100.00	0.00

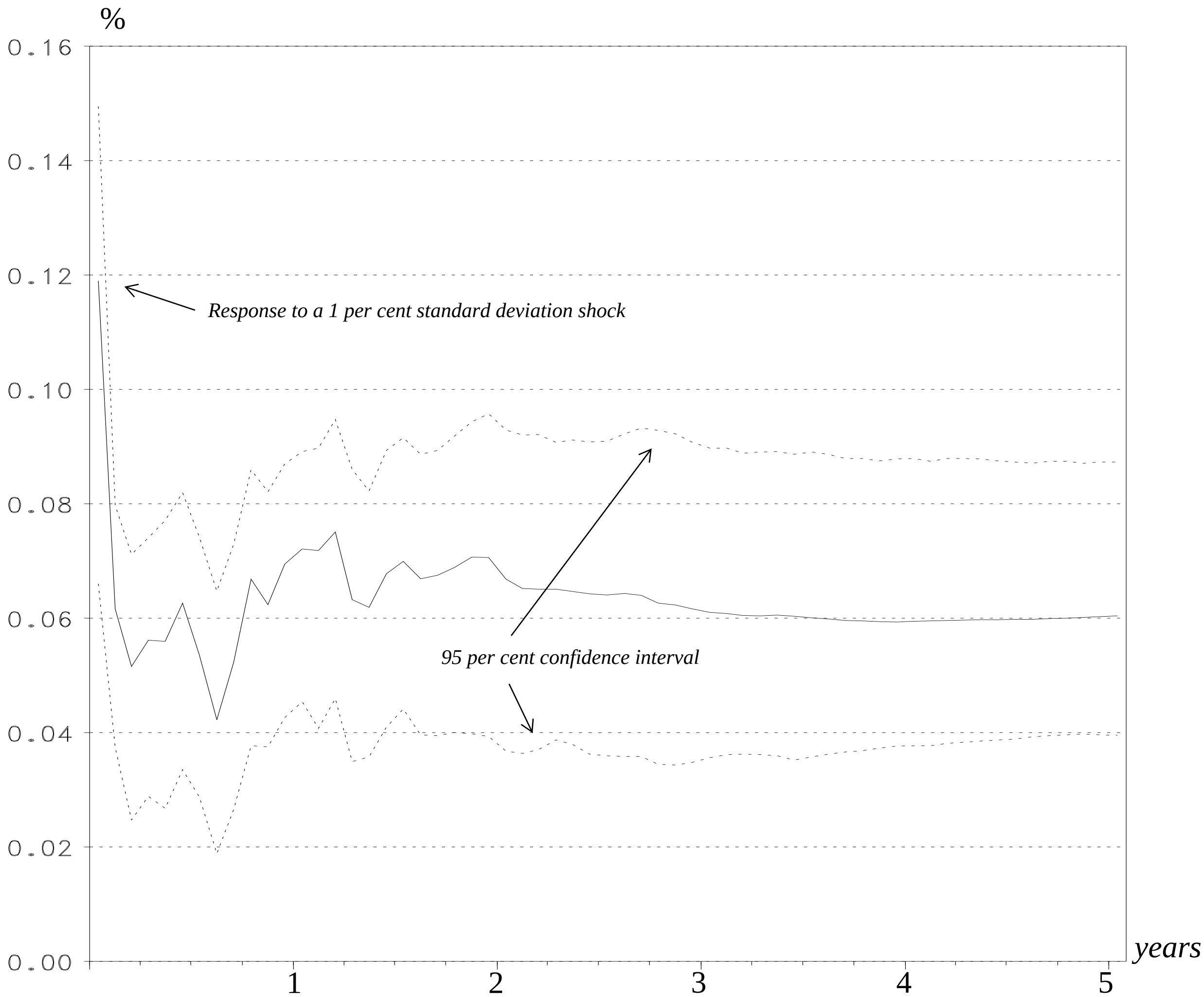
3.3.3 Impulse responses

Figures 4 and 5 present the impulse responses of the inflation rate to the transitory and the underlying trend inflation rate shocks.[10] The shocks are one standard deviation in size. Both types

10. Confidence intervals were generated using Monte Carlo simulations with 1,000 replications.

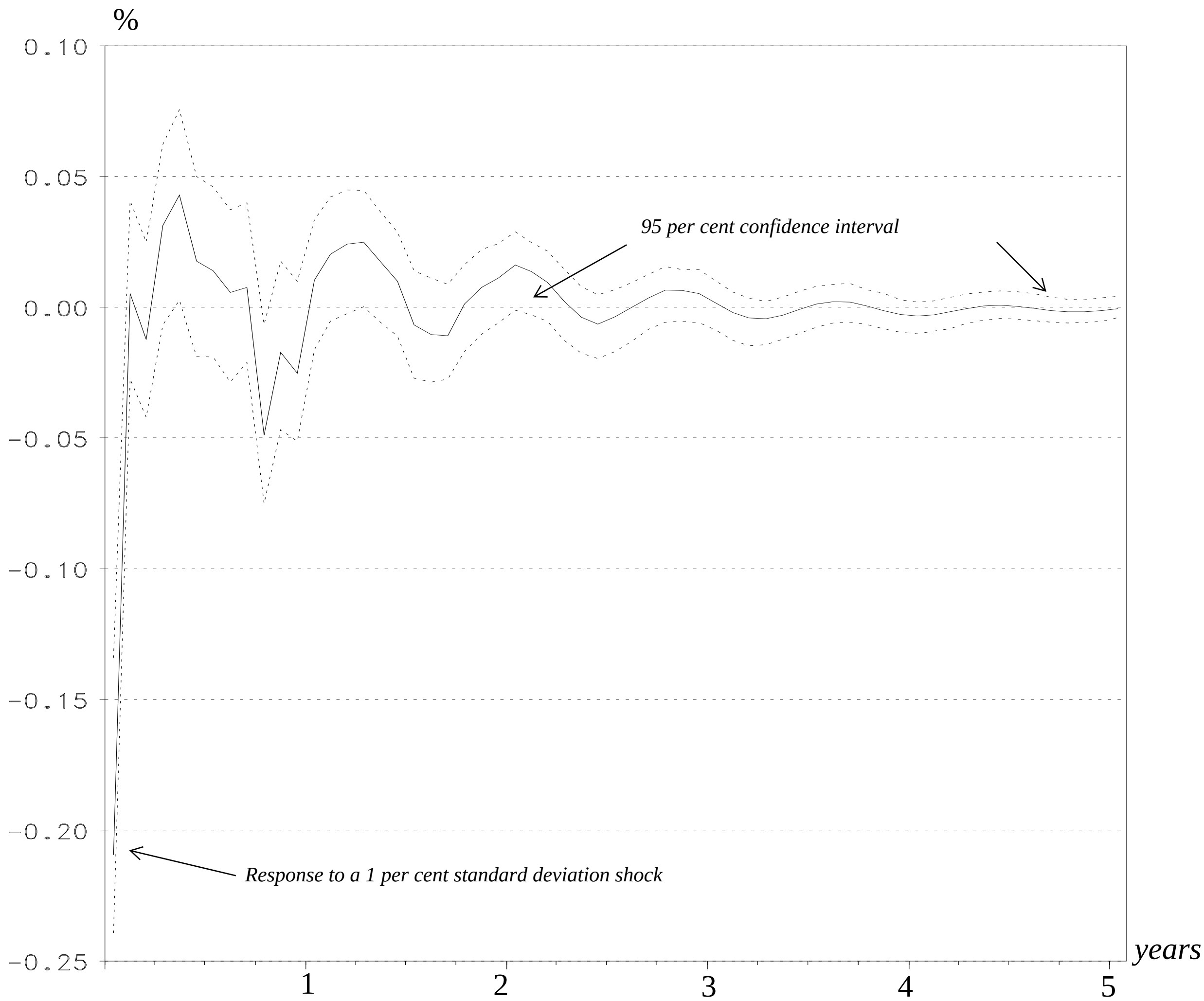
of shocks have the largest impact on the inflation rate in the first two years. The effect of the transitory shock to inflation vanishes after about three years.

Figure 4:
Response of the inflation rate to a trend inflation rate shock



Interestingly, the initial response of the inflation rate to a positive shock in the transitory component is a decline. This response is largely driven by capacity utilization and reflects the negative comovement of inflation and capacity utilization. Decomposition of the variance indicates that capacity utilization has the largest impact on the transitory movement in the inflation rate over the short term (not reported). The decline in the inflation rate is possibly the result of negative energy price shocks or temporarily lower real wages.

Figure 5:
Response of the inflation rate to a transitory shock



4. Concluding Remarks

In this paper the structural VAR methodology was applied to decompose shocks to U.S. inflation into temporary price shocks and long-lasting shocks to the underlying rate of inflation. More specifically, this allowed us to obtain a measure of the underlying trend inflation rate in the United States. Evidence was provided that measured inflation was below its underlying trend rate in 1994 and 1995, a period when inflationary pressures remained subdued despite above-potential growth and tightness in the labour market. The empirical evidence provided in this paper supports the view that temporary factors have helped to contain inflationary tendencies. Past shocks should exert some further downward pressure on inflation. The Federal Reserve's tightening in 1994–95 coincided with an upward trend in the underlying inflation rate, while measured inflation was still trending downward, and suggests that the monetary authority focusses on underlying inflation as a guideline for monetary policy.

There are several possible extensions to this paper. The model could be estimated using an alternative measure of economic conditions. One possible measure is the output gap that would capture whether the economy was in excess demand, excess supply, or equilibrium. Moreover, the assumption that the response of the inflation rate to positive and negative shocks is symmetric could be tested.

Finally, applying the methodology to other countries could yield interesting results. In the 1990s, a number of countries adopted explicit inflation targets as the goal of monetary policy. These targets were generally introduced to reflect the commitment of policymakers to achieving and maintaining low rates of inflation in their economies. Although the inflation targets are often defined in terms of the total consumer price index, monetary authorities that target a specific inflation rate tend to focus their near-term policy actions on some "core" measure of underlying inflation. These core measures are generally constructed from the consumer price index. An alternative measure to evaluate a monetary authority's success in keeping inflation within the target ranges could be an estimate of underlying trend inflation obtained by applying the structural VAR methodology.

Appendix 1: The data

Capacity utilization - Manufacturing, Mining and Utilities - Proportion. Seasonally Adjusted. Source: Board of Governors of the Federal Reserve. Statistical Release G.17.

Consumer price index - All Items. Seasonally Adjusted. Index base 1982-84 = 1.0. Source: U.S. Department of Labor. Bureau of Labor Statistics.

Import Price of Goods.

> Imports of Goods. Balance of Payments Basis. Billions of Current Dollars. Seasonally Adjusted. Source: U.S. Department of Commerce. Bureau of Economic Analysis and Bureau of the Census. Statistical Release Ft 900.
>
> Imports of Goods. Custom Value Basis. Billions of 1992 Dollars. Seasonally Adjusted. Source: U.S. Department of Commerce. Bureau of the Census. Statistical Release Ft 900. "U.S Merchandise Trade."
>
> International Monetary Fund (IMF) Import Price Series series M.111f75Z.

Producer price index - Finished Consumer Goods. Seasonally Adjusted. Index Base 1982 = 1.0. Source: U.S. Department of Labor. Bureau of Labor Statistics.

Figure 6: Capacity utilization and consumer price inflation

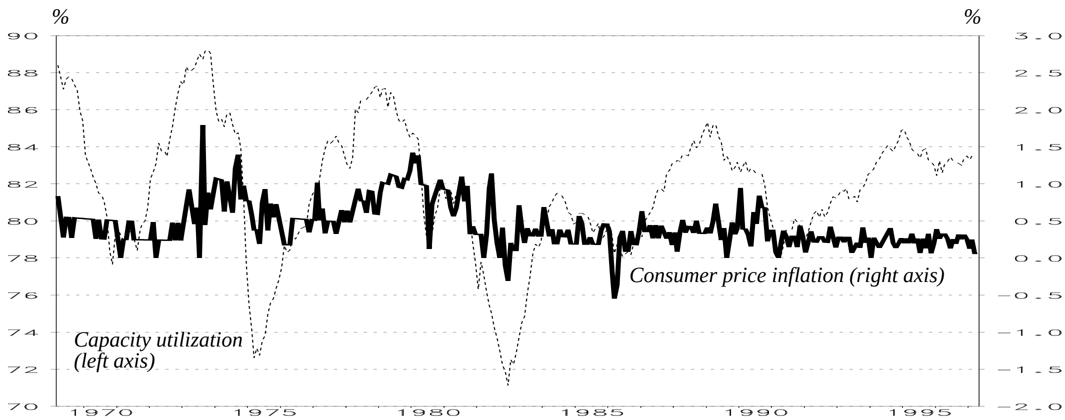


Figure 7: Producer price and consumer price inflation

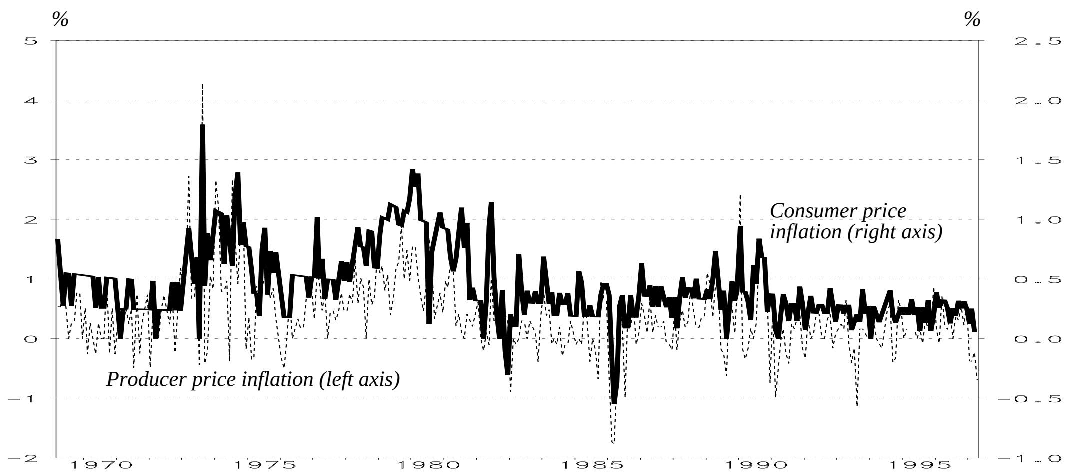
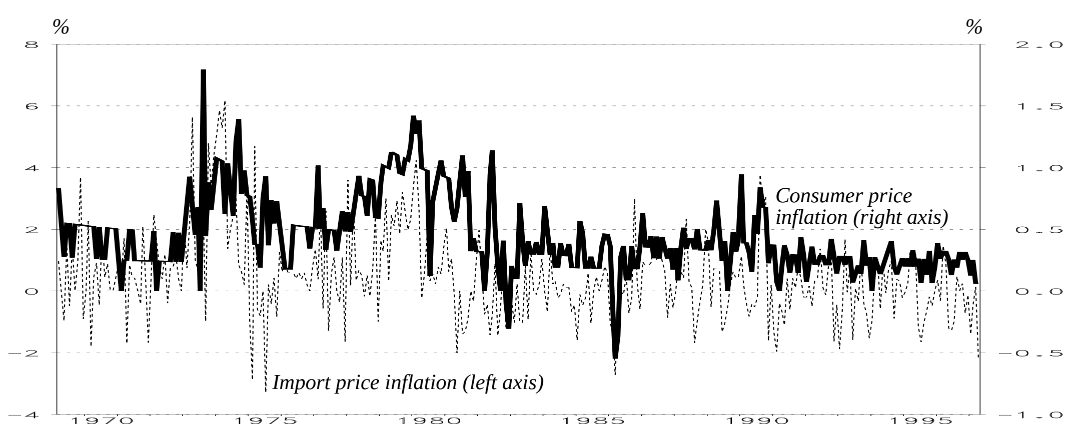


Figure 8: Import price and consumer price inflation



Appendix 2: Test for integration

Variable	Augmented Dickey-Fuller Test[a]			
	No Trend		**Trend**	
	t_ρ	**Process / Lags**	t_ρ	**Process / Lags**
CPI	-1.77162	12	-1.05493	12
$CAPUT$	-4.08735 *	8	-4.05268 *	8
PPI	-2.05221	11	-1.26478	11
IMP	-2.22036	10	-1.19569	10
ΔCPI	-2.02712	ARMA(1,1)	-2.55453	ARMA(1,1)
1% critical value[b]	-7.61316		-8.45397	
5% critical value	-6.22802		-7.46522	
ΔPPI	-2.37154	ARMA(4,1)	-2.90747	ARMA(4,1)
1% critical value	-9.26395		-9.70822	
5% critical value	-7.55927		-8.62629	
ΔIMP	-3.03796	MA(1)	-3.69592	MA(1)
1% critical value	-8.77116		-9.71511	
5% critical value	-4.69740		-8.34581	
$\Delta^2 CPI$	-11.55309 *	7	-11.54429 *	7
$\Delta^2 PPI$	-9.87392 *	9	-9.86501 *	9
$\Delta^2 IMP$	-10.29270 *	8	-10.27697 *	8
* H_0 of a unit root is rejected at the 1% level[c]				

a. For details see Page (1996a, 1996b). We use the lag length selection procedure proposed by Paquet (1994) that tests the included lagged terms for significance at the 10 per cent level. The initial number of lags is set equal to the seasonal frequency, i.e., 12.
b. Critical values for the ADF test in first-differences were generated by performing Monte Carlo simulations with 5,000 replications.
c. Critical values were obtained from Table 1 in MacKinnon (1990).

Appendix 3: Cointegration tests

Augmented Dickey-Fuller Test[a]	
Stock-Watson Procedure[b]	**Engle-Granger Procedure**
CPI , $CAPUT$, PPI , IMP	
-1.95914 (8) *	-1.75661 (6) *
ΔCPI , $CAPUT$, ΔPPI , ΔIMP	
-3.67442 (10) *	-1.62331 (10) *
* H_0 of no cointegration cannot be rejected at the 10% level[c]	

a. The data dependent lag is in parentheses.

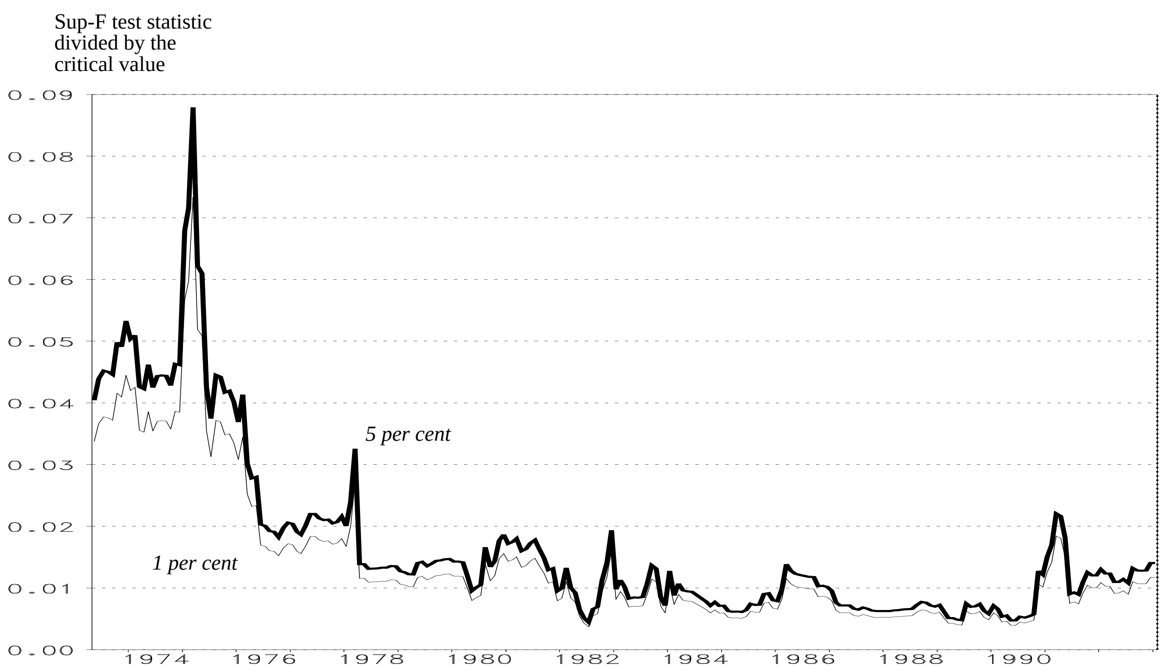
b. The Stock-Watson estimates are based on a leads and lags, Newey and West (1987) consistent variance-covariance estimator with the truncation parameter set equal to the seasonal frequency, i.e., 12. The number of leads and lags is chosen based on a stationary VAR model that includes 11 lags with all variables in levels and 10 lags with the price variables in first-differences to eliminate serial correlation from the residuals. The lag length was chosen based on likelihood ratio tests at the 10 per cent level. The initial number of lags was set equal to the seasonal frequency, i.e., 12.

c. Critical values were obtained from Table 1 in MacKinnon (1990).

Appendix 4: Sup-F tests[11]

Figure 9: Consumer price equation

Figure 10: Capacity utilization equation

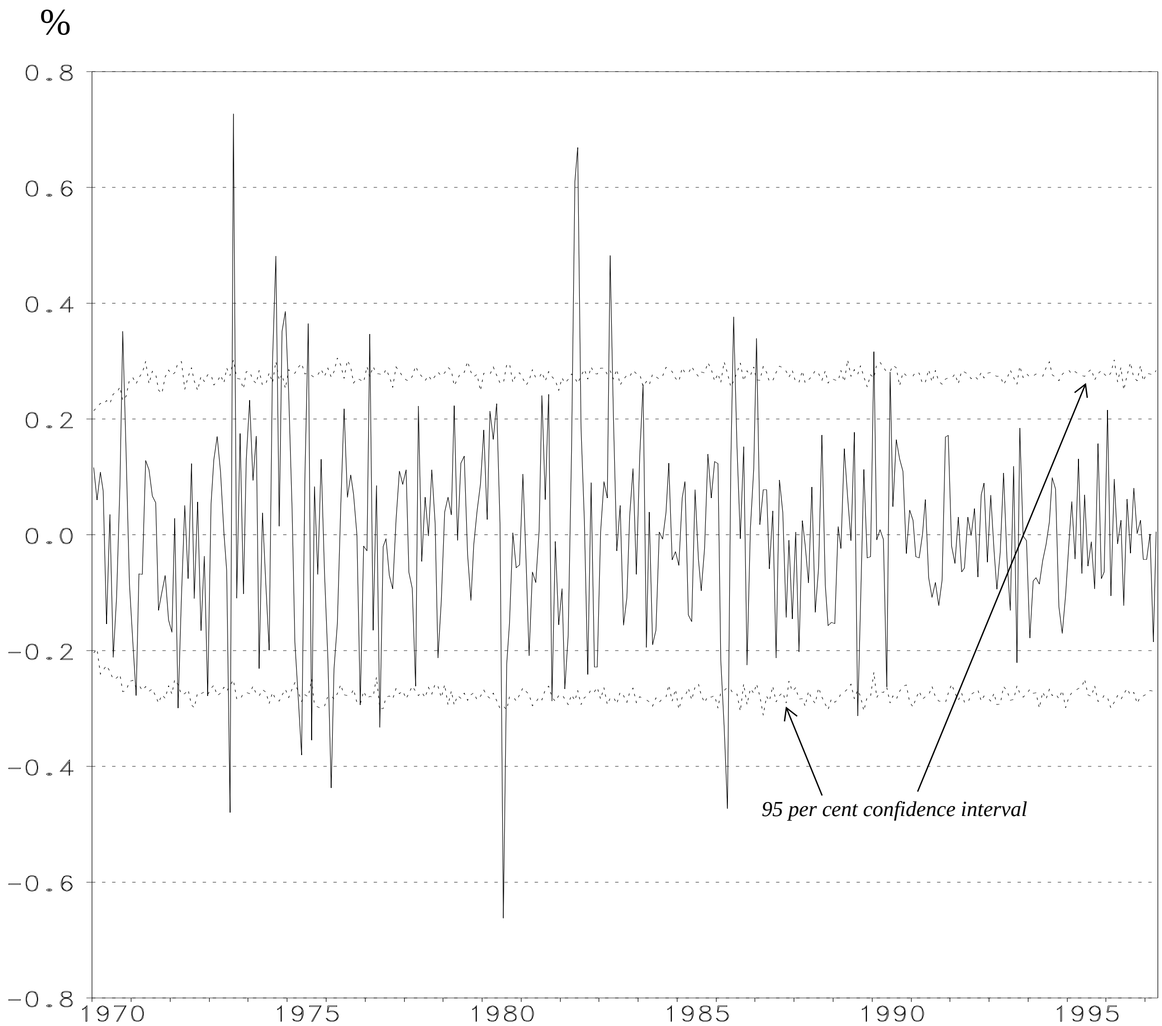


11. Critical values were obtained from Andrews (1993).

Figure 11: Producer price equation

Figure 12: Import price equation

Appendix 5: The transitory component of the inflation rate



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