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The U.S. Capacity Utilization Rate: A New Estimation Approach

by

René Lalonde

Bank of Canada Banque du Canada

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by
René Lalonde
International Department
Bank of Canada
Ottawa, Canada K1A 0G9
rlalonde@bank-banque-canada.ca

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Abstract

The recent strengh of the U.S. economy and historically low rates of inflation have sparked considerable debate among economists and Federal Reserve officials. In order to better explain the recent behaviour of inflation, some observers have raised the concept of a non-accelerating inflation capacity utilization rate (NAICU). In this study, the author presents a new methodology to estimate the NAICU. A simple structural vector autoregression, including industrial production, the inflation rate, and the long-run real interest rate, is used to identify production capacity. Results show that production capacity is consistent with stable trend inflation. Using simple Phillips curves, out-of-sample forecast exercises show that the capacity utilization rate generated by the methodology presented in this paper seems to outperform the one now published by the Fed.

JEL classifications: E32, E37
Bank of Canada classification: Business fluctuations and cycles

Résumé

La forte croissance de l’économie américaine combinée à des niveaux d’inflation historiquement bas ont soulevé un débat important au sein de la Réserve fédérale et parmi les économistes en général. Pour tenter d’expliquer le comportement récent de l’inflation, certains observateurs ont mis de l’avant le concept du taux d’utilisation de la capacité non accélérationiste (TUCNA). Dans cette étude, l’auteur présente une nouvelle méthodologie visant à estimer un TUCNA. Un simple VAR structurel formé de l’indice de la production industrielle, du taux d’inflation et du taux d’intérêt réel de long terme est utilisé pour générer le niveau de la capacité de production. Les résultats montrent que le niveau de la capacité de production est compatible avec aucune modification de tendance de l’inflation. Un exercice de prévision hors échantillon à l’aide de courbes de Phillips semble démontrer que le taux d’utilisation de la capacité généré à partir de la méthode présentée dans cette étude donne de meilleurs resultats que celui qui est présentement publié par la Réserve fédérale.

JEL : E32, E37
Classification de la banque : Cycles et fluctuations économiques

Introduction

An important potential role for the capacity utilization rate is as an indicator of inflationary pressure. When an economy is operating at a high percentage of its productive capacity there is likely, *ceteris paribus*, to be more inflationary pressure than when it is at a low percentage of capacity. Discussions at the Federal Reserve on the inflation process have included the concept of a non-accelerating inflation capacity utilization rate (NAICU).[1]

The Fed publishes a monthly measure of the capacity utilization rate. However, the Fed's methodology suffers from several drawbacks that limit the information content. The capacity utilization rate is based on an annual survey, annual data is interpolated into monthly figures, and arbitrary "filtering" regressions are used. Furthermore, as Kennedy (1998) points out, some of the information used to generate the capacity utilization rate has changed or disappeared over time, creating a time-consistency problem. Finally, the Fed's definition is referred to as a practical concept of capacity level, and is unconnected with economic concepts. For instance, the Fed assumes that the NAICU is 82 per cent (i.e., the average capacity utilization rate) and therefore any capacity utilization rate higher than 82 per cent will lead to inflation pressures. However, this is an ad hoc judgment, since the Fed's methodology cannot identify any particular rate as being non-inflationary. The approach presented in this paper addresses these drawbacks.

Following Kennedy (1998), I suggest a measure of capacity that corresponds to the trend level of industrial production. A structural vector autoregression (SVAR) is used to decompose industrial production into permanent and transitory components. Shocks affecting trend production, thereby driving capacity, are assumed to be supply shocks. Shocks affecting production on a temporary basis are associated with demand shocks, and capture the deviation of production from capacity. Consequently, demand shocks determine the capacity utilization rate.

The proposed approach does not rely on interpolation. Arbitrary filtering methods, such as the Fed's, and mechanical filters are avoided. On the contrary, it lets the data determine production capacity based on the information included in the SVAR, thereby associating estimated productive capacity more closely with economic information. The capacity utilization rate can be particularly useful to central banks if it helps to predict inflation. Using some simple Phillips curves, I show that the SVAR approach explains and forecasts changes in the U.S. inflation rate at least as well, and in several cases better, in and out of sample, than does the Fed's current method.

1. According to Alan Blinder, former Fed Governor, the Federal Reserve is already looking at the NAICU as a way to measure inflation pressures.

The remainder of this paper is divided into five sections. Section 1 explains the concept of the NAICU. Sections 2 and 3 describe the method used by the Federal Reserve and the SVAR-based alternative. Section 4 reports the results, followed by the conclusion.

1. The NAICU and the "American Miracle"

Strong U.S. growth and historically low rates of inflation have sparked considerable debate among economists and Fed officials. Some observers argue that inflation has shown behaviour more consistent with the current capacity utilization rate than the NAIRU (i.e., non-accelerating inflation rate–unemployment rate) gap. Consequently, discussions at the Federal Reserve have included the concept of a NAICU. The Federal Reserve assumes that the currently published measure of the capacity utilization rate is consistent with a non-accelerating rate of inflation when its level is under 82 per cent (i.e., the historical average). However, this is an ad hoc judgment, since the Fed's methodology cannot identify any particular rate as being non-inflationary. In fact, within the Fed's present framework, industrial capacity is defined as the highest level of production achievable with the current level of capital and realistic working schedules. Consequently, the capacity utilization rate now produced is based on a practical concept of capacity level, and is therefore not directly connected with explicit economic concepts.

Kennedy (1998) estimates a NAICU that corresponds to the trend of industrial production estimated with the HP (Hodrick-Prescott) filter. Obviously, this method suffers from the drawbacks inherent to the HP filter (St-Amant and van Norden 1997). Furthermore Kennedy's approach, like the Fed's present methodology, does not imply that the trend of industrial production is consistent with a non-accelerating rate of inflation. The goal here is to suggest an alternative methodology for estimating the NAICU that may have some advantages relative to these other approaches.

This paper does not address the question of whether the NAICU gap is better to forecast inflation then the NAIRU gap. In a paper that attempts to explain recent forecasting errors of inflation, Stock (1999) concludes that a Phillips curve using a capacity utilization rate outperforms a Phillips curve based on the NAIRU gap. Obviously, this question depends on the methodology used both to estimate the NAICU and the NAIRU, and would be an excellent topic for future research. Another possible answer is that the NAIRU gap and the NAICU gap should be used together to forecast and explain inflation. In fact, central banks already look at more than one indicator to gauge inflation pressure. For example, the NAIRU gap may capture inflation pressure coming from the labour market on wages, while the NAICU gap may explain pressure coming from the goods market. This could be important, given that the goods sector is more closely linked to economic cycles than is the service sector. Nevertheless, one must also take into account the fact that industrial production is less important to the economy than the labour market or the service sector.

2. Methodology now used by the Federal Reserve

The first step of the Fed's methodology consists of obtaining a measure of production capacity (CAP) that is equal to the ratio of the industrial production index (IP) divided by a measure of the capacity utilization rate based essentially on the U.S. Census Bureau's Annual Survey of Plant Utilization (CU).

$$CAP_t = IP_t / CU_t$$

The Federal Reserve views this measure of capacity as too volatile. To smooth capacity they estimate:

$$\log(CAP_t) = a + \log(K_t) + \Sigma\beta_i f_i(t)$$

where K is the stock of capital and $f_i(t)$ is a polynomial deterministic function of time. The fitted values of this equation are the annual measures of production capacity. The monthly data are obtained by interpolation. The capacity utilization rate is then calculated by dividing the level of industrial production by the estimated productive capacity.

3. Proposed methodology

This section presents a simple structural VAR used to estimate an alternative capacity utilization rate. To keep the model simple, the choice of variables is inspired by the model used in Lalonde, Page and St-Amant (1998), although the model could be improved in future work. The following variables are included in first differences: industrial production (y), the monthly CPI inflation rate (π), and the long-term real interest rate (rr).[2] To identify the moving average representation of the model, I use a stationary model. According to the unit root tests, it appears that the variables of the model are stationary in first difference. The shocks and the variables of the structural model are:

$$\varepsilon_t = \begin{bmatrix} \varepsilon_s \\ \varepsilon_{d1} \\ \varepsilon_{d2} \end{bmatrix} \text{ and } Z_t = \begin{bmatrix} \Delta y \\ \Delta\pi \\ \Delta rr \end{bmatrix} , \tag{1}$$

2. The long-term real interest rate is the interest rate on 10-year government bonds minus the CPI inflation rate (month over month at an annual rate).

where: ε_s is the supply shock, the only shock that permanently affects output; and ε_{d1} and ε_{d2} are temporary shocks associated with demand shocks. In this model, ε_s drives industrial capacity and the transitory shocks affect the deviation of industrial production relative to its capacity (i.e., the capacity utilization rate). Note that ε_{d1} is analogous to a monetary shock because it affects the trend inflation rate, while ε_{d2} has a transitory effect on the inflation rate. Note that, for the purposes of this paper, I do not distinguish between monetary shocks and other demand shocks, since both affect the capacity utilization rate.

The moving-average representation of the structural model is:

$$Z_t = \Gamma(0)\varepsilon_t + \Gamma_1\varepsilon_{t-1} + \Gamma_2\varepsilon_{t-2} + \dots = \Gamma(L)\varepsilon_t, \quad (2)$$

where, $E(\varepsilon_t\varepsilon_t) = I$. For simplicity, the elements of the diagonal are set to 1.

To identify the structural model, its autoregressive reduced form must first be estimated:

$$Z_t = \sum_{i=1}^{p} \Pi_i Z_{t-i} + e_t \quad (3)$$

where p is the number of lags, e_t is the estimated reduced form innovations, and $E(e_t e_t) = \Sigma$.

Given that the model is stationary, the MA representation of equation 3 is:

$$Z_t = e_t + C_1 e_{t-1} + C_2 e_{t-2} + \dots = C(L)e_t, \quad (4)$$

and the reduced form innovations are linked to the structural residuals by:

$$e_t = \Gamma(0)\varepsilon_t \quad \text{and} \quad (5)$$

$$E(e_t e_t) = \Gamma(0)\Gamma(0)' \quad \text{because} \quad E(\varepsilon_t\varepsilon_t) = I . \quad (6)$$

Finally, the matrix of long-run effects of the reduced-form residuals $C(1)$ is related to the equivalent matrix of the structural residuals $\Gamma(1)$ through the following relationship:

$$\Gamma(1) = C(1)\Gamma(0). \quad (7)$$

To identify $\Gamma(0)$, three restrictions on the system of equations must be imposed. The Blanchard-Quah decomposition consists of imposing restrictions on the matrix of *long-run* effects of the structural shocks $\Gamma(1)$. Therefore, we make the assumption that the matrix of long-run effects of the structural shocks is triangular. Given these restrictions, equations 6 and 7 are exactly identified and $\Gamma(1)$ is given by:

$$\begin{bmatrix} \varepsilon_s & \varepsilon_{d1} & \varepsilon_{d2} \end{bmatrix}$$

$$\begin{bmatrix} y \\ \pi \\ rr \end{bmatrix} \begin{bmatrix} r_{11} & 0 & 0 \\ r_{21} & r_{22} & 0 \\ r_{31} & r_{32} & r_{33} \end{bmatrix} = \Gamma(1),$$

where the dependent variables and the vector of structural shocks are shown for presentation purposes. The supply shocks are, by construction, the only shocks that have a permanent effect on industrial production. They are therefore associated with shocks that change the level of capacity. Since ε_{d1} and ε_{d2} are assumed not to affect trend industrial production, we impose the restriction that demand shocks have no permanent effect on real output. A final restriction, which has no impact on the estimated capacity utilization rate, is $r_{23} = 0$.

4. Results

This section is divided into three subsections. The first presents the variance decomposition of industrial production and the dynamic effects associated with the structural shocks. The second reports the estimated capacity utilization rate and compares it with that of the Federal Reserve. The last section analyses the performance of inflation forecasts based on the structural VAR approach.

4.1 Variance decomposition and impulse responses

Table 1 shows the variance decomposition of industrial production as modelled by the SVAR. Figures 1 and 2 show the impulse responses of output and inflation to the model's structural shocks. At impact, the two demand shocks account for two-thirds of the variance in industrial production, while shocks affecting production capacity (i.e., supply shocks) explain the remainder. It takes about a year for the effect of supply shocks to surpass that of the demand shocks. It is important to note that, initially, supply shocks have a negative impact on the inflation rate, while demand shocks generate inflation in the short run.

Table 1: Variance decomposition of industrial production

Number of months	ε_s	ε_d
1	31	69
3	25	75
6	33	67
12	49	51
24	74	26
48	84	16
96	91	9
∞	**100**	**0**

Contamination of supply shocks by monetary shocks does not appear to be an important problem, as demand shocks account for 80 per cent of the long-run variance in inflation. In fact, the long-run effect of supply shocks on the inflation rate is not statistically significant. Consequently, the productive capacity generated by the model can be considered as an approximation of the non-accelerating inflation-rate level of production. In any case, the long-run effect on inflation could be linked to some supply shocks accommodated by the monetary authorities.

Figure 1: Impulse responses of industrial production

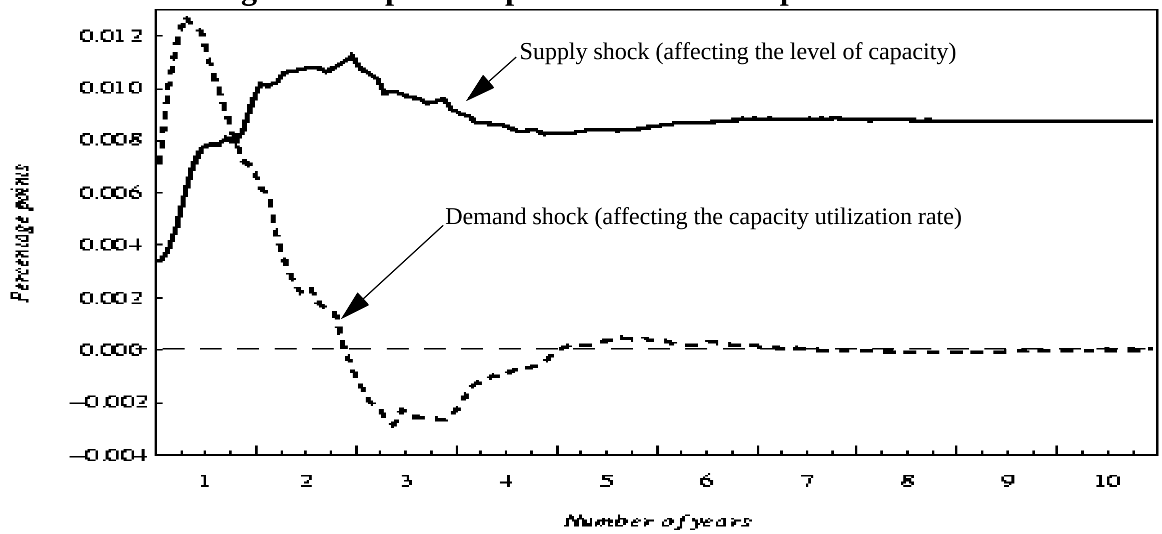
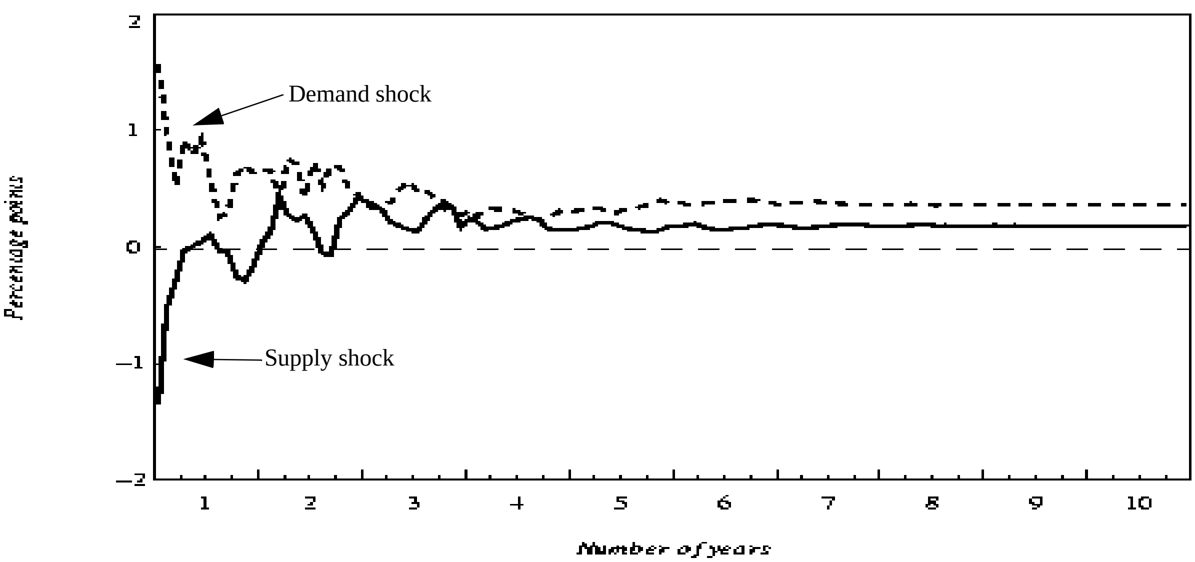


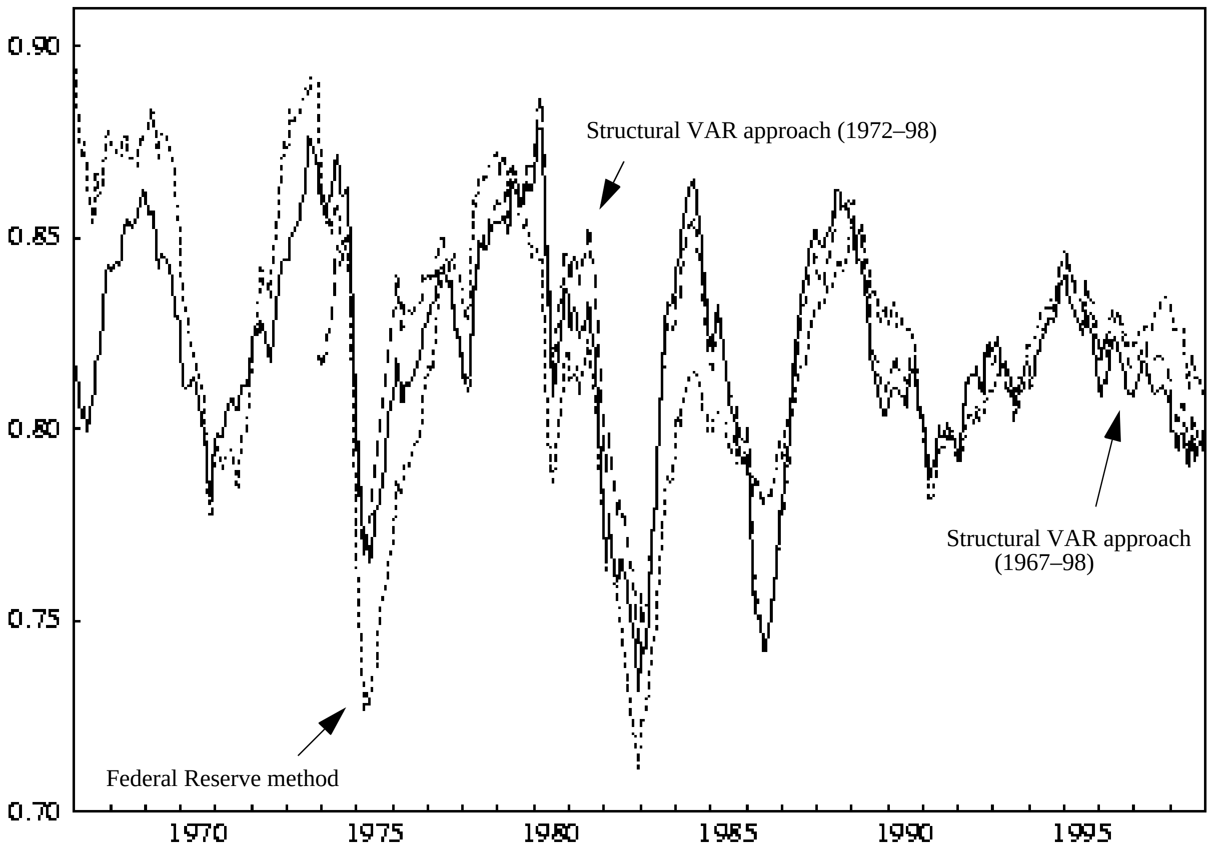
Figure 2: Impulse responses of CPI inflation rate



4.2 The capacity utilization rate and capacity of production

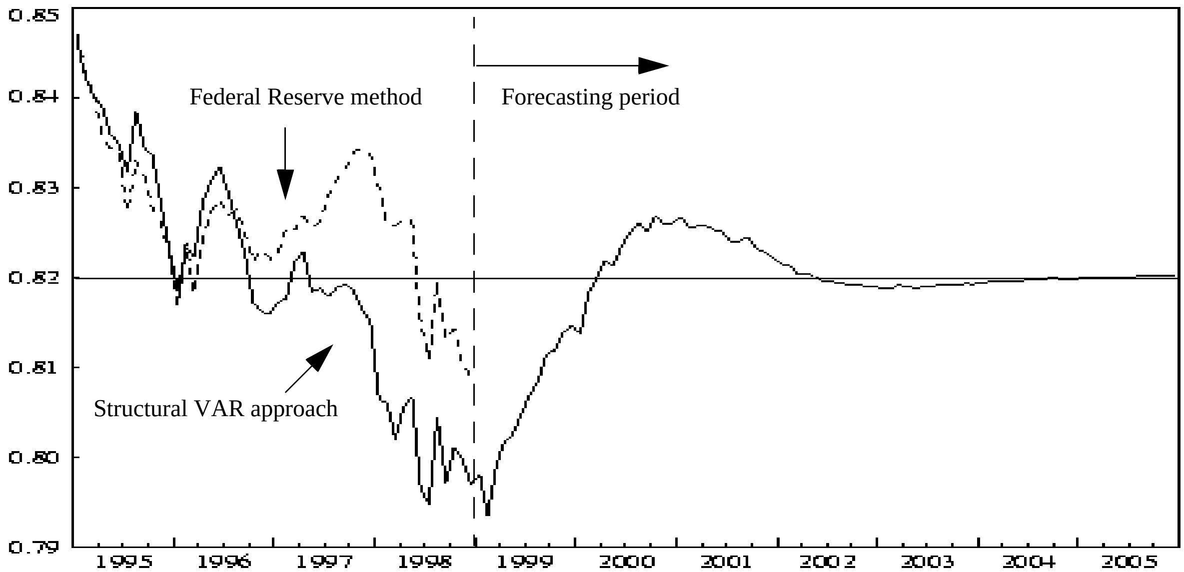
Figure 3 compares the estimated capacity utilization rate with the one employed by the Federal Reserve. For presentation purposes, the capacity utilization rate corresponding to the SVAR approach is centered to the average of the latter measure (i.e., 82 per cent). The graph presents the results of the SVAR approach for the same sample period as the Fed's measure, as well as for the post-Bretton Woods period. The results for the two sample periods are nearly identical. Appendix 1 presents the confidence intervals (significance level: 67 per cent) around the estimates of the centered capacity utilization rate. It shows that any deviation of more than 2 per cent of industrial production from its capacity is statistically significant.

Figure 3: Capacity utilization rate



Although Figure 3 shows that key shifts in the capacity utilization rate are similar using both the Fed and SVAR approaches, in some episodes the two measures tell a different story. For example, according to Figure 4, since 1996 the SVAR approach indicates a systematically lower capacity utilization rate than the Fed's measure. Figure 4 also shows that the SVAR approach predicts that the level of production will gradually return to trend capacity through the year 1999. However, from the beginning of 2000 until the end of 2001, the model forecasts that the production level will be higher than capacity.

Figure 4: Capacity utilization rate, January 1995 to the end of the forecasting period



As Figure 5 shows, since the end of the 1990–91 recession the level of production more closely follows capacity than in the earlier part of the sample. This ended in 1998, when adverse demand shocks opened a gap between production and capacity. These shocks may be linked to the Asian crisis.

Figure 6 shows that since the end of 1995 the growth rate of productive capacity has been higher than the growth rate of production, which would explain the low capacity utilization rate. This rise in capacity may also explain why we have observed both strong output growth and low inflation since 1995. The next section addresses this question more directly.

Figure 5: Level of industrial production and productive capacity

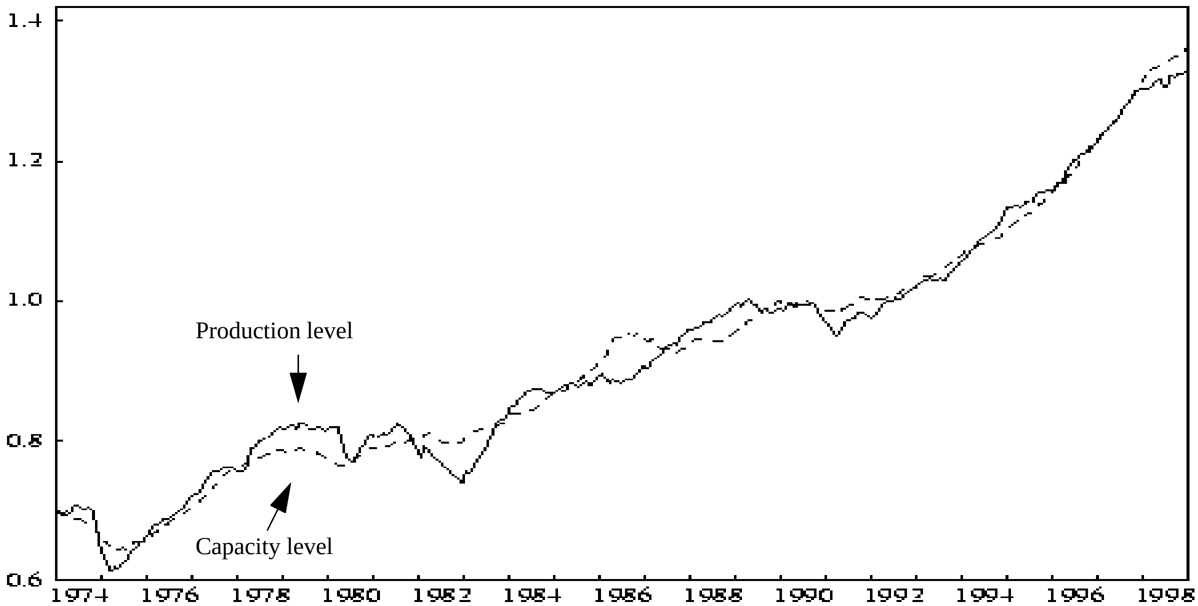
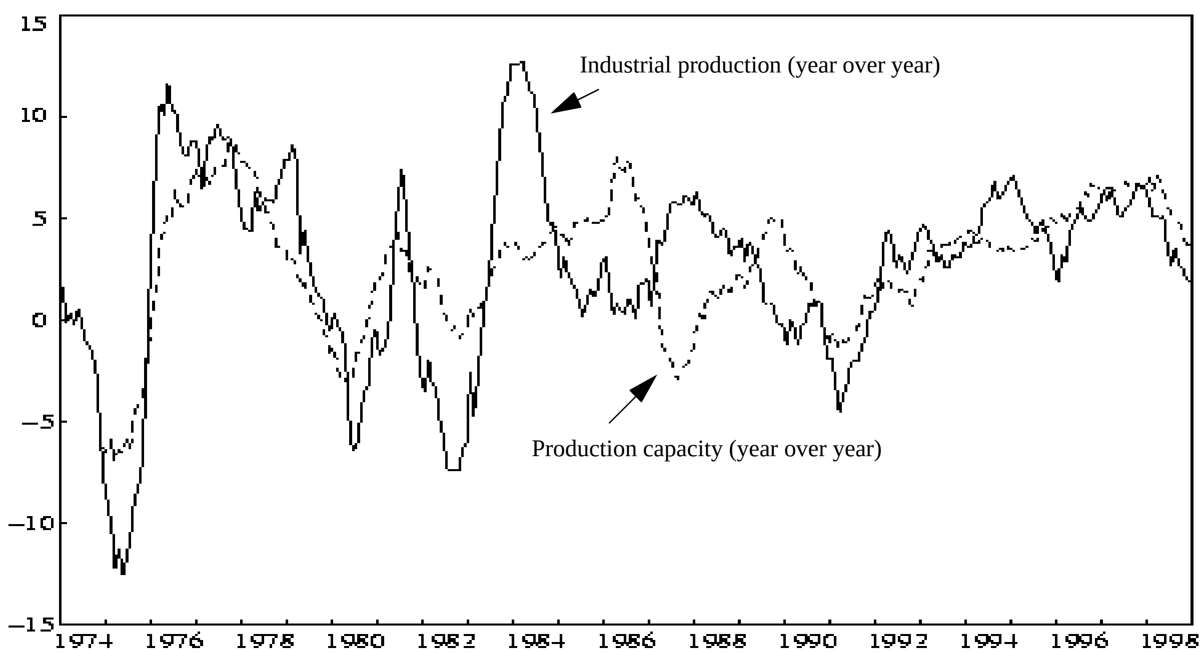


Figure 6: Growth rates of industrial production and productive capacity



4.3 Inflation forecasts and explanatory power

One way to assess the usefulness of alternative measures of capacity utilization is to test their relative inflation forecast performance in the context of some simple models. We have estimated indicator models of the first difference of the monthly inflation rate, where the explanatory variables are simply lags of the dependant variable and of the capacity utilization rate. A contemporaneous value of the capacity utilization rate is also added to the indicator model.[3] In doing so, we obtain simple Phillips curves using both the Fed series on capacity utilization and the series developed in this paper. The number of lags is specified using the Akaike criterion, with a maximum of 12. The sample period is from January 1972 to December 1998.[4] We further compare these models with an autoregressive model. Tables 2 and 3 show the results of the indicator models for both the change of the total CPI inflation rate and the change of the CPI inflation rate excluding food and energy, respectively.

For both models, the capacity utilization rate has the expected positive effect on inflation. However, the SVAR approach has somewhat greater explanatory power than the model based on the capacity utilization rate produced by the Federal Reserve; the R^2 is larger and the Akaike criterion is smaller.

For central banks, the capacity utilization rate could be useful if it helps to predict inflation. To test the ability of the proposed measure to forecast inflation in the current U.S. context of solid growth and low inflation, we have generated out-of-sample forecasts of the change in the CPI inflation rate (both total and core) for the period January 1995 to December 1998. For the purposes of this paper, out-of-sample forecasts for 3 and 12 months ahead are computed; the results are presented in Table 4. Note that out-of-sample forecasts under the SVAR approach use the projected capacity utilization rate for the contemporaneous value, whereas the model based on the Fed's measure assumes that the contemporaneous measure is known. This tends to bias the results against the SVAR approach, given the importance of data revision and estimation uncertainty.

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3. The inflation lags are present to differentiate between the information included in the inflation lags and in the capacity utilization rate terms. In the case of the SVAR model, information is only used that would have been available at the starting point of the forecast. For the contemporaneous value of the capacity utilization rate, I use the projected value derived from the SVAR, which is based only on the information included in the lags of the dependant variables.
4. The Federal Reserve measure of capacity utilization begins in 1967. Even though the capacity utilization rate is almost identical when I use the post-Bretton Woods period, the out-of-sample performance of the Phillips curves is superior when I use the 1972–98 period.

Table 2: Indicator model for change in the CPI inflation rate

	Structural VAR approach	**Federal Reserve measure**	**Autoregressive model**
Lag of $\Delta\pi$	1 to 8, 10, and 11	1 to 10	1 to 8, and 11
Lags of the capacity utilization rate (*T*-statistic)	0[a] (8.1) 1 (7.1) 3 (3.4) 4 (3.3) 12 (1.9)	0 (3.6) 3 (1.7) 4 (2.8)	—
Akaike criterion[b]	2,083.95	2,421.58	2,450.94
Adjusted R^2	41.9%	38.7%	30.0%
Sum of the coefficients associated with the capacity utilization rate	14.87	23.98	—
Significance level of the test excluding the coeffi-cients related to the capacity utilization rate	0.000	0.000	—

a. Contemporaneous value.
b. The objective is to minimize this criterion.

Table 3: Indicator model for change in the CPI inflation rate excluding food and energy

	Structural VAR approach	**Federal Reserve measure**	**Autoregressive model**
Lag of $\Delta\pi$	1 to 8	1 to 8, 10, and 12	1 to 8, 10, and 12
Lags of the capacity utilization rate (*T*-statistic)	0 (5.9) 1 (3.6) 2 (2.2) 3 (2.8)	0 (3.9) 1 (2.1) 2 (1.6) 4 (2.8) 5 (2.0)	—
Akaike criterion	2,143.37	2,256.26	2,298.02
Adjusted R^2	42.8%	42.4%	33.1%
Sum of the coefficients associated with the capacity utilization rate	13.45	18.27	—
Significance level of the test excluding the coefficients related to the capacity utilization rate	0.000	0.000	—

The results are supportive of the SVAR approach. For both total CPI and core CPI, the Theil-*U* statistics for the SVAR approach are smaller than those for the Fed's measure at all forecasting horizons. Furthermore, for 3- and 12 steps-ahead forecasts, the SVAR does better than the autoregressive model. The results therefore suggest that, in recent years, the proposed approach contains information useful to forecasting inflation. Table 5 shows that this is especially the case for the last two years, where the SVAR approach produced a systematically lower capacity utilization rate than the Fed's measure. According to Table 6, for these years, out-of-sample forecasts of the indicator model based on the SVAR approach are considerably more closely correlated to the actual change in the total CPI inflation rate than are either of the other two models. Appendix 1 confirms this, showing that the SVAR approach seems to track well the movements in the change in the inflation rate, even though it underestimates the amplitude. Nevertheless, the indicator model using the Fed's measures and the autoregressive model (see Appendix 2) tend to have difficulties capturing both the movements and the amplitude of the change in the inflation rate.

Table 4: Change in the CPI inflation rate, out-of-sample forecast: Theil-*U* from January 1995 to December 1998

Steps ahead (months)	Structural VAR approach Projected conptemporaneous value used	Federal Reserve measure Contemporaneous value assumed to be known	Autoregressive model
Change in the total CPI inflation rate			
3	0.75	0.83	0.78
12	0.57	0.64	0.62
Change in the CPI excluding food and energy inflation rate			
3	0.75	0.84	0.77
12	0.80	0.93	0.83

Table 5: Change in the CPI inflation rate, out-of-sample forecast: Theil-*U* from January 1997 to December 1998

Steps ahead (months)	Structural VAR approach Projected contemporaneous value used	Federal Reserve measure Contemporaneous value assumed to be known	Autoregressive model
Change in the total CPI inflation rate			
3	0.70	0.85	0.87
12	0.51	0.57	0.59
Change in the CPI excluding food and energy inflation rate			
3	0.74	0.82	0.78
12	0.79	0.87	0.84

Table 6: Correlation between out-of-sample forecast and the actual change in the total CPI inflation rate, January 1997 to December 1998

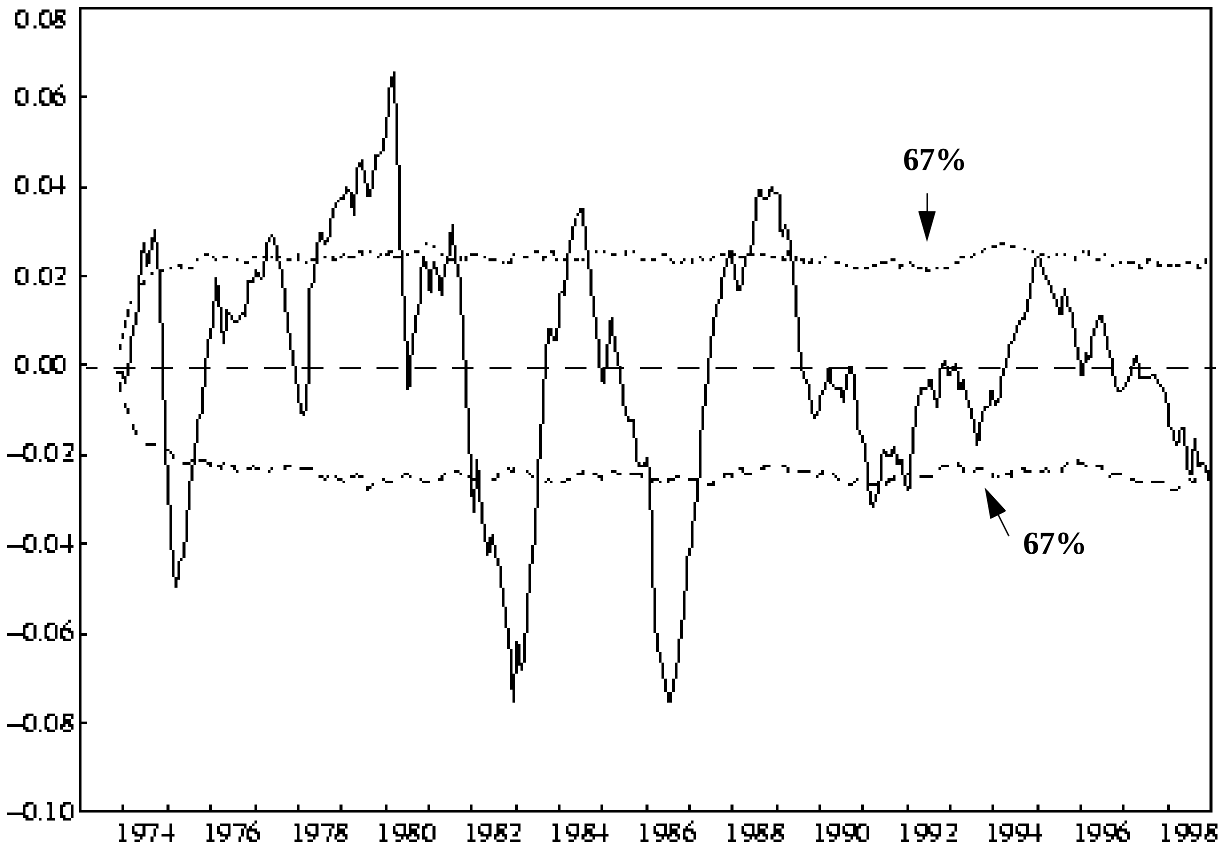
	3 steps ahead	12 steps ahead
SVAR approach	0.63	0.62
Fed approach	0.30	0.41
Autoregressive model	0.20	0.40

5. Conclusion

The method currently used by the Federal Reserve to estimate the industrial capacity utilization rate has important drawbacks. It is based on an annual survey, interpolation of annual data and arbitrary "filtering" regressions. It also suffers from time-inconsistency problems. This paper proposes and tests a new approach of estimating the capacity utilization rate. The proposed method is simple and allows the data to generate industrial capacity based on a non-accelerating rate of inflation and the capacity utilization rate based on information included in the SVAR.

Even though the SVAR presented in this paper is straightforward, the results seem to indicate that this method is preferable to the capacity utilization produced by the Fed. Based on simple Phillips curves, results show that the SVAR approach better explains and forecasts changes in the inflation rate. The model using a trivariate SVAR approach also provides an inflation forecast that is better than the forecasts generated by the autoregressive model for 3 and 12 steps ahead. Furthermore, note that the indicator model based on the SVAR approach gives an inflation forecast that can be explained by a structural concept, whereas the autoregressive model does not provide any structural explanation of projected inflation. Consequently, the approach here represents a useful tool for central banks to use alongside other indicators of inflationary pressures (e.g., the GDP gap and the labour market gap). In further research, the performance of the model could be improved using a richer structural VAR than the one presented in this paper.

Appendix 1: Capacity utilization rate (centered on zero) and confidence intervals[5]



5. The confidence intervals are computed based on 1,000 Monte Carlo experiments.

Appendix 2: Out-of-sample forecast

Figure 1: Change in the CPI inflation rate versus 3-months-ahead forecast (monthly data)

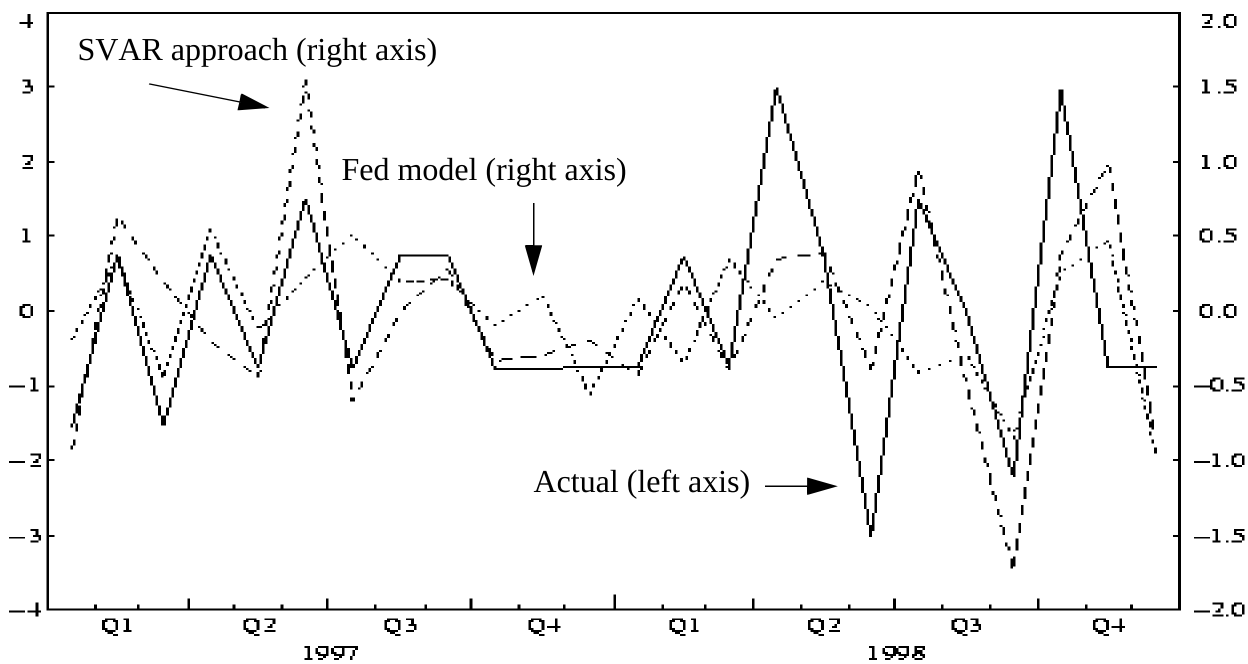
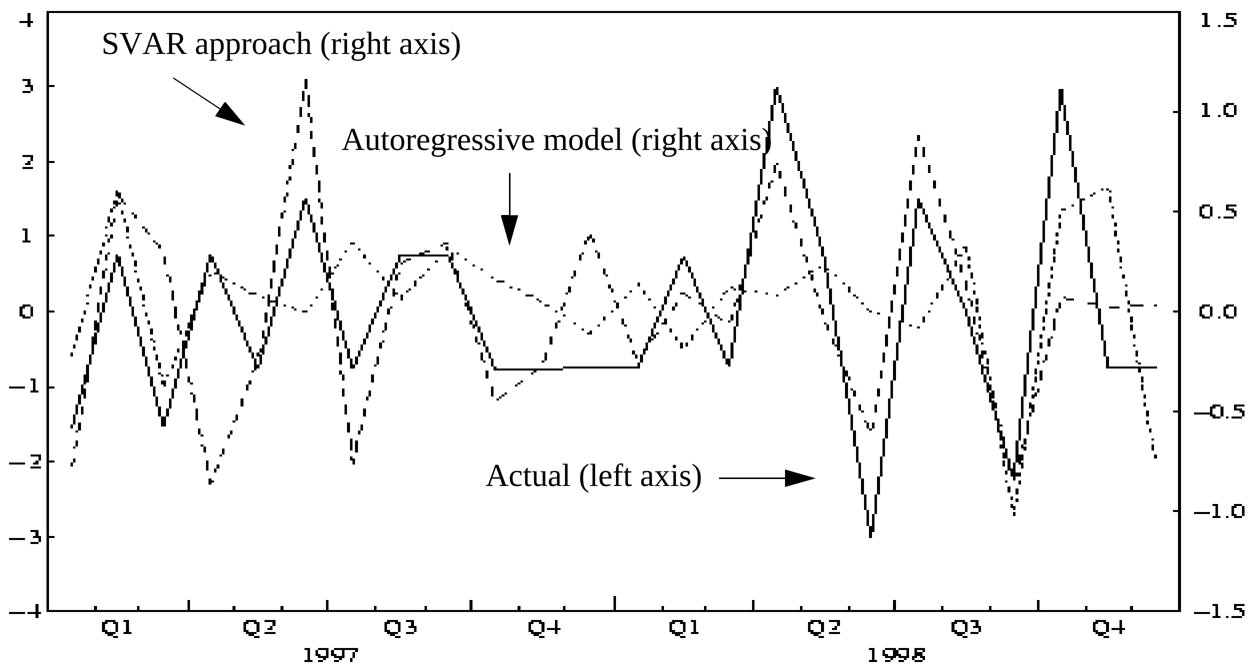


Figure 2: Change in the CPI inflation rate versus 12-months-ahead forecast (monthly data)



Appendix 3: Out-of-sample forecast

Figure 1: Change in the CPI inflation rate versus 3-months-ahead forecast (monthly data)

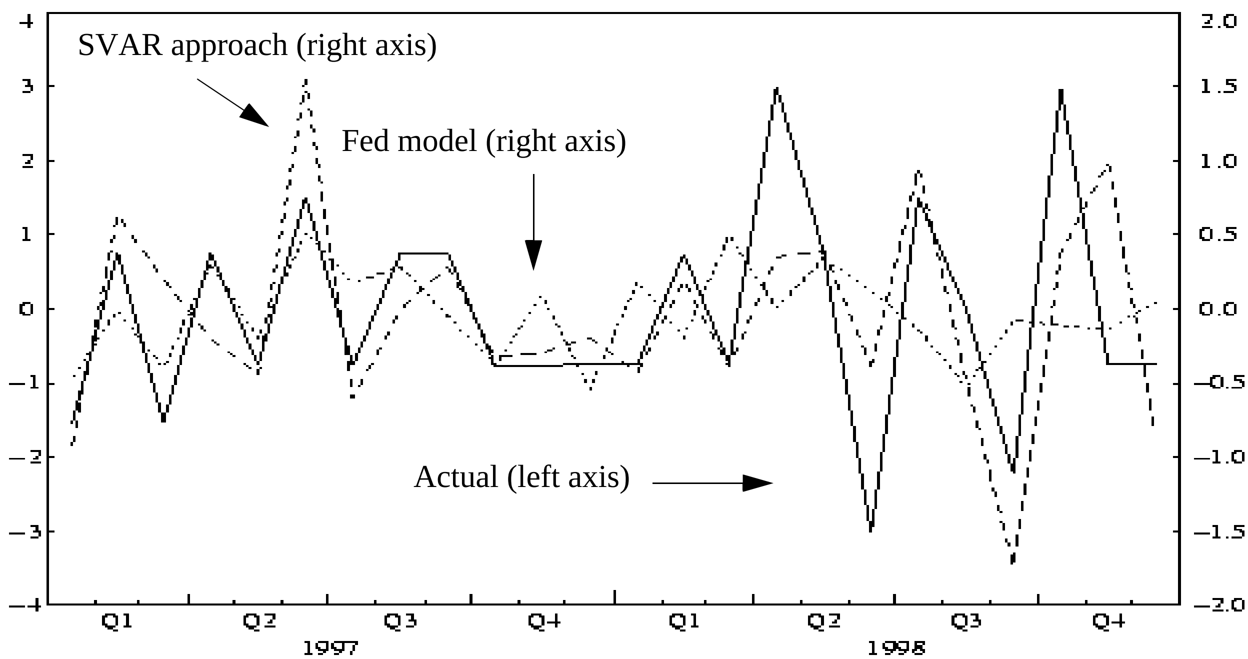
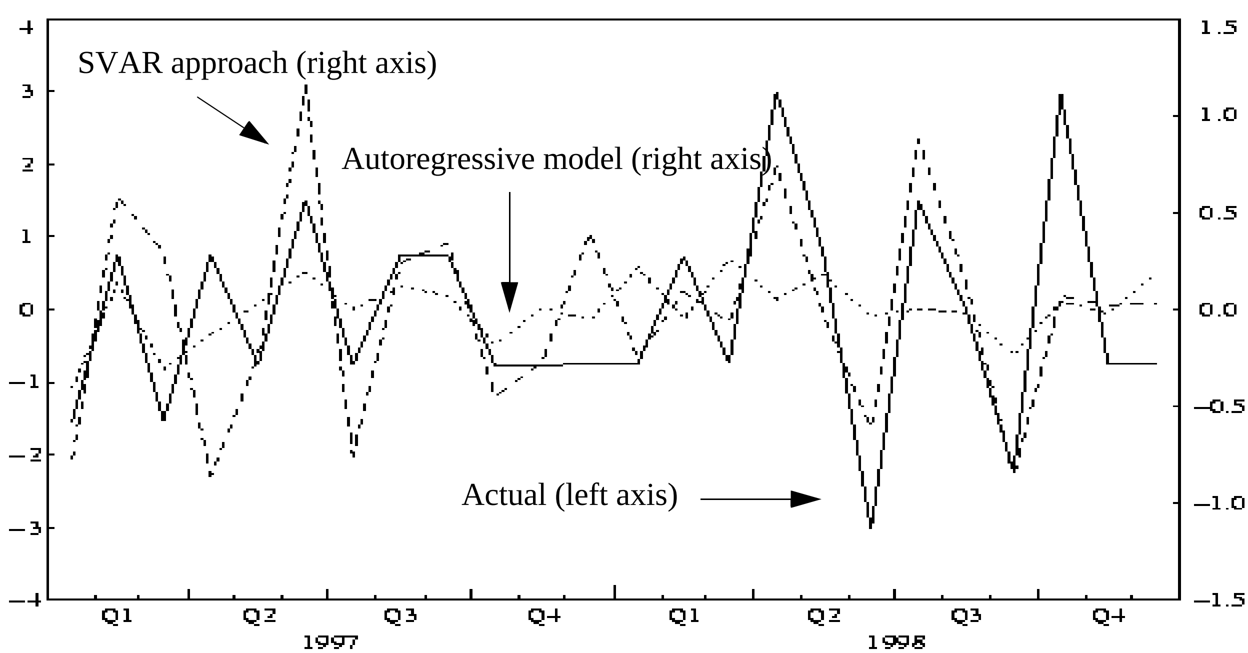


Figure 2: Change in the CPI inflation rate versus 12-months-ahead forecast (monthly data)



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