Capacity utilization and inflation

The connection between capacity utilization and inflation varies in time and intensity from industry to industry; this makes the aggregate economy-wide capacity measure less useful as a predictor of inflation

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From the fourth quarter of 1987 to the fourth quarter of 1988, industrial production increased by more than 5 percent and the capacity utilization rate for manufacturing increased by more than two percentage points, from 82.1 to 84.2. With the decline in the dollar over the past few years, many export industries are now producing at or near full capacity.

Historically, when manufacturing has been operating at the current levels of capacity utilization, inflation has tended to increase. For several years, the inflation rate has been remarkably stable in the range of 4 to 4 1/2 percent. This rate of inflation could increase in 1989 due to those factors that have pushed up the capacity utilization rates to levels that have not been reached since the late 1970s. While the linkage between capacity utilization rates and inflation is not very precise, capacity utilization does capture the general strength of the economy. Like the unemployment rate, the capacity utilization rate can be interpreted as a measure of excess demand pressures facing an economy. When demand is strong and capacity constraints become important, inflation is likely to increase.

This paper presents some empirical estimates of the macroeconomic linkage between capacity utilization and inflation and evaluates the usefulness of this approach. We begin by reviewing some theoretical explanations of how these variables might be related. Next we update earlier empirical estimates by McElhattan (1978, 1985) using annual data from the 1970s and 1980s; we then use these estimates to forecast how much inflation might increase in 1989. These forecasts are very uncertain because there are large standard errors in the estimates and questions about the appropriate sample periods.

Further questions are raised by a sector-by-sector analysis. Cost and price changes are highly correlated with each other and capacity utilization rates are insignificant in explaining short-run price movements. Nevertheless, for a limited number of industries using annual data, capacity utilization rates can identify what sectors could have unusually large increases in prices. However, these sector linkages are often highly nonlinear and involve significant lags. Additionally the utilization rates that are associated with price increases vary significantly across industries. These difficulties raise questions about interpreting the implications of aggregate capacity numbers for inflation.

Theoretical considerations

The idea that there is a link between capacity utilization and inflation follows from some rather simple economic notions. When there is unused capacity, competition among producers holds prices down. As capacity constraints are reached, competitive pressures are increased and prices can be raised. Furthermore, an industry that is facing capacity

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constraints may be subjected to price increases from suppliers that face excess demand pressures. Therefore, both costs and prices might rise together in sectors that are operating at high capacity utilization rates.

The situation is analogous to the better known Phillip's curve, which postulates a relationship between expected real wages and unemployment. When many people are unemployed, wages and prices do not rise as fast as when firms must compete for scarce labor. At some "natural" rate of unemployment, the actual and expected rates of inflation are equal.

However, as simple as the theoretical justification is, it does not predict what the relationship between capacity utilization and inflation should be. Questions about timing and functional form[1] remain. In this regard, sector analysis complements the aggregate approach and can help to develop a detailed forecast of where inflationary pressures are likely to be concentrated.

The empirical examination

Using annual data, McElhattan (1978, 1985) presents evidence that capacity utilization provides better estimates of inflation than unemployment rates in some simple reduced-form models. In her studies the expected inflation rate is assumed to equal the actual rate of inflation in the previous year. Since the coefficient is not significantly different from unity, the model assumes that the change in the rate of inflation is a function of the capacity utilization rate. At some "natural" rate of capacity utilization, inflation remains constant. Whenever capacity is above this stable-inflation utilization rate, inflation will continue to increase. Conversely, inflation will decrease only when capacity is brought below this natural rate.

Aggregate data

The first empirical results presented use the capacity utilization rate for manufacturing to estimate the change in four broad measures of inflation. These are the implicit GNP deflator, the fixed-weight GNP price index, the all-commodity producer price index, and the consumer price index less food and energy. The rate of change of the last index is some times referred to as the "underlying" rate of inflation.

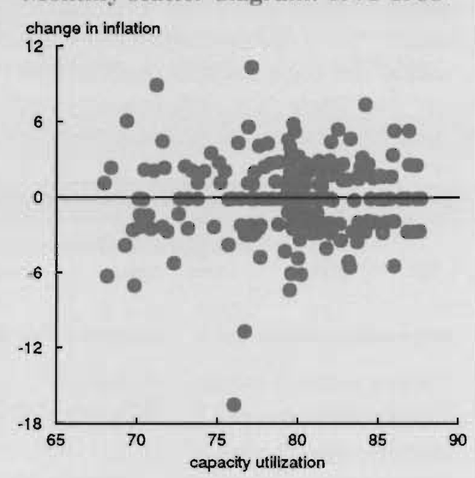
By definition, capacity utilization is the ratio of a seasonally adjusted industrial production index to a related capacity index. These series are estimated by the Federal Reserve Board's Division of Research and Statistics and are released monthly. A description of how capacity is estimated can be found in Raddock (1985). Since the level of capacity tends to grow smoothly over time, short-run movements in the capacity utilization rate are almost entirely due to changes in industrial production. This series can fall sharply during recessions and grow strongly during recovery.

The change in inflation rates between successive months can be very "noisy" or erratic. On a month-to-month basis, there is no statistically significant relationship between the change in any of the rates of inflation and capacity utilization. Figure 1 is a scatter diagram of monthly data from 1971 to 1988. Along the vertical axis is plotted the change in the underlying rates of inflation, and along the horizontal axis is plotted the capacity utilization rate. The correlation of these two series is essentially zero.

Because of the noisiness of these monthly data, economists estimate models after the data has been smoothed. In this case, the most common smoothing technique is to use annual data. The rate of inflation can then be calculated on a year-over-year or fourth-quarter-to-fourth-quarter basis. The change in the rate of inflation is simply the current year's rate of

FIGURE 1

Monthly scatter diagram: 1971-1988



inflation minus the previous year's inflation rate.

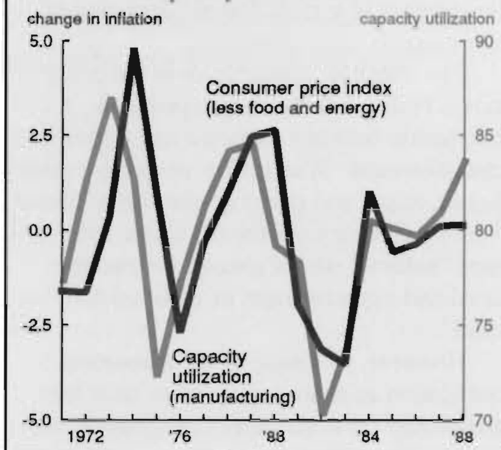
Table 1 lists the four inflation equations we estimated, using annual data from 1971 to 1988. Each of these equations estimates the change in the inflation rate as a linear function of the current rate of capacity utilization in manufacturing. This is the basic equation that McElhattan estimated using earlier sample periods and excluding any dummy variables. There are several properties of these regressions that should be pointed out.

The estimated "natural" rate of capacity utilization in these regressions is around 80 to 81 percent, or approximately one or two percentage points less than that estimated by McElhattan. Probably the primary reason for this difference is the fact that our sample does not include data from the 1950s or 1960s. During these decades there were years when the annual capacity utilization rate were very high by more recent standards and the rate of inflation was not increasing very much. According to these more recent estimates, the inflation rate will remain constant when capacity utilization rates remain around 81 percent.

A second difference is that a one-year lag for capacity utilization is sometimes significant and helps to fit the different turning points in the price and capacity series. Figure 2 plots the change in the underlying inflation rates and the level of capacity utilization rate as two time series. A quick glance at these time series reveals that there is a fairly uniform one-year lag. Table 2 lists some regressions that include current and/or lagged capacity utilization rates. In these regressions, the estimated increase in inflation when capacity utilization rate is one percentage point above its natural rate is greater than previous estimates. McElhattan's models typically predict an increase in the rate of inflation of about 0.1 to 0.2 percentage points. Our equations predict increases about twice as large.

FIGURE 2

Changes in inflation and capacity utilization



Using the models that have only lagged capacity utilization rates, we can predict the rate of inflation in 1989 by estimating the rate of inflation in 1988 and the capacity utilization rate for 1988. Figure 3 is a scatter diagram for the change in the underlying rate of inflation. The regression line has been drawn and the vertical line segment represents the 1989 point estimate, plus or minus one standard error. The length of this line reflects the large errors that are typical of economic forecasts.

Policy implications

If this particular estimated relationship between inflation and capacity utilization holds over the next several years, the implications for monetary policy would be dramatic. We will suppose that the natural rate of capacity utilization is about 81 percent and a one-percentage-point increase in capacity utilization causes an approximate 0.4 percentage-

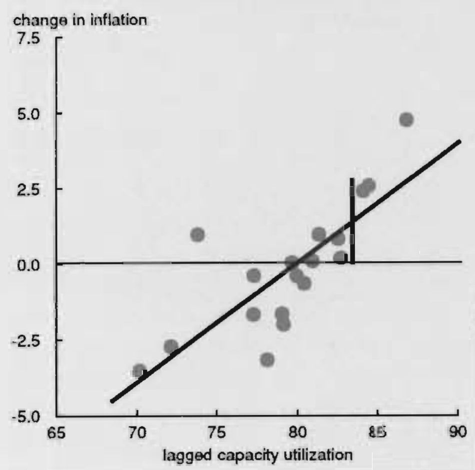
TABLE 1

Changes in inflation and current capacity utilization rates

Dependent variable	Intercept	(t-stat)	Capacity utilization	(t-stat)	Natural rate	R2
CPI (less food and energy	-20.67	(-2.49)	0.2577	(2.48)	80.2	0.278
Implicit GNP deflator	-18.63	(-3.26)	0.2321	(3.24)	80.3	0.397
GNP fixed-weight index	-21.80	(-4.86)	0.2736	(4.87)	79.7	0.597
Wholesale price index	-70.85	(-5.89)	0.8880	(5.90)	79.8	0.685

FIGURE 3

Annual scatter diagram



point increase in the rate of inflation in the following year.

Capacity utilization for manufacturing in 1988 was about 83.5 percent and the underlying rate of inflation was about 4.4 percent. Using our rule of thumb, the expected increase in inflation in 1989 should be 0.4 * (83.4 - 81.0) or one percentage point. This increase is larger than the average forecast (0.6) increase in inflation, as measured by the overall consumer price index, reported in the March survey of 51 economic forecasters by Blue Chip Indicators.

If both capacity and manufacturing output grow at 3 percent in 1989, then the capacity utilization rate for manufacturing should remain constant, but at a level that has been associated historically with rising inflation. If capacity utilization averages 83.4 percent in 1989, the rate of inflation could increase by another percentage point in 1990, that is, to 6.4 percent.

According to this particular model, in order to prevent an increase in inflation in 1990, capacity utilization would have to average the natural rate in 1989. For capacity utilization to fall this much, manufacturing output would have to grow approximately three percent less than the growth of manufacturing capacity.

Sources of uncertainty

The empirical results presented are subject to the usual uncertainties associated with any estimates that use small samples of economic data. In addition there are several other factors that need to be raised. As already mentioned, our estimates of the natural capacity utilization rate are lower than McElhattan's earlier results and the inflationary impact is larger. These results seem to depend upon the sample period used. By omitting data from the 1950s and 1960s, when changes in inflation were often quite small even when the capacity utilization rate was relatively high, we have biased our estimates. The rationale is that the 1970s and 1980s might provide better estimates of what inflation is likely to do in the next few years. Only time will tell if this was a reasonable assumption.

Another source of uncertainty has to do with estimating the average inflationary response for a sample period that includes such varying circumstances. From a macroeconomic point of view, the past two decades have included some very different periods. In the mid 1970s, when capacity utilization rates were fairly high, inflation increased rapidly following the large and rapid increases in energy prices. In the late 1970s when the

TABLE 2

Lagged capacity utilization rates

Dependent variable	Intercept	(t-stat)	Capacity Utilization		Capacity Utilization lagged 1 year		Natural rate	R2
CPI (less food and energy)	-31.24	(-5.04)			0.3914	(5.03)	79.8	0.612
	-37.24	(-5.31)	0.1261	(1.59)	0.3403	(4.20)	79.8	0.668
GNP Implicit deflator	-23.48	(-4.95)			0.2930	(4.93)	80.1	0.603
	-30.12	(-6.27)	0.1408	(2.60)	0.2360	(4.26)	79.9	0.727
GNP fixed-weight index	-22.02	(-4.73)			0.2771	(4.74)	79.5	0.585
	-31.40	(-9.08)	0.1974	(5.06)	0.1972	(4.94)	79.6	0.847

FIGURE 4

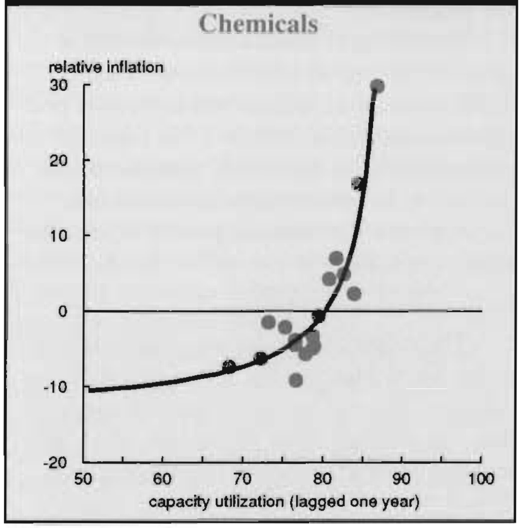
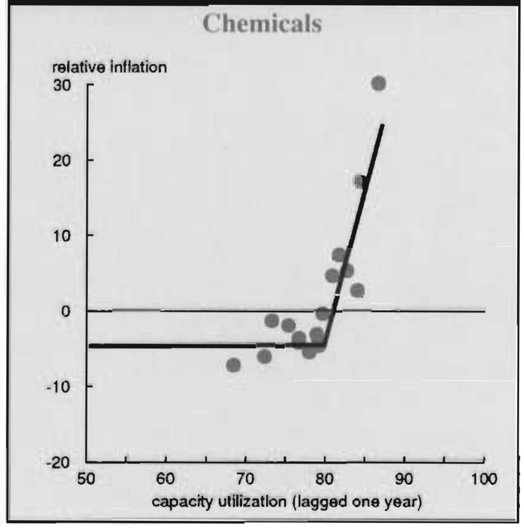


FIGURE 5



economy was very strong, double-digit inflation was pervasive and affected wages, costs of inputs, and prices of most goods and services. The early 1980s included sharp recessions as the rate of inflation was being brought down to below five percent. More recently, there has been a sustained economic recovery and remarkably stable inflation, especially when one factors out the volatile movements in energy and food prices. To use these different periods to estimate an average response may be as meaningful as estimating the average weather in Chicago. January's cold and August's heat might average to a nice temperature, but this average gives a very misleading impression of Chicago's weather.

Sector approach

Even more serious uncertainties are raised by a sector-by-sector analysis. At a theoretical level one can imagine a simple price-setting process whereby a sector or industry sets prices according to costs plus some factor that depends upon capacity or output conditions. Costs would be a function of wage rates and the prices of inputs used by the industry or sector. This could be a relatively simple markup process in which one of the relevant variables could be some measure of output, employment, or capacity utilization. A recent empirical study by Blanchard (1987) estimated industry prices as a function of wages and/or input costs. This study used input-output tables and producer prices series to construct input-cost series for different industries. It found no significant output or employment effects using monthly data.

However, when one uses annual data, it is possible to identify some sectors and commodity groupings that are likely to have large price increases in 1989. Instead of using the change in inflation as the dependent variable, the sector models use the percent increase in a producer price index. These price increases are assumed to be a function of the capacity utilization rate in the corresponding industry and the underlying rate of inflation. The coefficient on the underlying inflation rate is constrained to equal unity. In order to predict price changes by sector, the capacity and underlying inflation rates are lagged one year.

There is the problem at the sector level of matching a price series with the corresponding capacity rate. The capacity utilization numbers are disaggregated according to the two-digit Standard Industrial Classification (SIC) codes. This corresponds to the breakdown of industrial production numbers. Until fairly recently, producer prices were only grouped according to commodity groupings and not by the net output of major industry groups at the two-digit SIC code level. Furthermore, the Board's staff does not estimate capacity utilization for every two-digit SIC industry. The result is that there is only a small number of industries with adequate price and capacity time series.

TABLE 3

Nonlinear model for chemical industry 1971-1988

C2	(t-stat)	C2	(t-stat)	C3	(t-stat)	Natural rate	R2
-13.28	(-3.87)	89.67	(89.27)	-123.5	(-2.60)	80.4	0.885

Before estimating a sector model, it is necessary to select an appropriate functional form. Scatter diagrams are helpful when selecting the equation to estimate. Along the vertical axis is the difference between the rate of change of a price index for a sector and underlying rate of inflation in the previous year. The horizontal axis is the lagged capacity utilization rate for the sector.

Figure 4 and 5 are two scatter diagrams of the chemical industry. When plotted this way, it appears that the relationship can be estimated as a simple nonlinear equation[2]. In the first of these graphs a smooth and continuous curve has been estimated and plotted. The curve become steeper as the capacity utilization rate increases. The equation and coefficients for this regression[3] are listed in Table 3 along with some of the relevant statistics. For this sector, the natural capacity utilization rate is estimated to be about 80.4 percent.

Figure 5 plots the same historical data for the 1970s and 1980s and estimates a different type of nonlinear model. Here we assume that the economy switches from one regime to another whenever the capacity utilization rate crosses some threshold rate. When there is ample capacity, price changes in an industry tend to increase by less that the underlying rate of inflation. This constant difference corresponds to the horizontal line segment that has been plotted. Whenever demand is strong and capacity is pushed above the threshold rate, the change in sector prices becomes a linear function of the capacity utilization rate and the underlying inflation rate. This regime is represented by the positively sloped line segment.

FIGURE 6

Primary processing

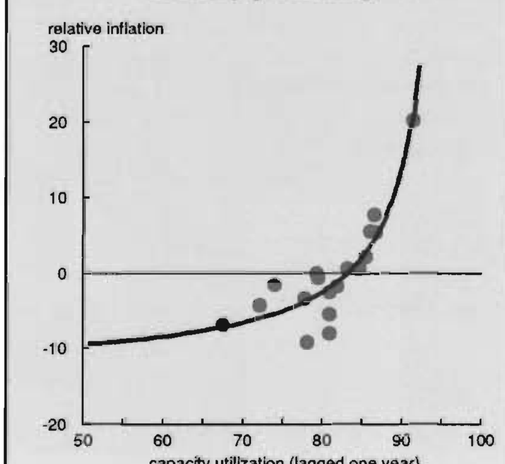


Figure 6–9 are scatter diagrams for some of the other sectors for which data is available. Each of these graphs are plotted using the same horizontal and vertical scales. The lagged capacity utilization rates are plotted along the horizontal axis, and the differences between inflation in the sector and the lagged underlying rate of inflation are plotted along the vertical scale.

Figure 6 displays the relation between capacity utilization in primary processing sectors for manufacturing and the relative inflation in the producer price index for intermediate materials and supplies. For this broad sector, the estimated natural rate is about 83 percent. The capacity utilization rate for primary processing was over 87 percent in 1988 or significantly above the estimated natural rate.

Figure 7 plots capacity utilization for nonelectrical machinery and the relative change in the producer price index for machinery and equipment. Although the fit is remarkably good, there is a considerable degree of mismatching between the particular industries that are grouped together in this two-digit SIC category and the types of machinery that are aggregated in this producer price index. For this reason the fit may be spurious.

Figure 8 plots the utilization rate for primary metals and the relative price changes for metals and metal products. This sector was chosen because it has a very large variance in the capacity utilization rate. The data point labeled 83 is the change in metal product prices in 1983 minus the underlying rate of inflation in 1982. It is plotted against the

FIGURE 7

Nonelectrical machinery

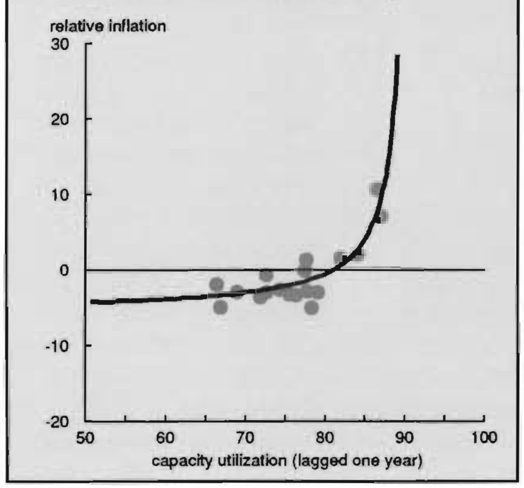
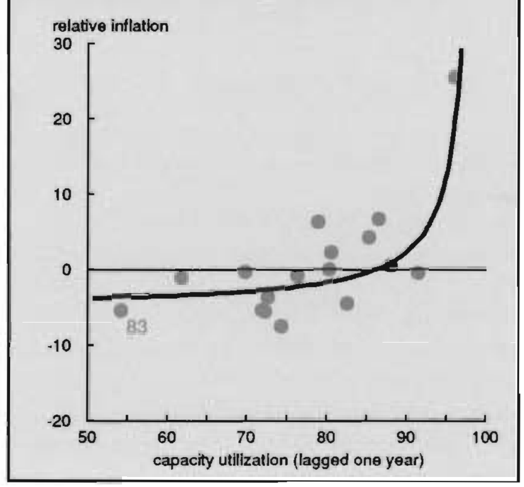


FIGURE 8

Primary metals



lagged capacity utilization rate. Capacity utilization fell below 55 percent in 1982 when the sector was especially hit by the recession.

Figure 9 displays capacity utilization for foods and the relative change in the price index for processed foods and feeds. This sector shows very little change in the utilization rates. The estimated curve is almost kinked and predicts extremely large price increases if capacity utilization were ever to approach 85 percent.

As one can readily see the degree of fit varies among the different sectors. Furthermore the natural capacity utilization rates and estimated curvatures are not the same among these sectors. This implies that aggregate capacity utilization rates can have different inflationary implications depending upon what sectors are experiencing capacity constraints.

These differences are illustrated in Figure 10 that plots a number of estimated curves in the same scatter diagram. These curves include those that have previously been presented and curves that were estimated for the paper and textile sectors. The points where these curves intersect the horizontal axis are

FIGURE 9

Foods

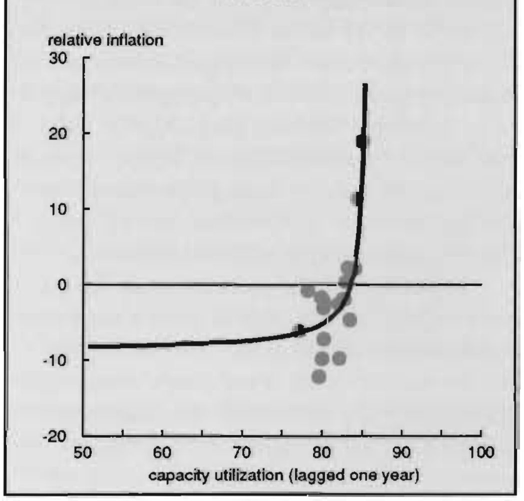
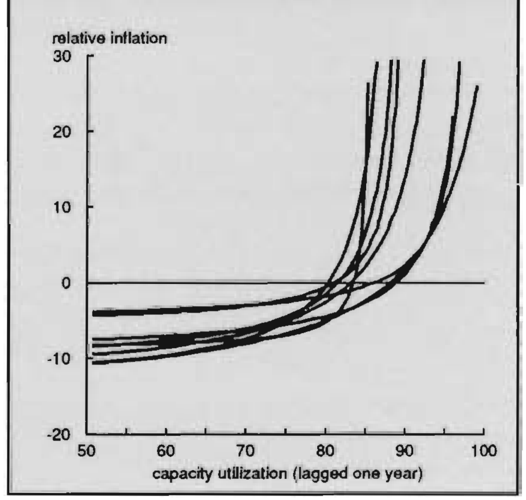


FIGURE 10

Sector differences



the different natural rates of capacity utilization for the various sectors. In this sample, the natural rates are between 79 and 89 percent, and the curvatures display a broad range of estimated values.

Conclusion

The linkage between capacity utilization and inflation is subject to a great deal of uncertainty. Even though the economic model estimated in this paper yields statistically significant coefficients, the standard errors are quite large. Using aggregate data, it appears that the economy is above its natural rate of capacity utilization and one could expect inflation to increase in 1989. If these results are accurate, in order to halt increases in the rate of inflation, the economy would have to be slowed until the capacity utilization rate has been brought back to a rate that is consistent with stable inflation.

However, on a sector-by-sector basis, there appears to be significant differences in the linkage between capacity constraints and the increase in the price of the sector's output. These differences include the level of a sector's natural rate of capacity utilization, the importance of lags, the appropriate functional form for summarizing the linkage, and the degree of fit or range of confidence intervals for predictions. These differences indicate that policy makers should be wary of an over-reliance on capacity utilization rates as a measure of inflationary pressures.

FOOTNOTES

[1]Functional form refers to the type of equation used to summarize the hypothesized linkage between capacity utilization and changes in inflation.

[2]The nonlinear equation estimated in this paper is a translated rectangular hyperbola. The function can be written as

$$y(t) = c1 + c3 / (x(t-1) \quad c2),$$

where c1 is the horizontal asymptote, c2 is the vertical asymptote, and c3 determines the degree of curvature. In this particular model, y(t) is the current rate of price change in the chemical sector minus the lagged rate of underlying inflation, and x(t-1) is the lagged rate of capacity utilization in the chemical industry.

[3]In the regressions, a grid search technique was used for different values of the coefficient that determines the degree of curvature (c3). For any given value of this coefficient, the two asymptotes were estimated by ordinary least squares. The proportion of total variation that can be explained by the regression is measured by the coefficient of determination (R2).

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