

# Is There a Stable Relationship Between Capacity Utilization and Inflation?

**Kenneth M. Emery**

Senior Economist and Policy Advisor  
Federal Reserve Bank of Dallas

**Chih-Ping Chang**

Graduate Student  
Southern Methodist University, Dallas

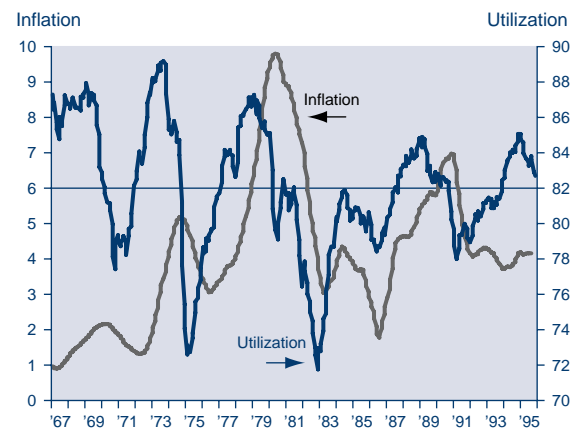
*In this article, we examine the predictive power of capacity utilization for inflation, with a focus on whether the forecasting relationship is stable.*

During recent years, the failure of monetary aggregates as reliable guides for future inflation has led financial market participants and Federal Reserve policymakers to monitor a broad range of economic statistics. On the real side, analysts increasingly rely on the Phillips curve—the perceived existence of a stable short-run trade-off between inflation and real activity. Most prominently, these analysts focus on the gap between the unemployment rate and the so-called NAIRU, or nonaccelerating inflation rate of unemployment, which is the unemployment rate at which inflation is constant.<sup>1</sup> Similarly, many analysts use the Federal Reserve’s industrial capacity utilization rate as an indicator of future inflation pressures.<sup>2</sup> Typically, utilization rates above 82 percent have signaled higher future inflation, brought on by the onset of production bottlenecks and supply shortages. This historical relationship is illustrated in Figure 1, which shows that after capacity utilization rates rose above 82 percent, consumer price inflation accelerated in most instances over the 1967–95 period.

During the past few years, however, the usefulness of both the capacity utilization rate and the unemployment rate as inflation indicators has come under scrutiny. Figure 1 shows that capacity utilization rose above 82 percent at the end of 1993 and that, to date, inflation has remained stable. Likewise, the unemployment rate has been below most estimates of NAIRU for some time.

The response to these recent developments seems to fall into two categories. First, some analysts argue that nothing has changed and that in due time inflation will begin to rise. A second and more varied group of analysts points to several possible developments to explain why inflation has remained stable: demographic factors have lowered NAIRU; increasingly glo-

Figure 1  
CPI Inflation and Capacity Utilization



balized labor and capital markets have lessened the importance of U.S. capacity utilization; unmeasured productivity increases have led to a rise in the U.S. economy's growth potential (relevant for gap analyses); and the Federal Reserve mismeasures capacity utilization.

Whereas many studies have examined the link between unemployment and inflation, comparatively fewer have explored the capacity utilization–inflation relationship. In this article, we examine the predictive power of capacity utilization for inflation, with a focus on whether the forecasting relationship is stable. We find evidence that while there was a significant positive relationship between capacity utilization and changes in inflation before 1983, this relationship has substantially weakened since the end of 1982. In fact, after 1982, one can reject the hypothesis that high capacity utilization rates have any predictive power at all for consumer price inflation. The results are similar for changes in producer price inflation, although the deterioration in the relationship is not as severe. In fact, at quarterly and semiannual horizons, there is evidence that capacity utilization after 1982 still has predictive content for changes in producer price inflation.

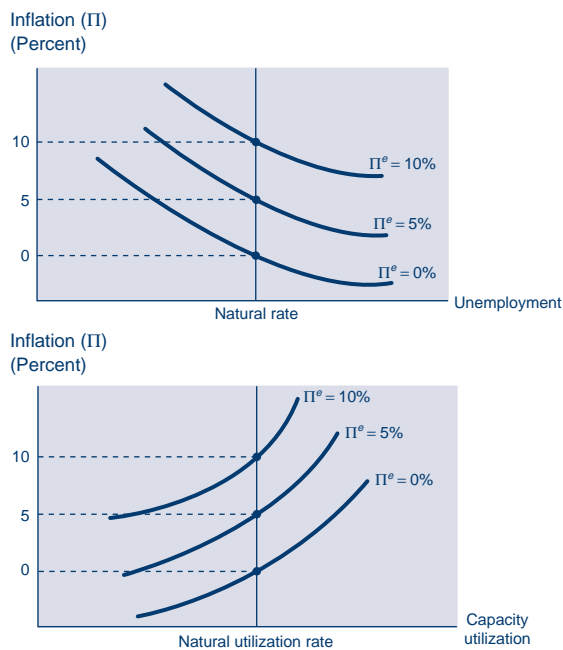
In the first section of this article, we review recent literature concerning the capacity utilization–inflation relationship. In the following section, we examine the empirical evidence as it relates to the capacity utilization–inflation relationship.

### Literature review

Although the literature examining the capacity utilization–inflation relationship is relatively sparse, there are several recent studies.<sup>3</sup> A prominent study is Garner (1994), which suggests that the relationship is stable and that capacity utilization currently remains a reliable indicator of future changes in inflation. Specifically, Garner uses simple ordinary least squares regressions (OLS) to show that over different sample periods, the nonaccelerating inflation rate of capacity utilization (NAICU) is roughly constant in the 82-percent range.

In his article, Garner points out the similarity between analyses using the concept of NAIRU and those using the capacity utilization rate. One way to show this similarity is by replacing the unemployment rate with the capacity utilization rate in a simple expectations-augmented Phillips curve model. Expectations-augmented Phillips curves posit a negative trade-off between levels of inflation and unemployment rates for a given level of expected inflation. The top panel of Figure 2 shows several Phillips curves associated

Figure 2  
Phillips Curves and the  
Capacity Utilization–Inflation Relationship



with different levels of expected inflation. The *natural rate* in the top panel of Figure 2 is that level of unemployment at which inflation equals expected inflation.<sup>4</sup> The bottom panel of Figure 2 shows the expectations-augmented Phillips curves that result when the unemployment rate is replaced with the capacity utilization rate. Similarly, the *natural utilization rate* is that rate at which inflation equals expected inflation.

However, most analysts posit a relationship between changes in capacity utilization and inflation. To derive such a relationship, an extra assumption must be made about the formation of inflation expectations—specifically, that the next period's expected inflation rate ( $\Pi^e$ ) is equal to a weighted average of lagged inflation rates, with the weights summing to one.<sup>5</sup> Under this

Figure 3  
Critical Utilization Thresholds in  
Short-Run Phillips Curve Models

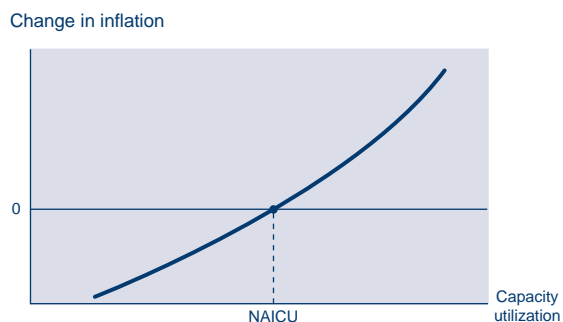


Table 1  
Linear Regression Results  
1967:1–96:2 Sample

	$R^2$	Constant	Coefficient on $CU_{t-1}$	Significance of lagged inflation	NAICU (Percent)
<b>CPI</b>					
Monthly	.35	-22.7 (.00)	.28 (.00)	(.000)	81.0
Quarterly	.32	-25.3 (.00)	.31 (.00)	(.000)	82.6
Semiannual	.18	-30.8 (.01)	.38 (.01)	(.021)	81.7
<b>PPI</b>					
Monthly	.43	-37.8 (.00)	.46 (.00)	(.000)	82.2
Quarterly	.50	-45.3 (.01)	.55 (.01)	(.000)	82.0
Semiannual	.36	-52.0 (.00)	.63 (.00)	(.000)	82.0

$p$  values in parentheses

assumption, the result is a positive long-run relationship between changes in capacity utilization and inflation, depicted in Figure 3.<sup>6</sup> Of course, if the expectations assumption does not hold, then at the least there may be instability in the relationship.<sup>7</sup>

Other studies of the capacity utilization-inflation relationship find mixed evidence on the issue of stability.<sup>8</sup> Franz and Gordon (1993) find that U.S. inflation depends more closely on the capacity utilization rate than on the unemployment rate. However, their only stability analysis is a comparison of the 1962–72 period with the 1973–90 period, which concludes stability cannot be rejected. Cecchetti (1995), in a paper that examines a number of inflation indicators, finds evidence that capacity utilization adds significant information to out-of-sample forecasts of inflation before 1982, but this information disappears after 1982.

The next section explores the stability of the capacity utilization–inflation relationship.

### Empirical results

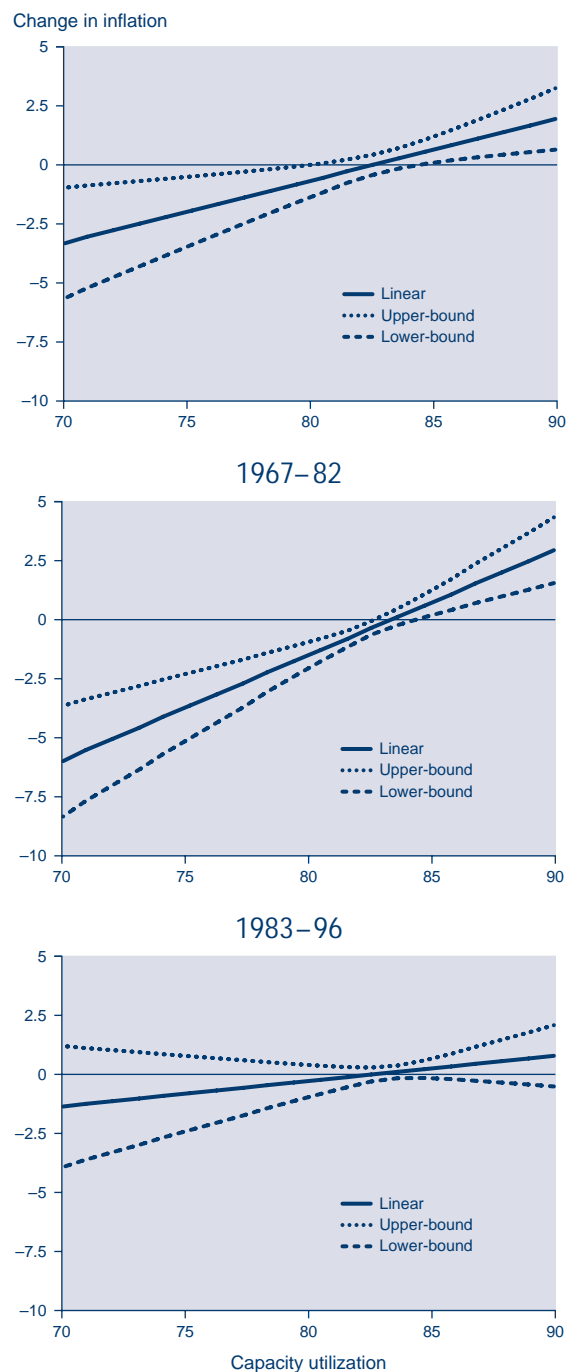
A standard OLS model. To examine more precisely the relationship between capacity utilization rates and changes in inflation, we run a series of regressions of the form

$$(1) \quad \Delta\Pi_t = A + B CU_{t-1} + \sum_{i=1}^n C_i \Delta\Pi_{t-i} + u_t,$$

where  $\Delta\Pi_t$  is the change in inflation from period  $t$  to period  $t - 1$ ;  $CU$  is the industrial capacity utilization rate;  $u$  is an error term; and  $A$ ,  $B$ , and  $C_i$  are parameters to be estimated.<sup>9</sup> Essentially, equation 1 is an in-sample forecasting equation

that uses lagged information to predict future changes in inflation rates.<sup>10</sup> To examine changes in inflation at horizons longer than one month, we estimate equation 1 using not only monthly data, but also quarterly and semiannual data that are constructed from the monthly data.<sup>11</sup> The data cover the sample period January 1967 through February 1996. For our measures of inflation, we use the consumer price index (CPI) and the producer price index (PPI).<sup>12</sup> Industrial capacity utilization may be more closely related

Figure 4  
Regression Models: CPI (monthly), 1967–96



for PPI inflation because the PPI includes only goods prices, whereas the CPI also includes the prices of services.

Table 1 shows both the CPI and PPI results. For the CPI results, the model explains roughly one-third of the overall variation of changes in inflation, and there is no evidence of serial correlation in the error terms. The lag of capacity utilization is very significant with a positive sign, which indicates that a high capacity utilization rate leads to rising inflation. The magnitude of the coefficient on capacity utilization varies with the data used. For example, with the monthly data, a one-percentage point increase in the utilization rate leads to a 0.28-percentage point increase in inflation at an annualized rate. The NAICU is near 82 percent for all three models. In other words, above 82 percent, inflation is rising, and below 82 percent, inflation is falling. These results are consistent with Garner (1994), who finds NAICUs in the 82-percent range.

For the PPI results, the explanatory power of the models is higher than for the CPI models. Depending on the data, the adjusted  $R^2$ s range from 0.36 to 0.50. The coefficients on capacity utilization are positive and significant, and larger than those in the CPI models. For the monthly data, a one-percentage point increase in the utilization rate leads to a 0.46-percentage point increase in inflation at an annualized rate. Similar to the CPI results, the NAICUs are in the 82-percent range for all three models.

In general, these results are consistent with previous work that finds a positive and significant relationship between capacity utilization and future changes in inflation.

**Stability of the utilization–inflation relationship.** On the basis of Figure 1 and because of recent assertions that the relationship between the change in capacity utilization and inflation has changed, we test for a break in the relationship by using January 1983 as the potential breakpoint.<sup>13</sup> The data indicate significant parameter instability.<sup>14</sup> Therefore, we reestimate equation 1 using the two separate subsamples. Table 2 shows the CPI results, and Table 3 shows the PPI results. For the CPI results, the NAICUs remain in the 82-percent range for both sample periods, which is consistent with Garner’s (1994) results. However, there are substantial differences across the two samples in other aspects of the results. First, the explanatory power of the model is reduced for the post-1982 period, as evidenced by the much smaller adjusted  $R^2$ s. Moreover, the marginal significance levels ( $p$  values) for capacity utiliza-

Table 2  
Sample Instability: Linear Regressions

<b>CPI</b>					
<i>1967:1–82:12 Sample</i>					
	$R^2$	Constant	Coefficient on $CU_{-1}$	Significance of lagged inflation	NAICU (Percent)
Monthly	.45	–38.9 (.00)	.47 (.00)	(.000)	82.7
Quarterly	.59	–43.7 (.00)	.53 (.00)	(.000)	83.2
Semiannual	.57	–37.6 (.00)	.45 (.01)	(.021)	82.8
<i>1983:1–96:2 Sample</i>					
	$R^2$	Constant	Coefficient on $CU_{-1}$	Significance of lagged inflation	NAICU (Percent)
Monthly	.28	–9.3 (.27)	.11 (.26)	(.000)	82.1
Quarterly	.35	–3.8 (.64)	.05 (.65)	(.000)	83.1
Semiannual	.09	–8.7 (.45)	.11 (.44)	(.010)	81.4

$p$  values in parentheses

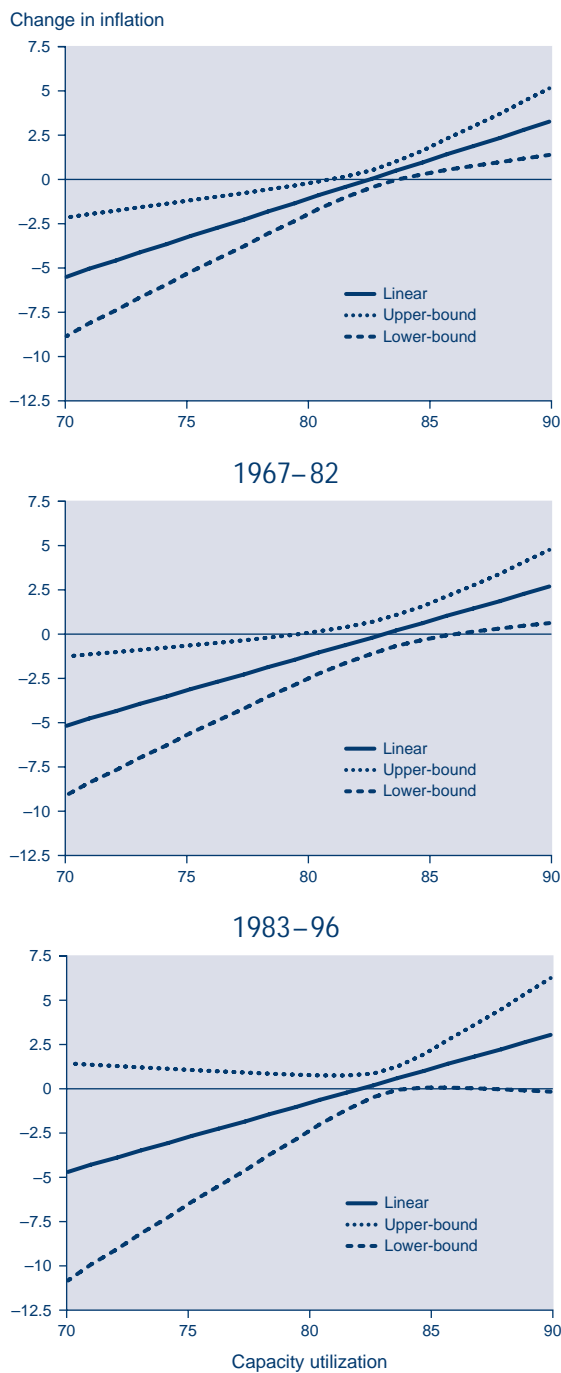
Table 3  
Sample Instability: Linear Regressions

<b>PPI</b>					
<i>1967:1–82:12 Sample</i>					
	$R^2$	Constant	Coefficient on $CU_{-1}$	Significance of lagged inflation	NAICU (Percent)
Monthly	.51	–34.2 (.01)	.41 (.01)	(.000)	82.5
Quarterly	.41	–54.5 (.01)	.66 (.01)	(.000)	83.0
Semiannual	.31	–61.5 (.00)	.74 (.00)	(.004)	82.9
<i>1983:1–96:2 Sample</i>					
	$R^2$	Constant	Coefficient on $CU_{-1}$	Significance of lagged inflation	NAICU (Percent)
Monthly	.31	–33.2 (.10)	.41 (.09)	(.000)	81.6
Quarterly	.58	–35.9 (.03)	.44 (.03)	(.000)	80.2
Semiannual	.45	–56.6 (.00)	.70 (.00)	(.000)	81.4

$p$  values in parentheses

tion indicate that utilization is no longer significant for any of the models in the post-1982 period. Also, the point estimates of the coefficients on capacity utilization are much smaller compared with the pre-1983 estimates.<sup>15</sup> Figure 4 shows the trade-offs between changes in CPI inflation and capacity utilization for the monthly

Figure 5  
Regression Models: PPI (monthly), 1967–96

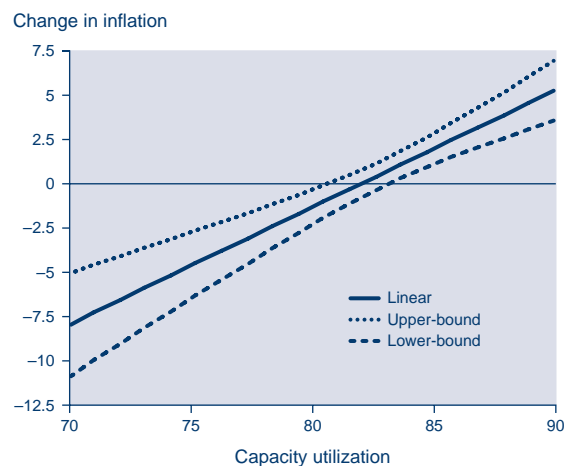


model estimated over the entire sample, as well as the two sub-samples.<sup>16</sup> Not only does the trade-off flatten during the later sample period, but our 95-percent confidence bands for the NAICU have widened to the point that any capacity utilization rate is consistent with no change in inflation.<sup>17</sup> In other words, the confidence bands encompass the zero change in inflation line across the utilization range that the U.S. economy has experienced.<sup>18</sup>

In Table 3, the differences in PPI results across the two samples are not as great as those for CPI. For the quarterly and semiannual data, the adjusted  $R^2$ s are actually higher in the later sample period. Also, the point estimates of the coefficient on capacity utilization are in the same range for both sample periods. Moreover, the NAICUs fall in the same range across the two subsamples and, if anything, are lower in the later period. However, Figure 5 shows that the lower confidence levels about the point estimates of the coefficient on utilization and the constant term imply reduced confidence about our estimate of the NAICU in the later sample period. Similar to the CPI results in Figure 4, for the monthly and quarterly models, the confidence bands for the NAICU in the 1983–96 period indicate reduced confidence about the utilization rate at which PPI inflation begins to accelerate. However, for the semi-annual data (Figure 6), the confidence bands remain relatively tight in the 1983–96 period, indicating that PPI inflation begins to accelerate six months after the utilization rate rises above the 80- to 82-percent range.

Overall, the conclusions from the subsample results are quite strong. For changes in CPI inflation during the 1983–96 period, there is no evidence that capacity utilization provides any useful information about future changes in inflation. In fact, at the 95-percent confidence level, any capacity utilization rate is consistent with no change in inflation. For monthly changes in PPI inflation, the results are similar to the CPI results. However, for the semiannual data, capacity utilization does have significant information for future changes in PPI inflation, and the 95-percent confidence range for the NAICU

Figure 6  
Regression Models: PPI (semi), 1983–96



is estimated to be between 80 and 82 percent. Results for quarterly PPI data are intermediate.

## Conclusions and Discussion

During recent years, the reliability of the unemployment and capacity utilization rates as future inflation indicators has come under question. Because the usefulness of these indicators is predicated on a stable short-run trade-off between real activity and inflation, this scrutiny has entailed a reexamination of the Phillips curve. Although much of the literature has focused on the unemployment–inflation relationship, in this article we have examined the relationship between capacity utilization and inflation.

We find evidence that although capacity utilization had significant predictive power for changes in consumer price inflation before 1983, this relationship has substantially weakened since the end of 1982. In fact, after 1982 there is no evidence that high capacity utilization rates forecast increases in consumer price inflation. For changes in producer price inflation, we find a significant positive predictive relationship before 1983 that is even stronger than the pre-1983 capacity utilization–consumer price inflation relationship. Additionally, although there is some deterioration in the relationship between changes in producer price inflation and capacity utilization after 1982, there is still evidence of a significant positive predictive relationship, especially at forecast horizons of six months.

There are a number of possible explanations for the deterioration in the ability of capacity utilization to forecast changes in inflation, including potential mismeasurement of capacity utilization and an increasingly global economy. Another potential explanation for the deterioration in the forecasting relationship is that the conduct of monetary policy has changed (Cecchetti 1995). In fact, many analysts have argued that the Federal Reserve has been more forward-looking and quicker to bring inflation pressures under control during the 1980s and 1990s than during the late 1960s and 1970s (Balke and Emery 1994). If the Federal Reserve is now quicker to tighten policy in response to such indicators as rising capacity utilization rates, these indicators may no longer be followed by rising inflation, simply because the Federal Reserve has already tightened policy and brought inflation pressures under control. Importantly, however, the policy implication is not that the Federal Reserve should stop monitoring the utilization rate. After all, it is because the Federal Reserve has monitored the utilization rate as an indicator of rising inflation pressures that infla-

tion has remained relatively stable. In any case, future research should focus on establishing the validity of the monetary policy explanation versus others that are put forward.

## Notes

We thank Nathan Balke, Carl Bonham, John Duca, Joseph Haslag, Evan Koenig, Charles Steindel, and an anonymous referee at the Board of Governors for helpful comments and suggestions.

- <sup>1</sup> *Output gap* analyses similarly reflect the belief in a stable short-run Phillips curve. In gap analysis, current output above estimated potential output signals rising inflation.
- <sup>2</sup> For examples, see the Board of Governors (1994), Citibank (1996 a, b, and c), Cooper and Madigan (1996 a and b), and Merrill Lynch (1996).
- <sup>3</sup> The recent literature examining the unemployment–inflation relationship includes Duca (forthcoming), Fuhrer (1995), King, Stock, and Watson (1995), Weiner (1993), and Koenig and Wynne (1994).
- <sup>4</sup> The natural rate of unemployment is also considered the long-run rate of unemployment to which the economy tends over time.
- <sup>5</sup> To see that this assumption is necessary, consider an empirical Phillips curve model in which a distributed lag of past inflation proxies for expected inflation:

$$\Pi_t = K + B U_t + \sum_{i=1}^n \lambda_i \Pi_{t-i} \quad (\text{as in Figure 2}),$$

where  $\Pi$  and  $U$  are the level of inflation and the unemployment rate and  $E(\Pi_t) = \sum_{i=1}^n \lambda_i \Pi_{t-i}$ . In the special case where  $\sum_{i=1}^n \lambda_i = 1$ , then

$$\Pi_t - \Pi_{t-1} = K + B U_t + \sum_{i=1}^{n-1} u_i (\Pi_{t-i} - \Pi_{t-i-1}),$$

where  $u_i = \left( \sum_{j=1}^i \lambda_j \right) - 1$ . In the long run, this equation

has the form of Figure 3 when lagged changes in inflation equal zero.

- <sup>6</sup> The NAIRU and NAICU are special cases of the natural rates where the expectations assumption described above is invoked.
- <sup>7</sup> Basically, the failure of this assumption is the Lucas critique.
- <sup>8</sup> Finn (1995) is another study that finds a positive relationship between capacity utilization and inflation. However, the issue of stability is not addressed.
- <sup>9</sup> Equation 1 includes two dummy variables to control for the Nixon wage and price controls. It also includes lags of changes in relative petroleum price inflation to control for energy price shocks. One dummy variable equals one for the year 1972, and the other equals one for the years 1974–75. The relative price of petroleum inflation is from the producer price index.
- <sup>10</sup> Cointegration is not a concern, as augmented Dickey–

Fuller tests indicate that the change in inflation and capacity utilization rates are stationary. The Akaike information criterion (AIC) and the Schwartz information criterion (SIC) indicate that one year of lagged changes in inflation and energy price inflation is sufficient. The results are qualitatively unaffected when only six months of lagged information is used. Only one lag of the capacity utilization rate is included because additional lags are statistically insignificant.

- <sup>11</sup> Policymakers and financial market participants are more concerned with trends in inflation rather than the more noisy monthly changes in inflation. The quarterly and semiannual data are constructed from the end-of-period monthly data.
- <sup>12</sup> There are no qualitative differences when we run these regressions using core-CPI inflation, which excludes food and energy prices.
- <sup>13</sup> Other reasons for choosing January 1983 include a change in the Federal Reserve operating procedures at this time and a change in the behavior of inflation (Emery 1994). The qualitative nature of the results is robust with respect to other dates near the end of 1982.
- <sup>14</sup> We use a likelihood ratio test to examine for instability in any or all of the coefficients.
- <sup>15</sup> However, when all of the coefficients in the model are allowed to vary across the two samples, the data are not strong enough to reject the hypothesis that the coefficients on lagged capacity utilization are equal in both samples at the 95-percent confidence level.
- <sup>16</sup> The trade-off is constructed from the coefficient estimate on the constant term and the capacity utilization term, setting all the other coefficients equal to zero.
- <sup>17</sup> The confidence bands reflect only the uncertainty associated with coefficient estimates on the constant term and the capacity utilization term, not the uncertainty reflected in the error term of the regression.
- <sup>18</sup> The figures are qualitatively similar for the quarterly and semiannual data.

## References

Balke, Nathan S., and Kenneth M. Emery (1994), "Understanding the Price Puzzle," Federal Reserve Bank of Dallas *Economic Review*, Fourth Quarter, 15–26.

Board of Governors of the Federal Reserve System (1994), "Monetary Policy Report to the Congress Pursuant to the Full Employment and Balanced Growth Act," *Federal Reserve Bulletin*, March, 199–219.

Cecchetti, Stephen G. (1995), "Inflation Indicators and Inflation Policy," *NBER Macroeconomics Annual*, 189–219.

Citibank (1996a), "Europe Ignores How Japan Finally Got Out of Its Slump," *Economic Week*, July 8, 1–3.

——— (1996b), "Slowing into 1997, Cool Economy Will Pull Yields Down," *Economic Week*, June 24, 1–2.

——— (1996c), "Forget the Windy Talk. The Inflation Winds Aren't Rising," *Economic Week*, June 10, 1–2.

Cooper, James C., and Kathleen Madigan (1996a), "A Pricey Stock Market Makes the Fed's Job Tougher," *Business Week*, July 1, 23–24.

——— (1996b), "Even the Bond Market Is Starting to Chill Out," *Business Week*, May 27, 29–30.

Duca, John V. (forthcoming), "Inflation, Unemployment, and Duration," *Economics Letters*.

Emery, Kenneth M. (1994), "Inflation Persistence and Fisher Effects: Evidence of a Regime Change," *Journal of Economics and Business* 46 (August): 141–52.

Finn, Mary G. (1995), "Is 'High' Capacity Utilization Inflationary?" Federal Reserve Bank of Richmond *Economic Quarterly* 81 (Winter): 1–16.

Franz, Wolfgang, and Robert J. Gordon (1993), "German and American Wage and Price Dynamics," *European Economic Review*, May, 719–62.

Fuhrer, Jeffrey C. (1995), "The Phillips Curve Is Alive and Well," Federal Reserve Bank of Boston *New England Economic Review*, March/April, 41–56.

Garner, Alan C. (1994), "Capacity Utilization and U.S. Inflation," Federal Reserve Bank of Kansas City *Economic Review*, Fourth Quarter, 1–21.

King, Robert G., James H. Stock, and Mark W. Watson (1995), "Temporal Instability of the Unemployment–Inflation Relationship," Federal Reserve Bank of Chicago *Economic Perspectives*, May/June, 2–12.

Koenig, Evan F., and Mark Wynne (1994), "Is There an Output–Inflation Trade-Off?" Federal Reserve Bank of Dallas *Southwest Economy*, Issue 3, 1–4.

Merrill Lynch (1996), Credit Market Memo, June 14.

Weiner, Stuart E. (1993), "The Natural Rate and Inflationary Pressures," Federal Reserve Bank of Kansas City *Economic Review*, Third Quarter, 5–9.