ANO 2001/2

Oslo
May 31, 2001

Working Paper

International Department

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ISSN 1502-5780
ISBN 82-7553-178-0

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Explaining the low US inflation – coincidence or "new economy"? Evidence based on a wage-price spiral

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Abstract: We study possible factors behind the subdued inflation in the United States since the mid-1990s. A standard expectations-augmented Phillips curve does not exhibit structural breaks. However, a wage-price spiral comprising wage growth, consumer price inflation and producer price inflation shows an otherwise unexplained downward shift in CPI inflation since the mid-1990s. We estimate this downward shift to be approximately 1 percentage point since 1994. The result emerges in spite of a large number of explanatory variables and seems to reflect "deep" structural changes of the economy. Counterfactual simulation of the wage-price spiral shows that the low level of U.S. inflation during the late 1990s stems from coincidental favourable shocks as well as factors that may reflect "new economy" developments.

Keywords: Inflation, wage-price spiral, unemployment, productivity
JEL Classification: C32, E31, E37

* We would like to thank Farooq Akram, Anne-Berit Christiansen and Nils T. Eide for helpful comments. Any remaining errors are our responsibility. Bergljot B. Barkbu provided research assistance. All opinions expressed are those of the authors and do not necessarily reflect the views of the Central Bank of Norway. Staehr is corresponding author: tel. (+47) 22 31 67 24, fax (+47) 22 33 35 68, e-mail: karsten.staehr@norges-bank.no.

1. Introduction

Over the last decade inflation in the United States has been surprisingly low and stable. Consumer price (CPI) inflation has hovered in the interval 2-3½ % per year, the lowest inflation level since the early 1960s. The inflation performance is the more remarkable taking into account the real economic developments. The expansion is the longest in history and the unemployment has declined steadily to levels not seen for 30 years. Still, inflation has remained subdued. These developments are difficult to reconcile with the standard perception that, ceteris paribus, low unemployment and high growth is associated with high inflation.

The question we address in this paper is why inflation in the US has remained low since the mid-1990s in spite of high GDP growth and a tight labour market. The issue has important connotations. Changes in the inflation process have important consequences for inflation forecasting and the conduct of monetary policy, see e.g. IMF (2000).[1]

The unexpected inflation developments have sparked a debate on the possible causes.[2] The focal issue is whether the subdued rate mainly is the result of standard shocks or whether deeper structural changes, often epitomised by the "new economy" (NE) label, have kept inflation low. Those favouring the coincidence hypothesis point to temporary shocks, e.g. falling import and oil prices in 1998-99. Those favouring the NE hypothesis argue that new information technologies and globalisation have helped restrain inflation.

The starting point for the NE proponents is that new technologies within the fields of communication, computation, and data processing have reshaped the economy in fundamental ways. In addition, many economies have become more integrated into the world economy with increased openness for trade, capital and intellectual ideas; a process partly following from improved information technologies. NE proponents argue that these developments have led to reduced inflationary pressure: the economy can grow faster and unemployment can be at a lower level than traditionally thought without generating higher inflation. (See Appendix 1 for a fuller discussion of the NE concept.)

A growing literature, based on the estimation of Phillips curves, examines the recent low level of inflation in the United States. The papers usually test whether standard Phillips curves are stable and able to predict actual inflation since the mid-1990s. In most cases it is shown that stability or prediction properties are improved if one or more explanatory variables are added.

The findings in the literature can be summarised in four points: First, most studies find that temporary supply shocks like import and energy prices should be included in the Phillips curve specification, see e.g. Brinner (1999), Chan-Lau and Toarick (1999). Gordon (1998, 1999a) finds that also food and computer prices have contributed in keeping inflation down. Second, unit labour costs enter significantly in many Phillips curve estimations, cf. see Lown and Rich (1997), Brayton *et al.* (1999), Chan-Lau and Toarick (1999). However, Hogan (1998, 2000) finds that unit labour costs do not enter the Phillips curve, while Gordon (1998, 1999a) argues that productivity growth has been so low that it has had at most a marginal effect on inflation. Third, a number of studies find that a lower natural rate of unemployment (NRU) has helped relieve labour market pressures and thereby reduced inflation, see Hogan

[1] IMF's forecasts of consumer price inflation published in the October edition of *World Economic Outlook* for the following year is an example. Every year between 1992 and 1999 the IMF over-predicted the following year's consumer price increase.

[2] See e.g. Blinder (1997), Harris (1999), Stiroh (1999), *The Economist* (2000), *Financial Times* (1999), Rich and Rissmiller (2000), Phelps (2000), and Council of Economic Advisors (2000).

(1998, 2000) and Gordon (1998, 1999a). Fourth, utilisation of installed production capacity seems to a better indicator of inflationary pressure than measures of unemployment, see Staiger *et al.* (1997) and Stock and Watson (1999).

Few of the studies above explicitly address whether NE effects have been important in curbing inflation. It is difficult to "translate" conclusions with respect to the impact of specific variables into the two main hypotheses, i.e. coincidence versus NE. Oil price changes are most likely unrelated to NE effects. Low import price inflation seems unrelated to NE, but might also be caused by the periodically appreciating dollar. (Appreciating of the dollar may be the result of higher productivity growth in the USA than abroad and, thus, could reflect NE developments.[3]) Lower unit labour costs might stem from higher productivity (possibly because of new technology) but could also be the result of wage restraint unrelated to NE developments. A lower NRU might reflect NE effects if it is caused by better job matching (e.g. because of the Internet), but it could also be caused by factors unrelated to the NE (e.g. demographic changes and incarceration trends). Lower capacity utilisation might be the result of new technologies and increased flexibility but could also be caused by other factors. On balance, when trying to interpret the results in light of the NE hypothesis the existing empirical evidence points strongly to coincidental and temporary shocks from oil and import prices as important factors behind the low rate of inflation. However, NE effects in the form of lower unit labour costs growth, a lower NRU, or lower capacity utilisation might also have played a role.

We depart from most of the existing literature by estimating a wage-price spiral consisting of three equations explaining wage inflation, producer price inflation, and consumer price inflation. This – more "structural" – modelling of the wage and price setting in the economy has several advantages. First, it opens for an analysis of the dynamic relationship between the wage and price inflation. Second, it enables us to ascertain in which of the three processes possible structural changes have taken place. Third, it enables us to include a large number of variables in the equations and, hence, cast a wider net in our search for NE effects. Fourth, it calls for separate inclusion of wage and productivity terms (not only unit labour costs) and, hence, allows these two terms to affect prices asymmetrically.

The wage-price spiral is an important tool for analysis of inflation dynamics and the process of nominal adjustments to supply and demand shocks, see e.g. Blanchard (1986) and Kolsrud and Nymoen (1998). Recent empirical applications of the wage-price spiral include Huh and Trehan (1995) and Bårdsen *et al.* (1998). However, wage-price spirals have not been systematically employed for analysis of the factors behind the recent low US inflation rate.

We start out by estimating a standard expectations-augmented Phillips-curve incorporating a time-varying NRU and import price shocks. The Phillips curve turns out to be stable and without structural breaks and it produces respectable out-of-sample forecasts. The stable and low inflation since the mid-1990s is well accounted for using a standard Phillips curve.

This result, however, does not carry over to the wage-price spiral. We find evidence of a structural break in the consumer price equation even when controlling for a large number of explanatory variables. A step dummy explains 1 percentage-point of the reduction in yearly consumer price inflation since 1994. Thus, while the low inflation levels since the mid-1990s

[3] Empirical analyses generally show that only a rather modest part of short-term exchange rate movements can be explained by changes in fundamentals, see De Grauwe (2000). The empirical relevance of productivity differentials as determinants of the (real) exchange rate is much stronger for long-term movements than for short-term movements, see Canzoneri *et al.* (1999).

can easily be traced by a simple Phillips curve, the wage-price spiral indicates structural breaks in the processes linking consumer price inflation to wage inflation, producer price inflation and other explanatory variables. This shift conceivably results from "deeper" changes in the economy.

We extend the analysis by running counterfactual simulations of the wage-price spiral, allowing us to quantify the effect of various shocks. It appears that the falling import prices combined with increased openness are the most important factors restraining consumer price inflation in 1997-99. In 1999-2000, the inflationary pressure from the capacity utilisation seems to reside, possibly because of NE supply side effects. Productivity seems only to have played a minor role. Trend productivity growth has only increased rapidly in 1999-2000 and the direct effect of productivity growth on consumer price inflation is partly offset by its increasing effect on wages. On balance we find that the structural shift is an important factor restraining inflation since the mid-1990s but unusual productivity and capacity developments also play a role.

The paper is organised as follows: Section 2 shows that a standard Phillips curve makes good forecasts. Section 3 presents the estimated wage-price spiral. Section 4 contains analyses of the stability and forecast properties of the wage-price spiral. Section 5 shows simulations depicting how various factors have influenced the inflation rate since 1994. Section 6 summarises and outlines proposals for future research. Appendix 1 presents our interpretation of the NE paradigm. The data series used are explained in Appendix 2.

2. Low inflation and the Phillips curve

The original Phillips curve linked money wage growth and the unemployment rate, cf. Phillips (1958). Modern versions often comprise the inflation rate on the left-hand side and expected inflation, measures of the labour market slack and various supply shocks are on the right-hand side.[4] Expected inflation is usually assumed to be backward-looking and approximated by lags of the inflation rate. Labour market slack can be captured by the difference between actual unemployment and the natural rate, possibly including lagged values. Commonly used supply shocks include import price inflation and oil price changes.

In this Section we show that the combination of low inflation and falling unemployment during the second half of the 1990s does not imply that the Phillips curve has broken down. The estimation is carried out on quarterly data for the period 1976:4-2000:4.[5] The Phillips curve explains quarterly consumer price inflation, DLCPI. The operator DL denotes quarterly change in the logarithm of the variable. (See Appendix 2 for a detailed description of data, sources and the notation used.)

The actual unemployment rate, U, is an inappropriate measure of labour market slack if the natural rate of unemployment changes over time. There are two main methods for calculating time-varying measures of NRU. One approach is to estimate a NRU so that inflation, conditional on other variables determining inflation, remains stable, see e.g. Gordon (1997). The other approach is to estimate NRU from a range of variables believed to influence underlying

[4] Jossa and Musella (1998) discuss the development of the Phillips curve.

[5] The rather short estimation sample is chosen in order to correspond to the sample used when estimating a wage-price spiral in Section 3. Qualitatively similar results are obtained if the estimation starts in the early 1960s.

structural unemployment, e.g. age composition, unemployment compensation and unionisation. Applying this approach, Hogan (1998, 2000) derives an estimate of the natural rate of unemployment for the US. We use the resulting variable as a measure of natural (structural) unemployment and label it NRUHOG. The graph of NRUHOG is hump-shaped with a starting value of 5 percent in the 1960s, a maximum of 7 percent in the mid-1980s and a rapid decline to a little more than 5 percent in the late 1990s. The variable UGAPHOG = U – NRUHOG is our measure of the labour market slack.

IPI is the import price index, measured in dollars. The US imports oil so IPI also comprises oil prices. SHRF is the share of imports in total GDP. It seems natural to expect that the effect of import price inflation on domestic inflation increases when import penetration rises. Following Turner (1995) we have chosen to capture the impact of changes in openness by constructing DLISHRF defined as SHRF·DLIPI. The variable DLISHRF is meant to measure the total impact of imported price changes on domestic inflation. The non-linear specification implies that the impact of, say, increased openness (larger SHRF) is dependent on import price movements (DLIPI). If import prices rise markedly, increased openness will amplify the associated inflation upturn.

Quarterly consumer price inflation DLCPI is explained by lags of itself, by the labour market slack variable UGAPHOG and by the congregate import price inflation variable DLISHRF. We have employed a general-to-specific approach including four lags of the right hand side variables and gradually eliminating insignificant variables. The resulting Phillips curve is presented in Table 1.

Table 1. *The expectations-augmented Phillips curve, OLS, sample 1976:4-2000:4*

Variable	Coefficient	Std. error	*t*-value
Constant	0.000824	0.000651	1.266
DLCPI(-1)	0.418	0.0623	6.703
DLCPI(-3)	0.440	0.0628	7.003
UGAPHOG	-0.301	0.0687	-4.390
UGAPHOG(-2)	0.271	0.0643	4.206
DLISHRF	1.298	0.206	6.289
$R^2 = 0.858$, $\sigma = 0.00304$, DW = 1.98			
Diagnostic tests for equation			
AR 1-5 $F(5,86) = 0.57637$ [0.7179]			
ARCH 4 $F(4,83) = 3.1088$ [0.0195]			
Normality $\chi^2(2) = 2.082$ [0.3531]			

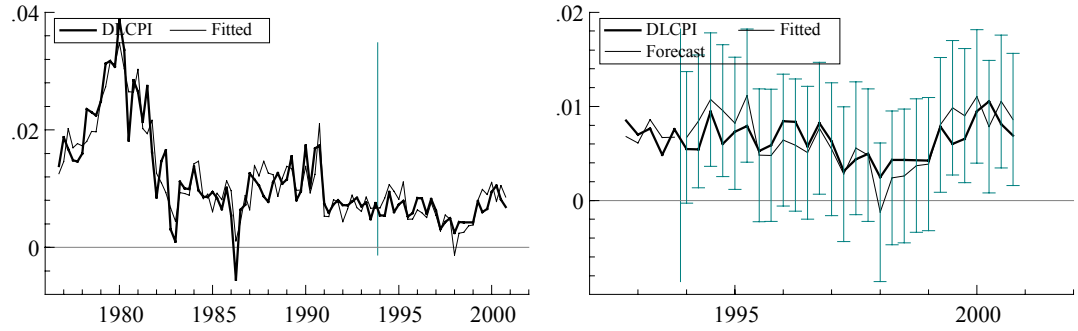
Notes: The symbol σ denotes the estimated residual standard error. The *p*-values for the diagnostic tests are in brackets.

Consumer price inflation depends positively on inflation lagged one and three quarters. In addition, CPI inflation depends negatively on contemporaneous labour market slack, and positively on the variable lagged two quarters. The sum of the coefficients to the unemployment terms is approximately –0.03.[6] The coefficient to import price inflation multiplied by the import share is somewhat (although not significantly) above one. The relation has satisfactory statistical properties. The ARCH test indicates some heteroskedasticity but it can easily be removed by including dummies for the oil price shocks in the first half part of the sample.

[6] See Stock and Watson (1999) for details on the interpretation of the unemployment terms in the Phillips curve.

The estimated Phillips curve in Table 1 is quite robust. Chow tests do not indicate any structural breaks during the 1990s. Also recursive estimation does not reveal unstable parameters. As a further check of stability, the sample has been reduced to 76:4-93:4 and the remaining observations used for test of the predictions of the Phillips curve. Figure 1 shows actual inflation, the predicted values within the estimation sample and the out-of-sample forecast.

Figure 1. *Actual, fitted and 1-step ahead out-of-sample forecast of DLCPI from Phillips curve*



A number of large outliners around the second oil price shock, the "Volcker disinflation" and the rapid oil price fall in 1986 are noticeable in the left panel. The out-of-sample forecasts follow actual CPI inflation reasonably well and are within the confidence interval depicted by vertical lines in the right panel.

These results demonstrate that the Phillips curve has not "broken down" as long as supply shocks (e.g. in the form of import price inflation) are included. This conclusion is in line with most of the literature, cf. the survey in Section 1. We have also experimented with a specification where the NRU is a constant. Although the fit deteriorates marginally, the estimated relation still tracks the inflation developments since the mid-1990s. The Phillips curve retains its position as having strong predictive power in spite of its limited theoretical underpinnings, see Fuhrer (1995), Stock and Watson (1999) and Mankiw (2001).

This conclusion is perhaps not surprising. The standard version of the expectations-augmented Phillips curve is highly autoregressive. This implies that predicted inflation moves smoothly and tracks inflation fairly well in the absence of large changes. Since inflation in the period since 1992 has moved smoothly, the expectations-augmented Phillips curve has not been put to a real test. Changes in underlying inter-linkages can have taken place but might not be uncovered by the highly autoregresive standard expectations-augmented Phillips curve.

3. An empirical wage-price spiral

In this Section we examine whether the stability of the simple expectations-augmented Phillips-curve can be repeated in a more "structural" model. To accomplish this we estimate a wage-price spiral on quarterly data from 1976:4 to 2000:4. The choice of sample is dictated by the availability of data capturing, inter alia, wage costs. The system consists of three equations; wage costs growth in private industry (DLWC), consumer price inflation (DLCPI), and producer price inflation (DLPPI). The following explanatory variables are used in our empirical wage-price spiral:

The variable DLISHRF measures the impact of import price inflation, while UGAPHOG is the labour market slack, cf. Section 2. OILW denotes the world oil price, calculated as the average of three important oil prices.

CAP measures the utilisation of installed production capacity in the non-farm business sector (manufacturing, mining, and utilities) and is compiled by the Federal Reserve. The measure is constructed from the FED's measurement of industrial production and by one or two independent surveys of capacity utilisation; the McGraw Hill survey and/or the Bureau of the Census survey, cf. Belton and Cebula (2000). The FED does not publish the precise method used to combine these three sources of information. We simply assume that the variable contains information regarding the degree of slack in the economy relative to the production possible with the available production facilities (machines, buildings etc.).[7]

The variable Z measures productivity in the non-farm business sector. The series DLZ is highly volatile. Preliminary estimations revealed that the series DLZ has little explanatory power. In line with most other analyses of the US inflation process, e.g. Gordon (1998, 1999a) and Brayton *et al.* (1999), we have chosen to work with trend productivity growth. MA8DLZ is trend productivity growth measured as the eight quarter moving average of DLZ.

The wage-price spiral is a dVAR-model where all variables except UGAPHOG and CAP appear as differenced logs (relative changes) and with no modelled error correction mechanism. This choice of model is motivated by several factors. First, we have problems obtaining satisfactory estimates of long-run vectors and the impact to the short-run specification (see also Rich and Rissmiller (2001)). Second, it seems a natural continuation of the thinking behind the Phillips curve, i.e. that disequilibria are gradually eliminated via slackness variables like unemployment or capacity utilisation. Third, it facilitates the comparison with the results from the Phillips curve in Section 2.

As before we follow a general-to-specific modelling procedure with two exceptions.[8] First, we "identify" the system in the following way: The variable capturing labour market slack UGAPHOG only enters the wage equation. Capacity utilisation CAP only enters the price equations. These assumptions ensure an intuitive interpretation of the individual equations in the wage-price spiral. Labour market slack only influences price inflation via wage growth, while capacity utilisation only impacts wage growth via price setting.

Second, we eliminate unnecessary variables. It turns out that the equation explaining consumer price inflation systematically overshoot actual inflation from the mid-1990s. Repeated experimentation with the included variables cannot eliminate this. However, by including a step dummy equal to zero for 75:1-93:4 and one for 94:1-00:4 (DUMSHF94), the systematic overestimation vanishes. The dummy is always highly significant, irrespective of the stage of the system reduction. For example, if DUMSHF94 is included in the unreduced system, the variable is always significant in the DLCPI equation but insignificant in the equations for DLWC and DLPPI. If DUMSHF94 is removed from the final specification and replaced by separate step dummies for each year from 1994 to 2000, all of the step dummies are negative and with one exception lie in the interval -0.004 to -0.002. Experimentation with other vari-

[7] The variable CAP is highly correlated with the gap between actual and HP-filtered industrial production. CAP has traditionally been negatively correlated with U and UGAPHOG, but this has lately been reversed. The correlation coefficient between U and CAP was -0.86 for the period 76:1-93:4 and 0.55 for the period 94:1-00:4. The correlation between U and UGAPHOG was -0.74 for the period 76:1-93:4 and 0.44 for the period 94:1-00:4.

[8] Reassuringly we generally found that the coefficient (or sum of coefficients) of a variable after eliminating insignificant variables was equal to the sum of the coefficients in the original system.

ables, including the step dummy multiplied by some of the right-hand variables, eg. trend productivity growth, does not produce better results than the stand-alone step dummy DUMSHF94. The preferred wage-price spiral is shown in Table 2.

Table 2. *The wage-price spiral, FIML, sample 1976:4-2000:4*

Variable	Coefficient	Std. error	*t*-value
Equation for DLWC			
DLWC(-2)	0.255	0.0828	3.084
DLWC(-4)	0.339	0.0813	4.169
DLPPI(-1)	0.0882	0.0290	3.040
DLCPI(-4)	0.230	0.0491	4.690
UGAPHOG	-0.149	0.0529	-2.815
UGAPHOG(-2)	0.117	0.0465	2.517
MA8DLZ(-4)	0.253	0.0952	2.659
σ = 0.00210			
Equation for DLPPI			
Constant	-0.0644	0.0144	-4.467
DLWC(-1)	0.355	0.146	2.432
DLWC(-2)	0.625	0.149	4.207
DLISHRF	2.641	0.352	7.504
CAP	0.0769	0.0180	4.278
DLOILW	0.00936	0.00406	2.306
MA8DLZ(-3)	-0.621	0.22347	-2.778
σ = 0.00446			
Equation for DLCPI			
Constant	-0.0449	0.00953	-4.709
DLWC(-2)	0.399	0.0935	4.263
DLPPI(-1)	0.185	0.0415	4.453
DLCPI(-3)	0.210	0.0649	3.232
DLISHRF	0.936	0.229	4.091
CAP	0.0601	0.0119	5.057
DLOILW	0.00646	0.00253	2.544
MA8DLZ(-2)	-0.278	0.145	-1.917
DUMSHF94	-0.00260	0.000697	-3.727
σ = 0.00269			
Diagnostic tests for system			
AR 1-5 $F(45,208) = 1.422$ [0.0521]			
Heteroskedasticity $F(354,158) = 1.2567$ [0.0501]			
Normality $\chi^2(6) = 3.0091$ [0.8077]			

Notes: The symbol σ denotes the estimated residual standard error. The *p*-values for the diagnostic tests are in brackets.

The diagnostic tests indicate borderline results for autocorrelation and heteroskedasticity. This is partly a consequence of the large outliers when oil or import prices have changed rapidly. Introduction of dummy variables reduces autocorrelation and heteroskedasticity, in general without changing parameter estimates. The problems are also reduced if more lags of the left-hand side variables are included. Gordon (1998, 1999a) includes up to 24 lags of the inflation rate in his Phillips curve estimations. Experiments have shown that the properties of our wage-price spiral do not change qualitatively when more (but independently insignificant) lags are incorporated.

Wage cost inflation is highly autoregressive with lagged values of wage inflation summing to 0.59. Wage inflation also depends on lags of CPI and PPI inflation, trend productivity growth with a long lag and labour market slack. Neither oil prices nor import price inflation were significant. A very small and insignificant constant term has been suppressed. Overall we find that wage growth depends on variables encapsulating demand and supply for labour but the regression also exhibits a significant degree of nominal wage growth *inertia*.

Producer price inflation is highly dependent on lagged wage growth; the sum of the relevant parameters is close to one. The direct effect of a one percentage point increase in trend productivity is 0.62 percentage point lower PPI inflation after three periods. Capacity utilisation, the impact of import price inflation, and oil price inflation also enter the regression. The parameter of DLISHRF is 2.6, significantly above one. The impact of import price inflation on producer prices is much larger than the share of imports in GDP. A possible explanation is that domestic producers adjust their prices in response to changes in import prices.[9] An interpretation of the equation is that producer price inflation is formed by a mark-up over labour costs with only incomplete adjustments to changes in trend productivity growth. The degree of capacity utilisation, oil price inflation and import price changes are shocks to this process. (The large constant reflects that CAP is a variable hovering in the interval 0.7 to 0.9 with an average of 0.816 for the estimation sample.)

Consumer price inflation depends – in addition to its own lags – on wage cost inflation, producer price inflation, trend productivity growth, import price inflation and oil price changes. In addition, the capacity utilisation term enters the equation. A possible interpretation is that consumer goods are domestically produced goods, imported goods and energy products prepared for sale using domestic labour and with a mark-up dependent on capacity utilisation. As outlined above, the step dummy DUMSHF94 is highly significant and reduces, ceteris paribus, quarterly consumer price inflation by 0,26 percentage points. The productivity term is marginally insignificant at the 5 percent level but we nevertheless choose to include the variable. First, by including the variable we ensure that the step dummy genuinely "belongs" to the regression and is not a result of omitted variables (i.e. that the dummy does not pick up variation that could be explained by trend productivity changes). Second, the parameter estimate is very robust; inclusion of additional dummies or changes in sample size has no discernible impact on the estimate.

It is noticeable that the three endogenous variables in the system influence each other in a rather asymmetric way. Wage increases impact producer and consumer price inflation strongly, whereas consumer price inflation and (even more pronounced) producer price inflation have small effects on wage inflation. In this sense wage inflation plays a "dominant" role in this system; the system exhibits significant nominal inertia as a result of highly autoregressive properties of the wage formation process.

The estimation of a wage-price spiral reveals that the system can not be estimated without a step dummy in the equation determining consumer price inflation. Further, the dummy does not enter significantly in the two other equations. Thus, it appears that the relationship between consumer price inflation and the other variables in the system has changed sometime in the mid-1990s. Our analyses indicate that the break occurs approximately in 1994, i.e. some time before the NE discussion gained pace. The very large number of explanatory variables in our system precludes that the step dummy simply picks up the effects changes in wages, pro-

[9] The large coefficient could also be the result of a simultaneity problem. US imports might be subject to "pricing to market" so that the large coefficient reflects an adjustment of import prices to PPI. Estimations where DLISHRF is lagged one or more periods provide a poorer fit but the coefficient is still large.

ducer prices, productivity, import prices, import share, oil prices, capacity utilisation, unemployment and the natural rate of unemployment. The shift must be associated with underlying changes that are not captured by any of the listed variables.

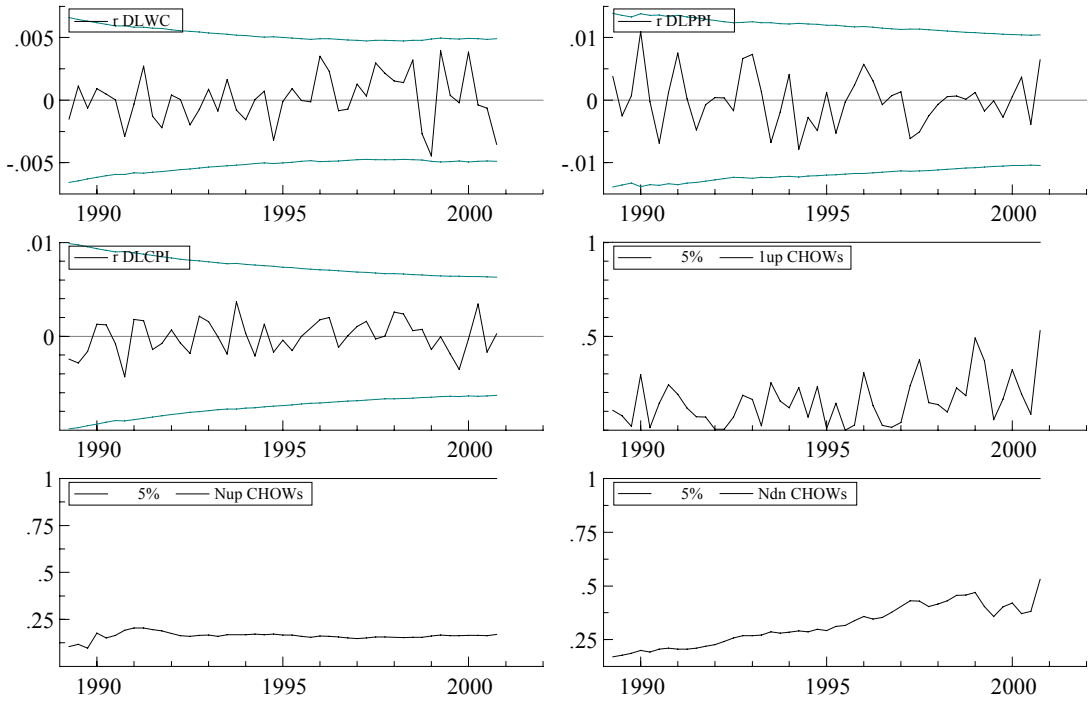
The analysis also reveals that it is possible to estimate a wage-price spiral for the US with a large number of variables, in which individual equations are interpretable and the estimated parameters generally have reasonable size. The large number of explanatory variables also makes the system suitable for quantitative analyses of the impact of various factors in explaining the low US inflation rate since the mid-1990s (see Section 5).

4. Stability of the wage-price spiral

The estimated wage-price system is stable and has good forecast properties when the step dummy DUMSHF94 is included in the CPI inflation equation, i.e. when allows for a structural shift in this equation. This can be illustrated in a number of ways.

Figure 2 presents the results from recursive estimation of the system. The first three panels (from left to right) reveal that the one-step ahead residuals remain within the estimated standard error bands. The test, however, has low power, as the confidence intervals are very broad. The errors are generally without systematic patterns. A possible exception is the residuals from the wage equation where the fluctuations seem to increase at the end of the sample. This is to a large extent the result of wage cost inflation being very fluctuating.

Figure 2. *Recursive stability tests of wage-price spiral*



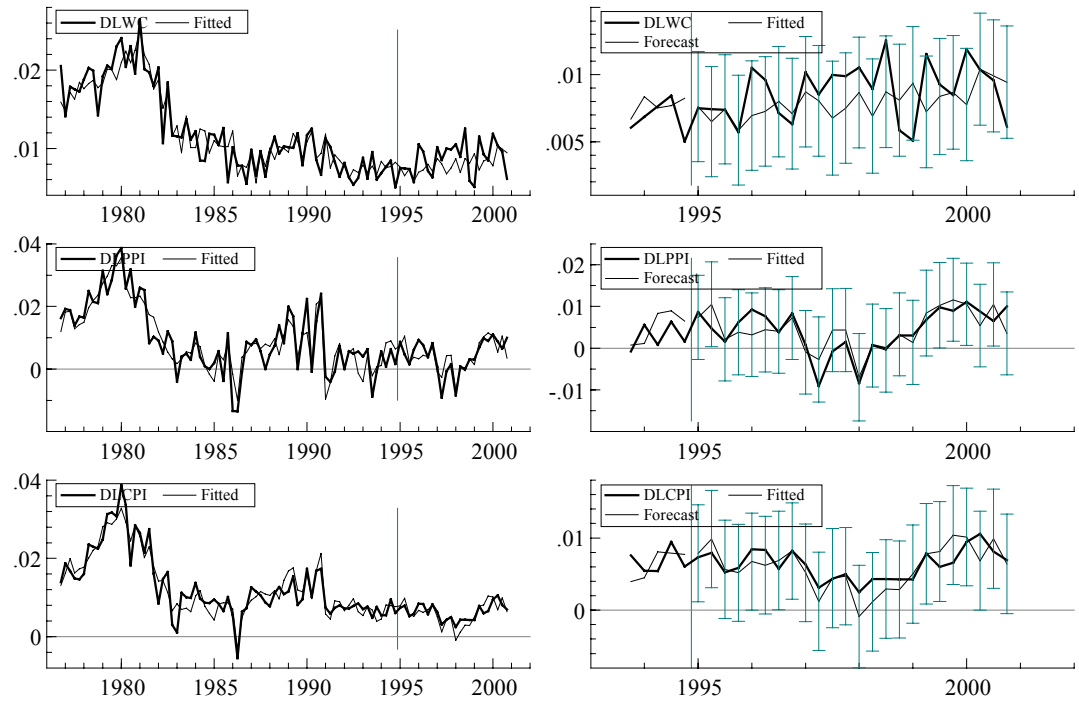
Note: Panels 1-3 (from left to right) show one-step ahead residuals for each of the equations. Panel 4 shows the one-step test ahead Chow test (scaled). Panel 5 shows the scaled breakpoint Chow test. Panel 6 shows the scaled forecast Chow test.

The Chow tests reveal no instability, cf. panels 4-6. Notice, however, that panel 4 shows a slight tendency of increased forecast errors in the latter part of the sample. The forecast Chow test in panel 6 also shows an increased probability of a break during 1998-99. The results are partly caused by the increased one-step ahead residual in the wage equation (panel 1).

An informal test of the stability of the wage-price spiral can be carried out by adding dummy variables to the system. Although a number of single quarter dummies are significant, the system essentially remains unchanged. For example, after including eight dummies for the period 79:1-80:4 and four dummies for the period 86:2-87:1, the coefficient estimates are little changed (not shown). As a result of the large number of estimated parameters, a couple of parameters are no longer significant at the 5 percent level, but they are still significant at the 10 percent level. The inclusion of other combinations of dummies has not revealed serious instability.

The stability of the system can be demonstrated by reducing the sample period and forecasting recent wage and price inflation developments. We have eliminated the last 24 quarters from the sample, i.e. the sample period is reduced to 76:4-94:4. The change in estimation period has a minimal impact on the estimated parameters (not shown). All parameters remain statistically significant although the DLOILW term in the producer price equation is barely significant at the 5 percent level. The statistical properties of the regression are unchanged. The new wage-price spiral is used to generate out-of-sample forecasts for the three variables DLWC, DLPPI, and DLCPI, see Figure 3.

Figure 3. *Actual, fitted, and forecast WC, PPI, and CPI inflation from wage-price spiral estimated on sample 76:4-94:4*



The realisation of each of the three variables is always within the forecast confidence interval (right hand panels). It is worth noting, however, that the precision of the forecasts varies within the three equations: Actual wage cost growth is under-predicted in most periods during 1997-99. The somewhat weak forecasts must be seen in the light of the unusual wage inflation

movements and higher volatility during the forecast period. The forecasts of producer price inflation mimic very precisely the actual movements. The forecast of consumer price inflation follows the actual movements closely, partly as a result of the included step dummy. Note that the equation under-predicts CPI inflation substantially in 1998, i.e. at the time the NE discussion gathered pace.

In sum, the forecasts are satisfactory although there is a tendency of substantial errors in the forecasts of DLWC. The rapid nominal wage cost growth during the second half of the 1990s also puzzles Gordon (1998, 1999a). We have been unable to detect any specific reasons for the under-prediction of DLWC, but experiments with a number of other specifications of the system indicate that the problem is quite general. It must be noted, however, that the erratic movements of DLWC during the second half of the 1990s limit the degree of precision which could reasonably be expected.

We conclude that the estimated wage-price spiral is stable and has reasonable forecast properties, especially for producer and consumer price inflation. However, this requires that the step dummy DUMSHF94 enters the equation for consumer price inflation.

It is noticeable that the estimation of the wage-price spiral revealed a structural break while this was not the case for the Phillips curve estimated in Section 2. Further, forecasts of CPI inflation from the wage-price spiral would have overpredicted actual inflation in the absence of the step dummy, whereas the forecasts from the Phillips curve did not call for inclusion of a dummy. This result is not too surprising in light of the autoregressive structure of the standard Phillips curve, see Clements and Hendry (1999). As long as inflation is rather stable and the labour market slack does not change rapidly, a standard Phillips curve would provide satisfactory forecasts. The wage-price spiral will in general only provide good forecasts as long as the structural relationship remains unchanged.

5. Factors behind the recent low inflation rate in the US

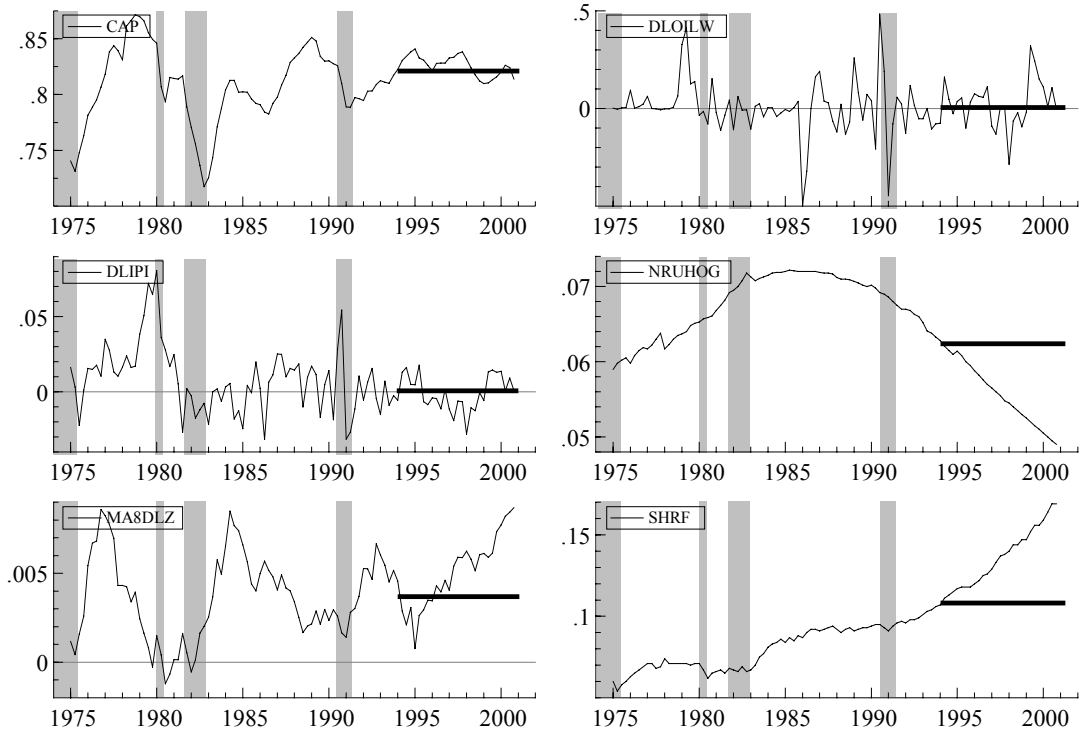
In this Section we look for factors behind the recent low inflation rate in the US in addition to the structural break identified in Section 4. By assuming a counterfactual development for the explanatory variables we are able to give a rough estimate of the impact of changes in the explanatory variables for recent changes in wage, PPI and CPI inflation.

Initially a baseline scenario for DLWC, DLPPI and DLCPI is generated by dynamic simulation of the wage-price spiral using *actual* values for the explanatory variables. Then a counterfactual scenario is derived by dynamic simulation of the wage-price spiral using an assumed counterfactual path for the explanatory variables for the period 94:1-00:4. By comparing the simulated values of DLWC, DLPPI and DLCPI we obtain estimates of the impact of changes in the explanatory variables.[10]

[10] In our system the explanatory variables can be changed independently. In practice these variables are interrelated. For example, increased productivity could under certain circumstances increase production capacity and reduce capacity utilisation.

The bold lines in Figure 4 illustrate the counterfactual path for the explanatory variables. The assumed path implies unchanged import prices, oil prices, NRU, capacity utilisation and import share from 1993:4. Productivity growth is assumed to remain constant at 0.4 per cent in every quarter from the first quarter of 1994. This is the average quarterly growth rate for productivity in the period 75:1-93:4. The thinner lines in Figure 4 gives the actual values.

Figure 4. *Actual explanatory variables and counterfactual assumptions with constant explanatory variables*



Note: The shaded areas indicate periods classified as recessions by the National Bureau of Economic Research.

The choice of counterfactual explanatory variables is somewhat arbitrary and the results are dependent on the assumed path. Our guiding post when choosing the counterfactual has been to keep things simple.

Figure 5 shows the difference between the simulated values. Each bar shows how much the change in each explanatory variable has contributed to changes in wage growth and PPI and CPI inflation on a quarterly basis. (Note the different scales for the three variables.)

Figure 5. *Contributions of explanatory variables on wage growth, PPI inflation, and CPI inflation*

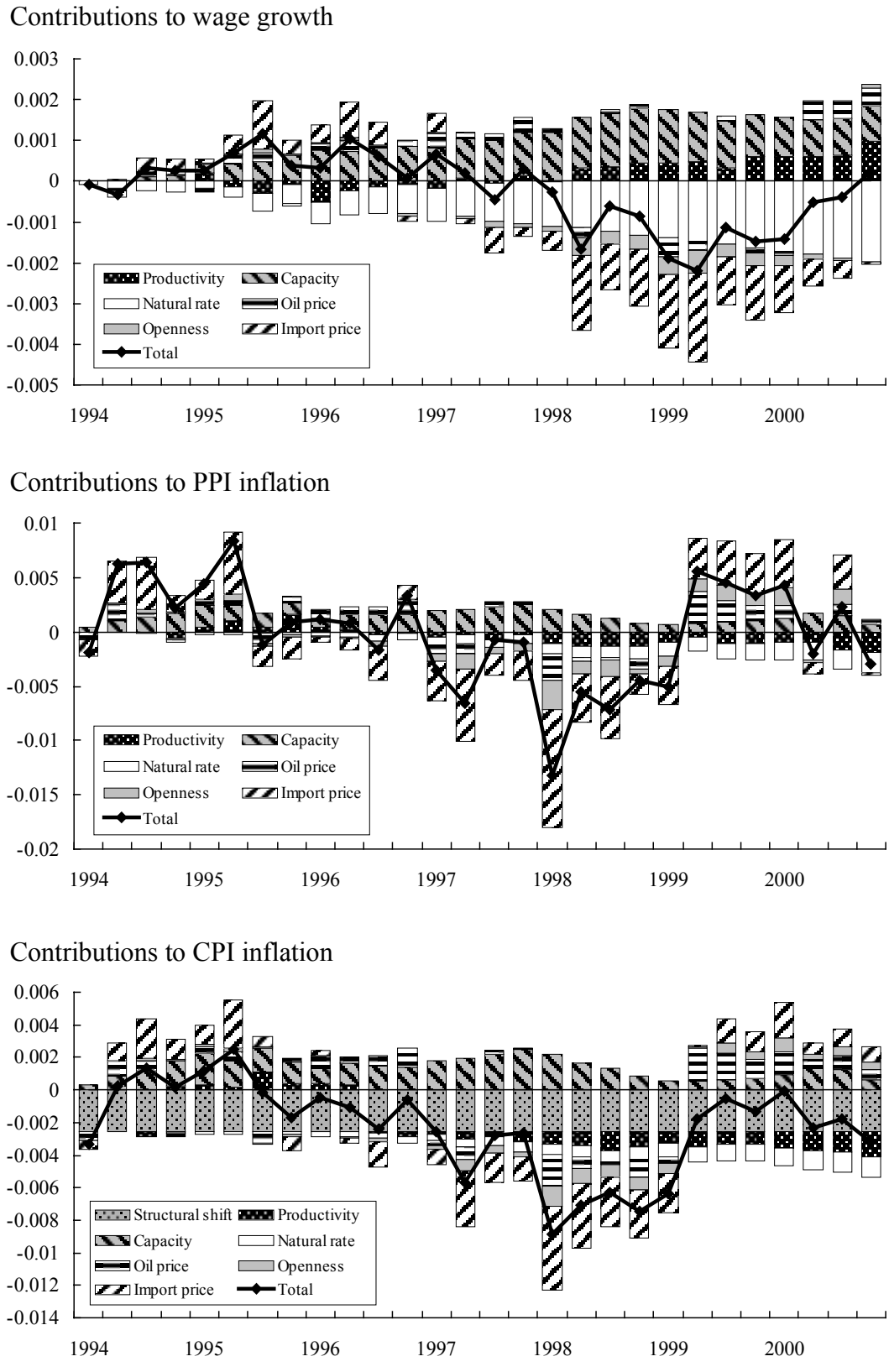


Table 3 shows the contributions of various factors on *annual* CPI inflation, based on the assumed counterfactual.

Table 3. *Contribution of explanatory variables to annual CPI inflation*

	1994	1995	1996	1997	1998	1999	2000
Counterfactual dynamic simulation of CPI inflation[a)]	3.3	3.3	3.3	3.2	3.3	3.4	3.4
Structural shift[b)]	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Simulated contribution of explanatory variables:[* b)]							
Import prices	0.2	**0.6**	0.0	**-0.6**	**-1.3**	**-0.6**	**0.5**
Import share	0.0	0.0	0.0	-0.1	-0.3	-0.1	0.2
Oil prices	0.0	0.1	0.2	0.1	-0.3	0.1	**0.5**
Natural rate of unemployment	0.0	0.0	-0.1	-0.2	-0.3	-0.3	-0.4
Productivity	0.0	0.1	0.1	-0.1	-0.3	-0.3	-0.4
Capacity utilisation	0.2	**0.6**	**0.5**	**0.7**	**0.8**	0.3	0.4
Baseline dynamic simulation of CPI inflation[** a)]	2.7	3.7	3.0	2.2	0.9	1.5	2.9

[a)] Percent p.a. [b)] Percentage points.
[*] Difference between baseline and counterfactual.
[**] Due to the non-linearity of import prices and import share in the estimated system, the sum of simulated contributions does not add up to the total contribution of the shocks.

Apart from the structural shift, changes in *import price inflation* seem the most important single factor in explaining inflation developments, especially during the second half of the period. In 1998, CPI inflation was pulled down by as much as 1.3 percentage points because of falling import prices. In 1997 and 1999, CPI inflation was more than half a percentage point lower for the same reason. Since the second quarter of 1999, rising import prices have increased CPI inflation.

An increasing *import share* has amplified the impact of import price changes somewhat. The simulations indicate that increased openness helped reduce inflation until from early 1997 to mid-1999. Since then greater openness has increased inflation as import prices have risen.

Oil price inflation has contributed fairly little to inflation developments during the 1990s. The oil price fall in 1998 lowered inflation somewhat, while rising oil prices had an inflationary impact in 2000.[11]

The falling *natural rate of unemployment* has had a downward impact on wage growth but the resulting fall in CPI inflation, however, was modest until the end of the 1990s. The effect is highly dependent on the starting point for our assumption of a constant NRU.

The effect on inflation of changing *trend productivity growth* is rather small. Our assumptions for the counterfactual path imply that initially trend productivity growth is higher than actual, but from 1997 actual productivity growth outpaces counterfactual. The effect has been positive and negligible until 1997. From 1998 higher trend productivity growth has a negative impact on CPI inflation. The relatively small effect is explained by two factors: First, the rather small difference between actual and counterfactual productivity growth for most of the years. Second, higher trend productivity growth reduces CPI inflation directly and indirectly via PPI, but also raises wage growth which increases PPI and CPI inflation. It follows from

[11] To some extent we might underestimate the impact of oil price changes, as oil prices are also included in our measure of import prices. We have not found sufficiently long data series for import prices excluding the oil price.

Figure 4 that increased trend productivity growth has increased wage growth from 1998. Note that higher trend productivity growth could have other effects, for example an appreciating dollar affecting import prices and prices. Similarly, if increased productivity growth increases investment some of the change in capacity utilisation is more fundamentally explained by changes in productivity growth.

Actual *capacity utilisation* is higher than the counterfactual through most of the period and has therefore increases wage, CPI, and PPI growth. However, the fall in capacity utilisation from 1998 implies a significant reduction in the inflationary effect of capacity utilisation in 1999-2000 relative to the previous four years. The outcome is highly dependent on the choice of counterfactual.

The results presented in Figure 5 and Table 3 are based on a counterfactual with constant variables. This is hardly a realistic assumption for e.g. productivity and capacity utilisation in light of the economic boom during the period. Long-lasting economic expansions tend to be associated with increasing capacity utilisation and slowing productivity growth. A more realistic counterfactual, assuming this pattern, would have led to greater downwards effects on inflation from productivity growth and capacity utilisation.

Based on the discussion of possible NE channels discussed in Section 1 and Appendix 1, we can draw the following conclusions regarding the importance of possible NE effects for subdued consumer price inflation since the mid-1990s:

- A structural shift, possibly related to NE effects, has had a large downward effect.
- A substantial part of the reduction in CPI inflation in 1997-99 was caused by factors like import and oil price changes. Part of the lower import and oil price increases might be attributed to an appreciating dollar during the period, possibly reflecting NE developments, although the bulk of the changes likely reflect factors unrelated to the NE.
- Greater import penetration is partly a result of the globalisation of the US economy, and consequently this NE effect has played a role. Note however, that increased openness makes CPI inflation more sensitive to import price changes but does not in itself lead to persistent downward pressure on inflation.
- The fall in the natural rate of unemployment could partly be related to NE developments but our analyses indicate that the effect on inflation has been rather small.
- Increased trend productivity growth likely reflects the NE. These effects have only played a discernible role since 1998.
- Falling capacity utilisation in 1999 and 2000 has helped reduce the upward inflation pressure. The moderation of capacity utilisation since 1998 could be the result of technical progress increasing the capacity of installed capital as well as inducing new investment. Moderate capacity utilisation might be an indication of NE effects.

In sum, the low level of inflation during the late 1990s in the United States must be related both to coincidental favourable shocks and to shocks that could be interpreted as reflecting NE developments. Notice that for the years 1997-99, when the discussion of NE gained pace, the bulk of the drop in CPI inflation can be explained by temporary factors like import and oil price changes. Our analysis indicates that NE effects show up in the form of a structural shift perhaps as early as 1994, and also in the form of changes in trend productivity growth and the natural rate of unemployment in 1999 and (more pronouncedly) in 2000.

6. Conclusion and final comments

We have considered the factors behind almost a decade of subdued and stable inflation in the US. The main results are derived from an estimated wage-price spiral comprising wage inflation, producer price inflation and consumer price inflation. Our estimated system is stable and has reasonable forecast properties, provided a step dummy is included in the equation for CPI inflation from 1994.

The step dummy in the consumer price equation suggests a structural shift in the functioning of the wage and price setting in the USA. This conclusion is not in line with most of the literature, cf. Section 1. Analyses based on single equation Phillips curves generally show that the Phillips curve is stable and without structural breaks that cannot easily be alleviated. Our analysis indicates that the single equation specification masks some of the underlying changes that have taken place.

Comparing a baseline dynamic simulation of the wage-price spiral with counterfactual scenarios, we obtain rough measures of the importance of each explanatory variable on inflation since the mid-1990s. Falling import prices are an important factor explaining the subdued inflation rate in 1997-99. Increased import penetration increases the sensitivity of the economy to import price changes. Falling oil prices led to lower inflation in 1998 but the picture was reversed in 2000. A moderate level of capacity utilisation appear to restrain inflation in 1999-2000. The direct effects of changes in trend productivity growth have been only been noticeable from 1999. A falling natural rate of unemployment has restrained inflation but seems relatively unimportant compared with other explanations. Apart from these factors, an unexplained structural shift in the equation for consumer price inflation plays an important role restraining inflation.

How should we interpret our results in the light of the NE discussion? Although the structural change points to NE effects, we have not explained what has caused the structural shift and, accordingly, cannot conclude that it is a result of the NE. Some of the changes in the explanatory variables can be attained to NE, and in sum these potential NE effects have significantly reduced inflation since the mid-1990s.

By using a wage-price spiral instead of a reduced form Phillips curve we are able to gain a deeper understanding of what has driven recent inflation developments in the United States. Still, the analysis has several shortcomings, pointing to avenues of future research.

The wage-price spiral is only concerned with the determination of wages and prices. There is no modelling of the real economy, a shortcoming which obscure the discussion of possible NE effects. For example, trend productivity growth, capacity utilisation and the natural rate of unemployment are likely to be interrelated but clearly our model provides no insights into this issue.

A related problem is that there are no mechanisms securing satisfactory long-run properties of the wage-price spiral. For example, long-run nominal homogeneity is not necessarily satisfied, thereby restricting the usefulness of the model to short-run inferences. A possible direction for future work is to use a vector error correction specification, possibly securing long-run homogeneity and opening for a firmer specification of the productivity spillover into wages and prices.

The inflation process has been hit by many shocks during the last 30 years, shocks which we would expect to lead to changes in the inflation process of a greater magnitude than could reasonably be expected from the NE. In addition, the period in which we would expect to see major NE effects on inflation is rather short. In combination these factors are likely to imply that all tests of NE effects on inflation are likely to have limited power.

The tests of NE effects on inflation undertaken in this paper are rather indirect; the links between the NE ideas and the variables included are uncertain. It would be useful to incorporate indicators capturing the degree of internal and foreign competition, the effect of information technology on labour markets, etc. into the estimations.

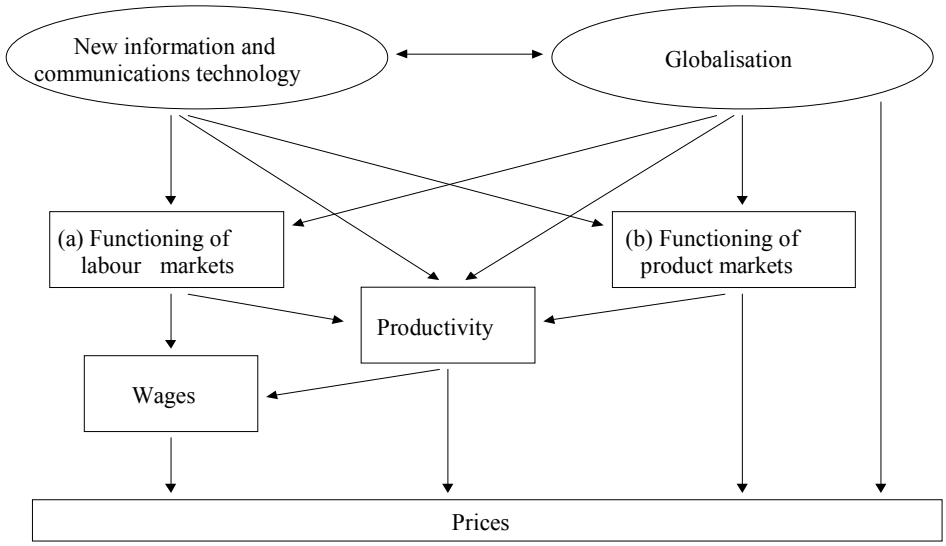
Appendix 1. The "new economy" – an interpretation

In this Appendix we present our interpretation of the "new economy" (NE) paradigm. The representation help us to better distinguish the different underlying hypotheses and determine which are most important.

The NE discussion is in essence about two related issues: First, what are the factors behind the remarkable growth experience in the US? Second, what are the factors that have kept down inflation in an environment of rapid growth and falling unemployment? The link between the two questions is the perceived monetary reaction function of the monetary authorities. If high growth and declining unemployment had been inflationary the FED would have increased interest rates to reduce growth and increase unemployment. In this paper we look at the second question, namely why inflation has been so subdued.

The NE paradigm has as its starting point the belief that two broad autonomous, but mutually reinforcing, trends are changing the economy in a fundamental way.[12] The trends and the channels they are thought to work through are illustrated in Figure A1.

Figure A1. *The "new economy" spider*



The emergence and diffusion of *new information and communication technologies* (ITC) are thought to improve the functioning of the labour market, increase productivity growth directly, and improve the functioning of product markets. We consider each "channel" in turn.

The idea behind the change in the functioning of the labour market is that for example Internet job sites represent a more efficient mechanism for matching workers and jobs than what has been available before. The result is a reduction of the natural rate of unemployment and/or a less steep Phillips curve. There might be greater effects on the NRU if the changes are unanticipated. The Bureau of Economic Analysis (2000) argues that an unanticipated increase in productivity can lower the NRU temporarily because it can take years for firms and workers to recognise these favourable developments and incorporate them into their wage-setting.

[12] See e.g. BusinessWeek (1997, 1999), Stiroh (1999), Lehman Brothers (1999).

ICT are believed to increase the efficiency of labour and capital and thereby influence productivity directly. In addition, the new technologies are likely to be embodied in equipment, increasing the profitability of investment. Higher investment might also add to productivity gains. The new technologies will potentially influence productivity in the whole economy as ICT are adopted in many sectors.[13]

Product markets might experience increased competition because search costs are lowered and information asymmetries reduced. Additionally, lower market entry costs limit price premiums sustainable by existing market participants (Smith *et al.* (1999)).

Globalisation is usually the label used to capture freer trade, freer capital movements, deregulation, reduced transportation and communication cost etc. Globalisation can also influence the functioning of the labour market as globalisation makes a threat of relocation more credible. Workers may feel more insecure and therefore make a greater effort, moderate their wage demands and increase their flexibility. The direct impact on productivity is thought to arise because globalisation opens for a more efficient spreading of technologies. The increase in competition in product markets comes through increased trade flows, increased direct investment, and lower prices for imported goods and services in competition with goods and services produced in the US. Globalisation will also have a direct effect on prices because lower tariffs will tend to reduce prices for imported products and services directly. See e.g. Harris (1999) and Katz and Krueger (1999).

The arrows from (a) and (b) to productivity illustrate that increased competition in labour and product markets can have the additional effect of spurring incentives for innovative efforts, thereby resulting in higher productivity.

The last line of hypotheses links the changes in the functioning of labour and product markets and increased productivity growth with changes in price inflation:

- Increased competition in product markets is assumed to exert sustained downward pressure on prices showing up as subdued inflation.
- Changes in the functioning of the labour market are assumed to exert downward pressure on wages. This is, however, essentially a "ceteris paribus" argument requiring that wages do not increase as much as productivity.
- The direct effect of increased productivity growth on price inflation goes through two channels. One is the price-reducing effect for a given level of competition. The other is that it might increase competition by increasing capacity in the economy. (See Pakko (1999) for models of the effect of technology improvements on productivity growth and capacity utilisation).

Apart from the Phillips curve related literature surveyed in Section 1 of the paper, several authors have studied the various underlying hypotheses more explicitly.

Katz and Krueger (1999) survey the evidence of different explanations for a perceived fall in the NRU during the 1990s. They find that improvements in labour market matching and competition from labour market intermediaries have contributed to a reduction in NRU, although

[13] What is the rationale for the term "new" in "new economy"? Innovations have been common since the beginning of mankind. Globalisation has occurred in waves, but the recent trend started long before the current US expansion. However, some innovations has a broad impact on the economy (e.g. the wheel, the steam engine, railroads, electricity) and the new ICT seem to belong to this group. Likewise, current international integration appears to be more broad-based and influence more sectors of the economy than previous globalisation episodes.

the improvement in matching is not explicitly considered to be connected to new ICT. They also find trends in self-reported worker security suggesting that insecurity may have contributed to wage restraint in the mid-1990s. But, the return of these survey measures to their levels at previous business cycle peaks suggests that worker insecurity was not abnormally high in 1996-98. Other factors, like an ageing working force and increased incarceration, are not related to the NE but have contributed to the falling NRU.

Gomme (1998) discusses whether theoretical models support the notion that technology shocks can change the NRU and reaches an affirmative answer depending on the underlying structure of the labour market. In sum, the literature suggests a lower NRU can be the result of NE effects, but on balance the evidence is not strong.

Figure A2. *Trend productivity growth*

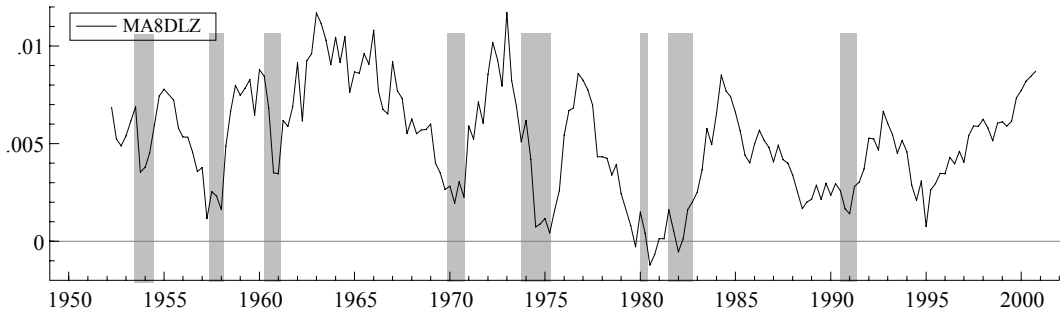


Figure A2 shows the increase in productivity growth in the second half of the 1990s. It also shows that rapidly increasing productivity is nothing new. What seems new is that there is increasing productivity very late in the boom. In a much-cited article, Gordon (1999b) examines the impact of ICT on the recent increase in productivity growth and finds that it has only had a minor impact on the increase in productivity growth in the economy outside the computer producing industries. Oliner and Sichel (forthcoming) find that the increased use of ICT has contributed to approximately 3/4 of the recent increase in labour productivity. Additionally, technological advances in the production of computers appear to have made an important contribution. Also Schreyer (2000) finds that the contribution of ICT is important for productivity growth in all sectors. The Council of Economic Advisors (2000) estimates that an important share of the uptake in multifactor productivity in the US is due to increased productivity in sectors other than the computer industry. However, the extent to which this is due to new information technology remains questionable. Taken together, these studies suggest some evidence of increasing productivity as a result of ICT.

The findings on increased competition in product markets because of ICT are ambiguous. Smith *et al.* (1999) surveys the empirical findings on the efficiency of electronic markets. They find mixed evidence regarding price discrepancies in electronic markets and conventional markets. In one of the studies surveyed, the price elasticity for homogenous products is found to be higher in the electronic market than in conventional markets. Other studies indicate that menu costs are lower online than in conventional outlets. However, they do not find evidence supporting the hypothesis suggesting lower price dispersion in Internet markets. All in all, this suggests some, but not strong evidence of increased competition in product markets. We are not aware of any studies testing explicitly for the impact of globalisation.

Appendix 2. Data

The variables are derived from the Datastream database unless otherwise indicated. The code for electronic extraction is given in brackets. The series are seasonally adjusted unless otherwise mentioned. (The data set is available from the authors upon request.)

Nominal variables

WC	Employment cost index for private industry workers, wages and salaries component. [USECWPIWF]. Not seasonally adjusted.
CPI	Consumer price index, all urban sample, all items. [USCP....E].
PPI	Producer price index, finished goods. [USFINGPRE].
IPI	Import price index (in US dollars), goods and services. [USIPDIMPE]. Not seasonally adjusted.
OILW	World average crude oil price (average of 3 spot market prices), US$/barrel. Source: International Financial Statistics, IMF. [q.00176AADZF...].

Real variables

Z	Output per hour of all persons in the non-farm business sector. [USOPHNBSE].
U	Total unemployment rate. [USUNRATEE].
NRUHOG	"Natural rate of unemployment" calculated by Hogan (2000). The variable is read from chart 2 for the period 1960:1-1998:1 and linearly extrapolated for the period 1998:2-2000:4.
UGAPHOG	U-NRUHOG ("labour market slack").
CAP	Capacity utilisation rate, all industries. [USOPERATE].
YI	Industrial production index. Constant prices. [USINPRODG].
BNPF	Gross domestic product. Constant prices. [USGDP...D].
IMPF	US imports, goods and services. Constant prices. [US001189D].
SHRF	Imports as share of GDP calculated as IMPF/BNPF.

Operators

L*x*	Natural logarithm of *x*.
D*x*	Difference between current *x* and *x* lagged 1 period.
MA8*x*	Eight quarters moving average of *x*.

Dummy

DUMSHF94	Step dummy, 0 for 1975:1-1993:4, 1 for 1994:1-2000:4.

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