

Do High Oil Prices Presage Inflation?

The Evidence from G-5 Countries

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Abstract: We estimate the effects of oil price changes on inflation for the United States, United Kingdom, France, Germany, and Japan using an augmented Phillips curve framework. We supplement the traditional Phillips curve approach taking into account the growing body of evidence suggesting that oil prices may have asymmetric and nonlinear effects on output and that structural instabilities may exist in those relationships. Our statistical estimates suggest current oil price increases are likely to have only a modest effect on inflation in the U.S, Japan, and Europe. Oil price increases of as much as 10 percentage points will lead to direct inflationary increases of about 0.1-0.8 percentage points in the U.S. and the E.U. Inflation in Europe, traditionally thought to be more sensitive to oil prices than in the U.S., is unlikely to show any significant difference in sensitivity from that in the United States and in fact may be less in some countries.

Keywords: inflation, Phillips curve, oil prices, exchange rates.

JEL Classification: E3, C2

Introduction

Movements in oil prices have complicated the tasks of policymakers and business leaders over the past three decades. Increases in inflation during the 1970's have been blamed, in part, upon rapid increases in petroleum prices. The long decline in inflation during the 1980's and 1990's have in turn been associated with declines in oil prices. Hence, a clear understanding of the strength of the empirical linkage between oil price changes and inflation is key to the proper conduct of monetary policy. To the extent that firms must alter their pricing policies according to the inflationary environment, firm managers also need to perceive the links accurately.

While most of the examples that come to mind are historical in nature, it would be a mistake to conclude that the impact of oil prices on the macroeconomy is now unimportant. For instance, we are more familiar with, in September 2000, crude oil prices in the United States reached \$37 per barrel, more than tripling from levels in December 1998. Similarly, average world oil prices increased from \$9 per barrel to \$33 per barrel. And while the oil market responded with additional production, oil prices remained high and volatile until the spring of 2001. As oil prices increased, so did concerns about increasing inflation both in the U.S. and abroad. Beginning in June 1999 through May 2000, the Federal Open Market Committee of the Federal Reserve Board, partly in response to increasing oil prices, increased the federal funds rate on six different occasions. In other countries, rising oil prices complicated central bankers' efforts to check inflation and moderate changes in exchange rates, a particular concern in Europe.

Even more recently, energy prices again took on a central role in 2003, as oil prices again breached the \$33 mark as international tensions increased in the run-up to the Iraq conflict.

While prices fell substantially in the wake of combat operations, by January 2004, they had again risen to the comparable levels.

This study examines two related questions. First, what is the effect of increasing oil prices on inflation? Second, does the inflationary effect vary across countries? We answer these questions by exploring the effect of oil prices on inflation in the United States and other industrialized countries, including the record-setting spike in oil prices in 2000 (larger than the 1973, 1979, and 1990 shocks in nominal terms). Our work also bears on the question of how much credit falling oil prices deserve for the relatively low levels of price inflation throughout the 1990s.¹

We estimate the effects of oil price changes on inflation for the United States, United Kingdom, France, Germany, and Japan using an augmented Phillips curve framework. Because oil prices are a component of our Phillips curve model, answers to these questions can be read directly from parameter estimates. We supplement the traditional Phillips curve approach taking into account the growing body of evidence suggesting (1) that oil prices may have asymmetric and nonlinear effects on output and (2) that structural instabilities may exist in those relationships. Davis and Haltiwanger [2001], for example, view the evidence for asymmetric responses to oil price ups and downs as well established. Others have argued [Lee, Ni, and Ratti, 1995 and Hamilton, 1996a; 1999] that large or surprising oil price shocks have proportionally larger effects. Not surprisingly, Hooker [1999] finds that many of these statistical results are sensitive to model specification and sample period considered.

¹ During this period, the U.S. economy achieved combinations of unemployment, growth and inflation thought unattainable by many economists. Observers have attributed this anomalous condition to special factors, like precipitously falling oil prices. Oil prices decreased from roughly \$23 per barrel in the fourth quarter of 1996 to just over \$10 at the end of 1998.

In deference to the controversy over a structural-break in the oil price/inflation relationship, we focus our estimation on the period 1980Q1 to 2001Q4.² We find that the abrupt oil price increases experienced in the late 1990s had only modest inflationary effects although differences in the size of the effects exist across the United States, Japan, and Europe. The econometric evidence for this result is fairly robust to different specifications of the Phillips Curve relationship, oil price shocks, and lag lengths.

Inflation in the 1990s

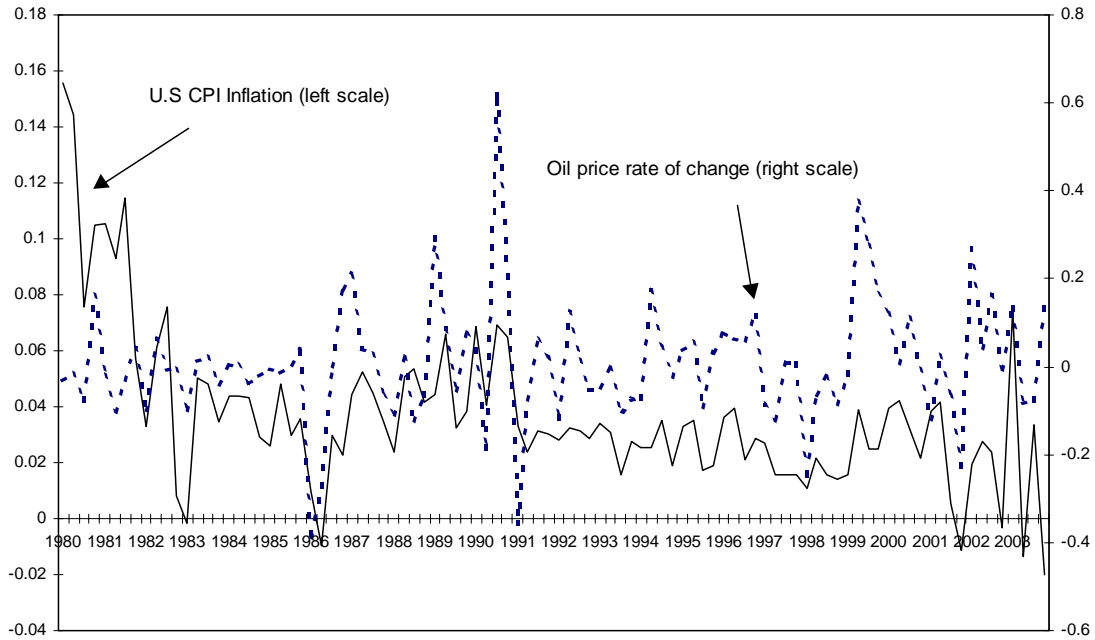
The average inflation rate in the United States during the 1990s was unexceptional. Inflation was lower in the 1950s and 1960s than it was in the 1990s. There was, however, less inflation in the 1990s than there was in the 1980s and especially the 1970s. The 1990s look more distinctive once we look at the variability of inflation. As measured by its standard deviation, inflation was only one-third as volatile during the 1990s as it was during the 1980s. It was 24 percent less volatile during the 1990s than during the 1960s, the second-best decade as ranked by inflation volatility. Inflation during the 1990s was perhaps more notable when viewed against the backdrop of prevailing economic conditions.

During the 1990s, price inflation in the United States and most industrialized countries was stable or even decelerating despite generally rising economic activity and tightening labor markets (*Figure 1*). Policy makers reveled in the coexistence of a strong economy with low inflation. Predictions by economists, however, tended to overstate underlying inflation pressures in many countries, perhaps providing evidence of an inadequate understanding of the inflation

²Hooker's [1996, 1999] work suggests a structural break in the oil price inflation relationship around 1980. This structural-break characterization appears robust to a variety of specifications. He suggests a change in the reaction of monetary policy to oil shocks is part of the explanation.

process. One plausible explanation for the unexpectedly slow rise in prices relative to wages was that economies benefited from favorable supply shocks from the energy sector throughout much of the decade.

Figure 1.
U.S. Oil and General Price Inflation



The precipitous run-up of oil prices beginning in 2000 was preceded by an exceptionally weak oil market. Early in the fall of 1998 several elements combined to weaken energy oil demand and prices in the United States. They included a drop in the demand for heating fuel and lowered expectations of continued strong commitment to production cutbacks by OPEC producers. The world-wide rate of oil inventory accumulation averaged about 1 million barrels per day in 1998, completing a 3-year run of storage builds totaling about 730 million barrels or well over 9 days of supply. This increase in stock levels was a major force in keeping downward pressure on oil prices in the U. S. throughout 1999 (*Figure 2*).

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Only one year later uncertainty, volatility, and inflexibility characterized the oil market. Industry stocks of crude and refined products were low during 2000, roughly in line with levels in 1996 when demand was 6 per cent below 2000 levels. With so little margin to meet unexpected demand increases, the market was exposed to disruptions and the threat of regional supply imbalances. The benchmark one-month forward price of crude oil peaked at \$37.80.

Energy prices continued to stay high throughout the fall of 2000, with oil prices showing little or none of the anticipated declines expected to be generated by excess production over demand. The monthly U.S. imported crude oil price in November was a little over \$31 per barrel (about \$34 for West Texas Intermediate crude oil), in nominal terms the second highest monthly average level in the decade.

The Inflation Transmission Mechanism

Oil price spikes pose a difficult problem for central bankers. An increase in the price of oil, for instance, raises firms' costs and the prices they charge for their products. Holding non-energy prices constant, this tends to raise inflation and, for given level of aggregate demand, pushes the economy toward recession. The central bank then has a choice between implementing a contractionary monetary policy to fight inflation and an expansionary policy to fight recession. In the face of supply shocks, the Fed cannot stabilize inflation and the real economy simultaneously.

Why might inflationary pressures from rising oil prices differ across countries? The implications of higher energy prices on inflation depend, in part, on how important energy is in

the economy.³ The importance of oil in production and consumption across countries (differences in energy intensities of production) may, however, be offset by differences in inflationary transmission mechanisms with respect to wage setting institutions. The U.S. and Japan use far more oil per dollar of GDP in production than other developed countries. Americans consume on average 24 million barrels per day of oil last year, according to the International Energy Agency, and Europe, roughly the same population size as the U.S., consumes about 15 million barrels per day. European economies, however, have stronger unions and institutional arrangements which may cause them to be more prone to wage-price spirals.

Energy intensity (as measured by the energy consumption/GDP ratio) is now substantially lower in the United States than it was in earlier decades. Indeed, from 1973 through 1999 the energy intensity of the U.S. economy declined by 41 percent. Petroleum intensity declined by 50 percent. Part of the change in intensity is due to the energy conservation-inducing effects of higher real energy prices in the 1970's and early 1980's. Another part is due to the changing structure of U.S. industry, with a declining share of manufacturing and a growing share of a less energy intensive services.

Nonetheless, the energy intensity of the U.S. economy is still far greater than any other European country, as illustrated in *Figure 3*. The United States produces, on a purchasing-price-parity basis, nearly three times as much as the United Kingdom, France, and Germany, but consumes between 6 to 9 times as much energy. Part of the explanation for the disparity is that retail energy prices are greater in Europe.⁴ Although international markets exist for most energy

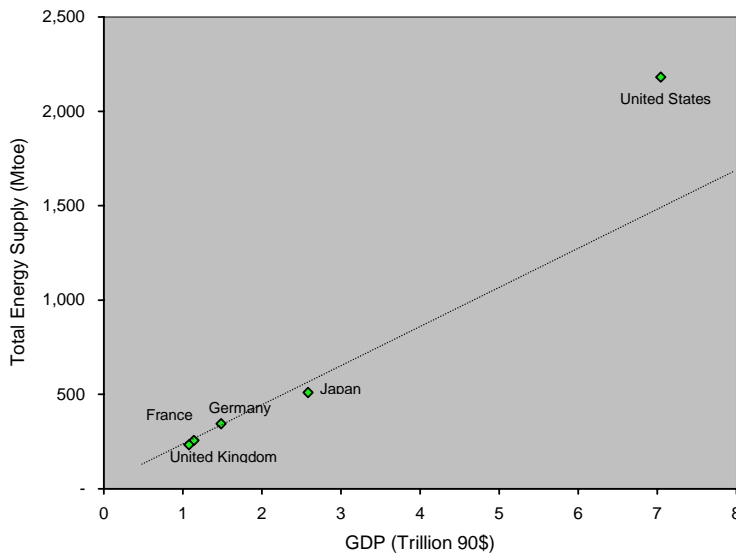
³ Of course, other factors may be at work, possibly including the policy reaction function of the central bank. However, since most central banks' behavior during the 1980's and 1990's seems well characterized by an inflation stabilizing Taylor rule, this does not appear to be at the heart of the difference across countries (although it might explain part of the decline over time of the impact of oil price changes on inflation in the US).

⁴ As pointed out by the referee, there are a number of policy-related factors in Europe that cause fuel prices to be higher than the U.S. that have nothing to do with consumers' demand or suppliers' willingness to supply fuel.

commodities, after-tax retail prices differ markedly across countries. For example, in 1999 the retail price of gasoline in the United Kingdom was nearly a dollar a liter more than gasoline in the United States. Gasoline in France was \$0.68 more and Germany was \$0.60 more than gasoline in the U.S. Similar patterns hold for natural gas and electricity.

There are two main reasons that European inflation is believed to respond more to oil price increases. First, labor unions are more powerful in Europe than in the United States and unions are more likely to extract higher wage concessions in response to rising consumer prices for energy. Second, because product market competition is less intense, European producers are more likely to pass along wage costs to consumers in the form of higher prices. Hence, oil price boosts are more likely to trigger a wage-price spiral in Europe, whereas in the United States workers are more likely to absorb higher oil prices through higher fuel prices and increases in other energy intensive goods and services.

Figure 3.
Energy Use and GDP for Selected Countries



The economic power of trade unions in Europe to affect wages was reflected in the two oil shocks of the mid-1970s and early 1980s. Trade union calls for permanent higher wages are generally credited with the increase in unemployment during this period. After the oil shocks were absorbed, the employment level was permanently reduced. This effect, observed in several European countries, is suggested by the step-wise increase in the unemployment rate following each oil shock. In contrast, in the U.S., where unions may have been less ‘hard-line’, unemployment rates increased at the time of each oil shock but then reverted towards earlier levels.⁵ To the extent that European trade unions have seen their bargaining power diminish over the past three decades, and product market liberalization has occurred under EU auspices, we should expect the sensitivity of European prices to oil price shocks to have diminished.

Oil Prices and the Philips Curve

The economics literature provides no consensus regarding a theoretical framework for explaining how changing oil prices affect economic activity. Researchers have identified a range of potential mechanisms arguing alternatively that oil primarily affects the economy by increasing input costs, increasing investment uncertainty, as a shock to the aggregate price level which reduces real money balances, and/or as a relative shock leading to costly resource reallocation among sectors. Compounding the problem of identifying the actual pathway of the

⁵ These ideas are summarized in various insider-outsider models of labor markets. See one formulation in Blanchard and Summers [1987].

oil price effects is that the effects are difficult to discern and estimate because monetary policy can mask the effects of oil price movements.⁶

The most obvious indicator of an oil price shock is the nominal oil price. In an early article, Hamilton shows that increases in the nominal price of oil Granger-causes downturns in economic activity. However, more recent data have shown this simple measure to have a rather unstable relationship with macroeconomic outcomes, leading subsequent researchers to employ increasingly complicated specifications of the "true" relationship between oil and the economy. In particular, Hamilton more recently [1996] argues that the correct measure of oil shocks depends on the how the price of oil affects the economy.

Hamilton has proposed a more complicated measure of oil price changes: the "net oil price increase." The measure distinguishes between oil price increases that establish new highs relative to recent experience and increases that simply reverse recent decreases. For quarterly data, the "net oil price increase" compares the price of oil each quarter with the maximum value observed during the preceding four quarters. If the value for the current quarter exceeds the previous year's maximum, the percentage change over the previous year's maximum is plotted. If the price of oil in quarter t is lower than it had been at some point during the previous four quarters, the series is defined to be zero for date t . This calculation makes clear that most of the individual price increases observed since 1986 were simply corrections to earlier declines.⁷

In addition to Hamilton's "net oil price" measure, the energy economics literature provides many alternative indicators of oil price shocks. Those proposed by Ferderer [1996] and Lee, Ni, and Ratti [1995] for example, focus on the volatility of oil prices rather than the

⁶ Hoover and Perez [1994] model oil price shocks as a dummy variable for the spike periods, and they are nearly coincident with the Romer and Romer [1989] monetary contraction dummies.

⁷ Hamilton provides some evidence for the usefulness of this variable, using semi-parametric methods, and Hooker also finds it to perform well, in the sense of having a relatively stable relationship with macroeconomic variables.

level. Mork [1989] proposed an asymmetric relation in which the regressor is given by the magnitude of the oil price change when oil prices increase but equal to zero when oil prices decrease.

The view expressed by Hamilton [1996a, b] is that oil shocks affect the macroeconomy primarily by depressing demand for key consumption and investment goods. Historical oil crises have been characterized by widespread concern about the price and availability of energy, concerns which could well cause certain irreversible investment decisions to be postponed. Our concern in this study is not on real economic effects, but rather the inflationary effects of oil price increases. For our purposes, the exact channels through which oil affects the economy are not crucial. What matters is that one can identify an exogenous movement in the price of oil that has a significant and a priori plausible reduced-form impact on inflation.

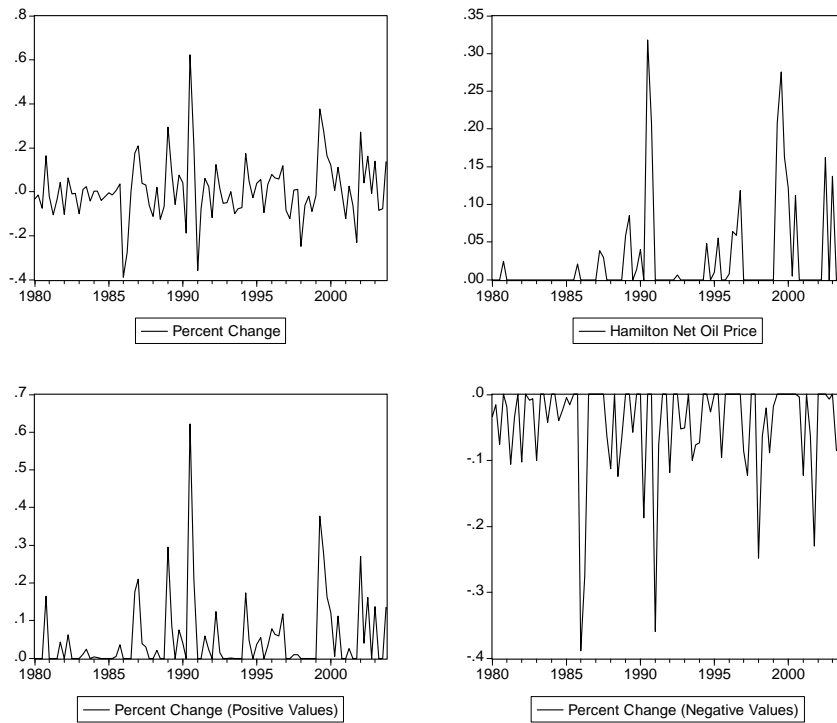
The U. S. Oil Price-Inflation Relationship

Inflationary pressures manifest themselves when the overall demand for goods and services grows faster than the supply, causing a decrease in the amount of unused productive resources. Economists have measured economic slack in various ways. Perhaps, the most common measure is the unemployment rate, which measures unused resources in the labor market. Another measure of slack is the real output gap, the estimated difference between actual real output and the economy's potential output. The main difficulty with output gap measures is that they depend on assumptions about the behavior of potential output, an area of macroeconomics where there is little consensus. Monetary policy is also a candidate explanation for any sustained change in the inflation process. Indeed, in the 1970s, many economists argued that relative price changes, even as large as the OPEC oil shocks, would only be inflationary if accommodated by monetary policy.

We utilize a short-run Phillips curve to describe the tradeoff between inflation (the log change in the All Items CPI-U) and a measure of economic slack, along with other variables that affect the price level by changing the cost of producing goods and services. Crude oil prices are included in the Phillips curve to test the proposition that petroleum prices are not only important in production, petroleum is used to produce and transport a wide range of goods and services, but also as a harbinger of inflationary pressure which may exceed its importance as a productive input. In addition, we also include interest rates (log change Federal Funds rate) as a measure of monetary policy (the data are described in greater detail in the Data Appendix). Our assumption that monetary policy works strictly through interest rates is conservative, as it ignores other policy channels. We relax this assumption by including the effective exchange rate as an exogenous variable in selected models.

We report results for the unemployment rate, as a measure of economic slack, and three alternative indicators of the state of the oil market (*Figure 4*). The benchmark model uses the percentage change in nominal oil prices. A second model utilizes a Hamiltonian “net price” definition of an oil price shock. A final version allows the percentage change in nominal oil price increases and decreases to be asymmetric.

Figure 4.
Alternative Oil Price Shock Variables



Alternative models are estimated for the United States using quarterly data (1980:1 through 2001:4). Each model is estimated using seasonally unadjusted CPIs and unemployment rates, and include lags of interest rates (i), inflation (π), unemployment rate (U), and the percentage change in nominal oil price (O). The underlying model can be written in a general form as:

$$\pi_t = \alpha + \beta(L)\pi_t + \gamma(L)U_t + \delta(L)O_t + \phi(L)i + \varepsilon_t, \quad (1)$$

where (L) signifies a polynomial in the lag operator and ε is the *iid* error term.

Parameter estimates and associated statistics, for a U.S. Benchmark Model (percentage change in nominal oil prices), a Hamilton Net Price Model, and an Asymmetric Price Effects Model are reported in *Table 1*. These results are from the set of preferred specifications as measured by parameter parsimony, statistical fit, and plausibility of the estimated lag structure.

Table 1.
Augmented Philips Curve Parameter Estimates and Associated Statistics for the U.S.

Variable	Benchmark Model	Hamilton Net Price Model	Asymmetric Effects Model
Constant	0.008564 (0.013919)	-0.004562 (0.017516)	0.007770 (0.015859)
Inflation(-1)	0.384672 (0.113096)	0.410454 (0.116849)	0.354264 (0.114051)
Inflation(-2)	-0.161153 (0.117485)	-0.170804 (0.120965)	-0.180884 (0.125125)
Inflation(-3)	0.491172 (0.121844)	0.464015 (0.126938)	0.497084 (0.129102)
Inflation(-4)	0.189593 (0.117728)	0.136949 (0.120207)	0.235886 (0.122294)
Unemployment(-1)	-0.048600 (0.057550)	-0.065829 (0.063132)	-0.050813 (0.061065)
Unemployment(-2)	0.055925 (0.086554)	0.098359 (0.096175)	0.056092 (0.091268)
Unemployment(-3)	-0.105418 (0.087371)	-0.120668 (0.097878)	-0.125480 (0.090060)
Unemployment(-4)	0.093525 (0.054387)	0.090781 (0.059983)	0.114874 (0.055622)
Interest Rate(-1)	0.034484 (0.020053)	0.038684 (0.021304)	0.032592 (0.020436)
Interest Rate(-2)	-0.004708 (0.020013)	-0.007046 (0.021426)	-0.004755 (0.020540)
Interest Rate(-3)	-0.008492 (0.018983)	-0.003024 (0.020473)	-0.009136 (0.019390)
Interest Rate(-4)	-0.045939 (0.017010)	-0.038911 (0.018356)	-0.048588 (0.017231)
Oil Price	0.058138 (0.011885)	0.110870 (0.034142)	0.049331 (0.018766)
Oil Price(-1)	0.000732 (0.013682)	-0.063346 (0.038664)	0.000791 (0.021280)
Oil Price(-2)	0.005678 (0.013642)	-0.004151 (0.035951)	-0.005437 (0.019667)
Oil Price(-3)	0.010900 (0.012872)	0.048012 (0.029544)	0.025145 (0.018280)
Oil Price(-4)	-0.001854 (0.011714)	0.019476 (0.025799)	0.011692 (0.016752)
R-squared	0.814055	0.785865	0.830439
Adjusted R-squared	0.768897	0.733861	0.773049
S.E. of regression	0.013569	0.014561	0.013446
Sum squared residual	0.012887	0.014841	0.011752
Log likelihood	263.6027	257.3919	267.6611
Durbin-Watson stat	2.005689	1.948820	2.098852
Mean dependent var	0.038788	0.038788	0.038788
S.D. dependent var	0.028225	0.028225	0.028225
Akaike info criterion	-5.581879	-5.440726	-5.560480
Schwarz criterion	-5.075152	-4.933998	-4.912995
F-statistic	18.02678	15.11160	14.47011

Several other model specifications were examined including those with alternative lag lengths, exchange rate effects, and those using a different measure of economic slack, an output gap variable.⁸ These alternative specifications did not improve predictive performance nor did they have measurable effects on parameter estimates of other exogenous variables, in particular the oil price-inflation parameter. Lag lengths greater than four quarters resulted in implausible and statistically insignificant parameter estimates.⁹

Estimated statistics suggest all three reported models are adequate fitting and structurally plausible. Each model passes the LM (2) test for serial correlation, the Jarque-Bera normality test, and the White Test for heteroskedasticity. CUSUM test statistics indicate no instability. The Akaike Information and Schwarz criteria suggest modest support for the Benchmark Model. Out-of-sample forecast statistics, RMSE, MAE, MAPE, and the Theil Inequality Coefficient do not unambiguously identify a preferred model (*Figure 5*).

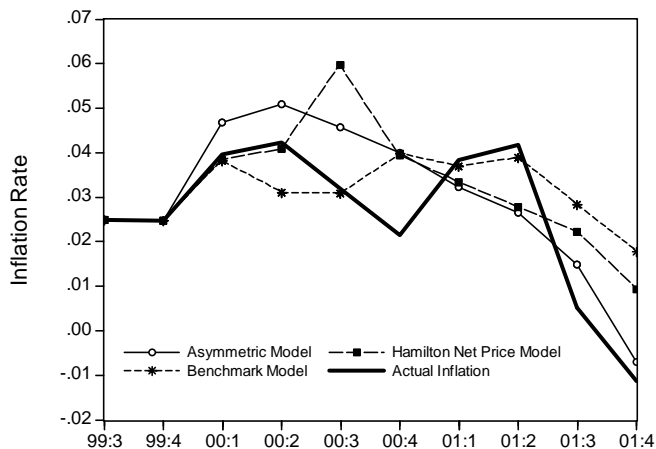
The effect of oil prices on inflation is significant and immediate. Each of the three models suggests inflationary impacts roughly commensurate with energy's share of GDP. The Benchmark Model predicts the smallest effect compared to the other models. In this model, a one time 10 percentage point increase in oil prices leads to 0.7 percentage point increase in CPI inflation after one year. The Asymmetric Price Model suggests a 10 percentage point increase in oil prices leads to 0.8 percentage point increase and the Hamilton Net Price Model predicts a

⁸ The output gap was derived as the difference between real GDP and a filtered real GDP series. Real GDP was smoothed using a Hodrick-Prescott filter with λ set to 1600.

⁹ Although the focus of the analysis was the run-up of crude oil prices during 2000, September prices reached \$37 per barrel, the stability of the model estimates was examined by re-estimating each model with additional data through 2003:4. Statistical tests (Chow Forecast Test) reject the null hypothesis of no difference between the base and "updated" models. The one-year effect of a change in oil prices on inflation in the Benchmark, Hamilton Net Price and Asymmetric Effects models differed from the "updated" estimates by an average of 0.4 percentage points. These results suggest a return to higher oil price-inflation relationship similar to those observed in the early to mid-1990s and reported in *Figure 6*.

1.1 percentage point increase after one year. Nearly 80 percent of the effect is immediate, as it occurs in the current period.

Figure 5.
U.S. Out-of-Sample Forecast: 2000:1-2001:4



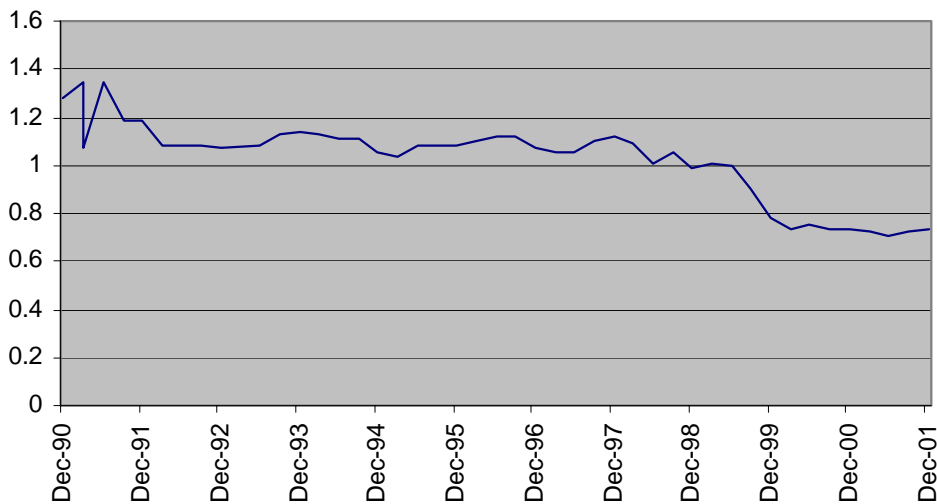
The magnitude of inflationary effect, particularly for the Benchmark Model, is fairly robust across specifications. Not unexpectedly, longer lag lengths produced larger one-year inflationary effects and the Asymmetric Effects Model and the Net Price Model generally suggest larger effects than the Benchmark Model. The magnitude of the inflationary effect depends most importantly on the choice of the oil shock variable. Excluding oil price downturns as in the Hamilton Net Price Model or segregating oil price downturns as in the Asymmetric Effects Model lead to higher estimated inflationary effects.

Most analysts believe that the economic effect of a large oil-price increase is smaller than it was 20 years ago. Since the oil crises of the early and late 1970s, oil use as a percentage of GDP has fallen in the U.S. and Europe. Production throughout the U.S. economy is less energy and oil intensive. In addition, European economies are also more flexible and deregulated than they were 20 years ago, making them better able to absorb oil-price shocks. European unions

have shown more restraint in demanding inflationary wage increases—a byproduct of global competition.

We examine this proposition of changes in the oil price/inflation relationship for the U.S. by estimating a series of recursive regressions. We first estimate the Benchmark Model for the period 1980:1 through 1990:4 and compute the one-year inflationary effect. We then re-estimate the Benchmark Model for each quarter over the 1980:1 to 2001:4 subsample. This provides 45 estimates of the inflationary effects, one for each quarter, beginning 1990:4 and ending 2001:4. In *Figure 6*, we provide the recursively estimated inflationary effects to examine the stability of the oil price/inflation relationship. Our estimates show the one-year inflationary impact of higher oil prices has declined over the sample. The estimated inflationary effects of a 10 percentage point increase in the price of oil after one year is about 1.2 percentage points in 1990 and slowly declines to about 1 percentage point by the end of 1998. Beginning in 1998, the one-year inflationary effects drops about 0.7 percent.

Figure 6.
Inflationary Effects of Oil Prices Decline in the U.S.: 1990:4-2001:4



International Oil Price-Inflation Relationship

To examine whether inflationary effects differ across countries we estimated a suite of models for the United Kingdom, Germany, France, and Japan and compared these results with estimates for the United States. These model suites consisted of alternative specifications of the oil shock variable, lag length (4 and 8 periods), and inclusion or exclusion of an exchange rate effect. In *Table 3* we present the estimated effect of a 10 percentage point increase in oil prices on each country's inflation rate for the Benchmark Model which uses the percentage change in prices as the oil price shock variable.¹⁰ Results derived from the Benchmark Model are consistent across other specifications. The relative magnitude and ordering of inflationary effects across countries is generally unaffected by the oil shock variable used. Estimated inflationary effects for the Asymmetric Effects Model and the Hamilton Net Price Model for the United Kingdom, France, Germany, and Japan are larger than those estimated using the Benchmark Model.

In the most general model specification (including an extended lag length and the effective exchange rate variable) the United Kingdom has the highest estimated one-year inflationary effect (2.5 percentage points) followed by Japan (1.1 percentage points) and the United States (0.8 percentage points). The model specification has a precipitous impact on the inflationary estimate for the United Kingdom, important impact on the estimate for Japan, and only modest impacts for France, Germany, and United States.¹¹

¹⁰ The estimated effect of a 10 percent increase on inflation for the Asymmetric Effects Model and the Hamilton Net Price Model are provided in Appendix A.

¹¹ Including the exchange rate effect is most important for the U.K. and extending the lag length is most important for Japan.

Table 3.

Estimated Effect of a 10 Percentage Point Increase in Oil Prices on Inflation:
Benchmark Model

Country	Extended Lag Length	Effective Exchange Rate Variable	Inflation Effect After One Year (Percent)	Rank
United Kingdom			0.7	3
France			0.1	5
Germany			0.3	4
Japan			1.5	1
United States			0.7	2
United Kingdom	x		1.2	1
France	x		0.1	5
Germany	x		0.5	4
Japan	x		1.2	2
United States	x		0.8	3
United Kingdom	x	x	2.5	1
France	x	x	0.1	5
Germany	x	x	0.5	4
Japan	x	x	1.1	2
United States	x	x	0.8	3

The estimated inflationary effects suggest no single obvious explanation across countries. Higher effects for the United States and Japan relative to German and France are indicative of the importance of the energy intensity of output and perhaps suggestive of the changing role of European trade unions. The results for the U.K. point to the importance of changes in the relative terms of trade. In any case, the relative results contradict commonly held views. That is, that the expected inflationary effect of higher oil prices in Europe is greater than the effect in the United States and Japan. OECD [2000], for example, estimated that a \$10/barrel increase in oil prices adds 1.1 percentage points to the European inflation rate two years later and only 0.6 percentage points in the U.S. Our estimates more closely parallel those of the International Monetary Fund [2000]. In a report published in December 2000, the IMF suggested a \$5 per

barrel increase in the price of oil (about a 16 percent increase) would increase CPI inflation in the United States by 0.8 percentage points, Japan by 0.3 percentage points, and the Euro Area by 0.7 percentage points, in the near-term.¹²

Our results suggest that the large differences in energy intensity of GDP in the United States and Japan are offset by institutional relationships in Europe as a whole. However, significant differences are apparent when the European Community is disaggregated. Inflationary effects for Germany and France are less pronounced than for the United Kingdom, Japan, and the United States with France being strikingly so.

Our model-based estimates are consistent with more casual observations of economic data. The rise in the oil price after early 1999 had little effect on underlying inflation trends in the U.S., Japan, or Europe. It modestly raised core consumer price inflation in the United States and the Euro area, but had little effect on other consumer or producer prices. The year-on-year increase in consumer prices excluding energy drifted up only slightly in both the United States and the Euro area. In addition, oil price developments did not appear to have given a push to wages. In the United States, despite a tight labor market, the growth rate of hourly earnings after accounting for productivity change showed only a modest increase. Similarly, wage growth after accounting for productivity change in Europe actually declined slightly. There were also no signs of higher longer-term inflation expectations as derived from the difference in yields on index-linked and conventional bonds.

Conclusions

The modest expected inflationary impact in the United States, Europe, and Japan contrasts with the 1970's episode of oil price hikes, when a wage-price spiral was put in motion.

¹² The underpinnings of this report are detailed in Hunt et al. [2001].

In addition to the reduction in oil intensity, several factors may account for the weaker inflation effects. The reduction of formal or informal backward-looking wage indexing arrangements removed the mechanism that passed energy price increases quickly through the economy in past oil shocks. The strengthening of competition in product markets has slowed down and/or limited the extent to which oil prices and induced wage effects can be passed on to customers. Finally, monetary policy has not provided the basis for a sustained change in the inflation process. Indeed, in the 1970s, many economists argued that relative price changes, even as large as the OPEC oil shocks, would only be inflationary if accommodated by monetary policy. The greater importance attached to price stability as a goal of monetary policy implies that oil-induced wage-price spirals are not being validated or encouraged by an accommodative policy stance.

Our statistical estimates suggest current oil price increases are likely to have only a modest effect on inflation in the U.S, Japan, and Europe. Oil price increases of as much as 10 percentage points will lead to direct inflationary increases of about 0.1-0.8 percentage points in the U.S. and the E.U. Inflation in Europe, traditionally thought to be more sensitive to oil prices than in the U.S., is unlikely to show any significant difference from the United States and in fact may be less in some countries. This suggests that in assessing the magnitude of effects, the higher energy intensity of the U.S. economy is counterbalanced by the increased inflationary pressures from stronger labor unions in Europe. Furthermore, depending on the state of the euro, inflation in Europe may be indirectly increased relative to the U.S. by an exchange rate effect associated with a dollar denominated oil price.

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Appendix Table A.

Estimated Effect of a 10 Percentage Point Increase in Oil Prices on Inflation:
Asymmetric Effects Model

Country	Extended Lag Length	Effective Exchange Rate Variable	Inflation Effect After One Year (Percent)	Rank
United Kingdom			0.7	2
France			0.1	5
Germany			0.3	4
Japan			1.3	1
United States			0.8	3
United Kingdom	x		0.3	4
France	x		0.1	5
Germany	x		0.6	3
Japan	x		1.0	2
United States	x		1.4	1
United Kingdom	x	X	1.7	1
France	x	X	0	5
Germany	x	X	0.3	4
Japan	x	X	1.0	3
United States	x	X	1.4	2

Appendix Table B.

Estimated Effect of a 10 Percentage Point Increase in Oil Prices on Inflation:
Hamilton Net Price Model

Country	Extended Lag Length	Effective Exchange Rate Variable	Inflation Effect After One Year (Percent)	Rank
United Kingdom			1.4	2
France			0.1	5
Germany			0.5	4
Japan			2.3	1
United States			1.1	3
United Kingdom	x		1.9	1
France	x		0.1	5
Germany	x		1.0	4
Japan	x		1.9	2
United States	x		1.4	3
United Kingdom	x	X	3.0	1
France	x	X	0.0	5
Germany	x	X	0.4	4
Japan	x	X	2.0	2
United States	x	X	1.9	3

Data Appendix

Most of the data are acquired from the IMF's *International Financial Statistics*, accessed from the Economic Data Sharing System in September 2001, updated with data from hard copies of *IFS*.

Inflation. log difference of seasonally unadjusted CPI-U for United States, and CPI for others, annualized, line 64 *IFS*.

Unemployment rates. In percent of labor force, line 67r, *IFS*.

Petroleum prices. West Texas Intermediate, in US\$/bbl, line 111 76z *IFS*.

Interest rates. Fed funds rate for the United States, money market rates for others, line 60b *IFS*.

Effective exchange rate. Trade weighted nominal exchange rate index, line neu *IFS*.