The decline in oil price pass-through to wage inflation

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ABSTRACT

Oil prices stopped feeding into core inflation around 1981 for the United States. A common explanation is that improvements in monetary policy over time led to inflation expectations becoming better anchored. The authors examine this hypothesis by looking at the effects of oil price shocks on wage inflation in a wage Phillips curve setting. A structural break is found on oil coefficients that matches the timing found elsewhere. Oil prices fed directly into wage inflation in samples prior to 1981, but had no effect afterwards. Inflation expectation surveys are checked in a Phillips curve-like setting. A similar structural break is found around 1981 with oil prices showing a large and positive effect prior to 1981, but no effect afterwards. The authors conclude that a better anchoring of inflation expectations played a role in the decline in oil price pass-through over time.

Keywords: wage inflation, oil price pass-through, anchored expectations, structural break

SECTION 1: INTRODUCTION

The twin oil price shocks and subsequent high inflation-low GDP growth experienced during the 1970s has led many economists to believe that oil prices play an important role in fluctuations to inflation and output. Specifically, many economists believe that oil prices at least partially pass through to "core" inflation (i.e. inflation less food and energy prices). The extent to which oil price pass-through occurs is important to central bankers as they try to maintain a low and stable rate of inflation.

Figure 1 plots the core inflation rate for the United States measured as the growth of the personal consumption expenditure (PCE) index less food and energy along with the real West Texas Intermediate oil price measured in 2017 dollars. The graph shows two noticeable oil price spikes in 1970s. The first spike occurred in 1973-74 when oil prices more than doubled from $18 a barrel to over $41. The second occurred in 1979-80 when oil prices increased from $44 a barrel to $100 a barrel. In each case core inflation increased sharply to about 10 percent. See Figure 1 in the Appendix.

The past 20 years has seen four oil price spikes of similar magnitude and size. Oil prices increased from $18 per barrel in the first quarter of 1999 to around $43 per barrel by the fourth quarter of 2000, rose from $44 per barrel in first quarter of 2003 to $84 per barrel by the second quarter of 2006, and doubled again from $69 per barrel in the first quarter of 2007 to $140 dollars per barrel by the summer of 2008. Oil prices collapsed due to the 2008 financial crisis falling to $49 per barrel by the first quarter of 2009, but more than doubled again to $112 per barrel by the second quarter of 2011. Core inflation remained remarkably stable during these shocks, never rising above 2.5 percent.

Several authors have formally examined the degree of pass-through from oil price shocks to inflation. Hooker (2002) estimates an expectations-augmented Phillips curve for the United States with core inflation on the left-hand side and finds a structural break in the oil price parameters around the middle of 1981. He finds that oil prices had a large effect on core inflation before 1981 but no effect afterwards. De Gregoiro, et al. (2007) analyze oil price pass-through for the 33 countries. Using a similar specification as Hooker they find a larger average pass-through during the 1970s than afterwards. Chen (2009) uses a Phillips curve specification for 19 OECD countries, but allows for time-varying coefficients. He finds that the coefficients on oil prices dramatically decreased starting around 1980. Clark and Terry (2010) use a VAR that allows for time-varying coefficients and stochastic volatility. They find that the degree of energy price pass-through to core inflation for the United States peaked in 1974, started falling through the 1970s and early 1980s, and became indistinguishable from zero from 1984 onward. Blanchard and Gali (2009) use a VAR separated into pre- and post-1984 sub-samples. They find that impulse responses of oil price shocks to CPI, GDP deflator, and wage inflation were all larger and more sustained in the pre-1984 period.

A possible explanation is that improvements in monetary policy since the 1970s have increased the Federal Reserve's credibility in fighting inflation, resulting in a better anchoring of inflation expectations. Economists have recognized the importance of public's inflation expectations and their effects on the actual inflation process (Mishkin 2007, Bernanke 2007,

Yellen 2015 and 2017). When expectations are well-anchored to inflation goals of the central bank, temporary oil shocks will quickly die out. If instead the central bank lacks sufficient credibility in its ability to fight inflation, inflation expectations become unanchored. In such an environment, temporary shocks to oil prices that raise overall inflation may indirectly enter the public's inflation expectations through current and backward components of inflation. A temporary oil price shock can then have a persistent effect on inflation.

Blanchard and Gali (2009) investigate whether a better-anchoring of inflation expectations or a decline in real wage rigidity can explain the declining pass through of oil prices to inflation and output. They construct a calibrated DSGE new Keynesian model that allows for real wage rigidity and where imported oil is both used in production by firms and consumed by consumers. They argue that for a given monetary policy rule, a reduction in real wage rigidity is associated with a decline in the volatility of output and inflation. They also argue that for a given degree of real wage rigidity, a more credible central bank reduces the volatility of output and inflation as well. They argue that both factors contributed to the declining oil price pass-through experienced during the 2000s.

Blanchard and Riggi (2009) expand on the Blanchard and Gali (2009) results by investigating the degree in which the structure of the economy has changed between the 1970s and the 2000s. The authors construct a DSGE new Keynesian model with imported oil both consumed and used in production. They conclude that both a reduction in real wage rigidity and greater central bank credibility explain the decline in oil price pass-through. Their results, however, depend on the way that inflation expectations are formed. If inflation expectations are formed based on the current period's inflation, the decline in real wage rigidity explains the main decline in inflation and unemployment. However, if inflation expectations are backward-looking and depend on lagged inflation, much of the decline in inflation and unemployment can be explained by the credibility of the central bank with almost no effect attributed to more flexible labor markets.

Given this background, the authors look to answer empirically whether an improved anchoring of inflation expectations can explain the decline in oil price pass-through. The motivation relies on the Phillips curve specifications and findings of Hooker (2002) and the theoretical models developed by Blanchard and Katz (1997), Ball and Moffitt (2001), and Blanchard and Gali (2009). The authors estimate wage inflation Phillips curves for the United States starting from the mid-1960s using a spliced dataset consisting of the Hourly Earnings Index (HEI) and the Employment Cost Index (ECI). The early part of the sample contains the Pre-Volcker Federal Reserve era where central bank credibility was perceived to be low and where inflation expectations were believed to be unanchored. The latter part of the sample period includes the Volcker-Greenspan-Bernanke Federal Reserve era with high central bank credibility and well-anchored inflation expectations. Consider Hooker's findings of a one-time structural break in the oil price coefficients around 1980/81, where oil prices fed directly into core inflation prior to 1980/81, but had a negligible effect afterwards. If inflation expectations are better anchored today, then oil prices should have a stronger, positive effect on wage inflation during the pre-Volcker sample period and a much smaller effect during the Volcker-Greenspan-Bernanke era. The authors find a structural break in the oil price coefficients that matches the timing found by Hooker. Oil prices led to large and persistent increases in wage inflation samples prior to 1981, but had a negligible effect in samples after 1981.

The authors then check to see if inflation expectations have become better anchored by looking at the behavior of surveys of inflation expectations. In a Phillips curve-like equation, with inflation expectations on the left-hand side and oil price shocks and unemployment gaps on the right-hand side, the authors find a similar structural break in the oil coefficients, where oil prices led to large persistent increases in inflation expectations prior to 1981, but had no or little effect afterwards. These findings are consistent with an improved anchoring of inflation expectations.

The remainder of this paper is outlined as follows. Section 2 writes down a simple wage inflation Phillips curve and explains how an oil price shock affects wage inflation under different degrees of anchoring of inflation expectations. Section 3 presents estimates of wage inflation Phillips curve. Section 4 presents the inflation expectations estimates. Section 5 concludes.

SECTION 2: WAGE PHILLIPS CURVE MODELS

Workers negotiate wages increases through a bargaining framework. Since workers care about real wages, nominal wage inflation π^w, will in part depend on workers expectations of inflation, π^e, when wages are set. Conditions in the labor market will affect the degree of bargaining power of workers. During economic downturns, the unemployment rate, u, typically rises above the natural rate of unemployment, u^n. This creates a large pool of idle workers competing for relatively few available jobs and thus lowers their bargaining power. These factors can be expressed in a wage Phillips curve:

(1) $$\pi_t^w = \alpha + \pi_t^e - \beta(u - u^n)_t, \qquad \alpha, \beta > 0,$$

where $u - u^n$ represents the "unemployment gap" or difference between the actual unemployment rate and the natural rate of unemployment.

Assume that workers do not observe the current period's unemployment gap, but instead must estimate it based on two lags of the unemployment gap:

(2) $$(u - u^n)_t = \sum_{i=1}^{2} \eta_i (u - u^n)_{t-i} + \varepsilon_t,$$

where ε is a white-noise error term. Substitute this expression into (2) gives:

(3) $$\pi_t^w = \alpha + \pi_t^e - \beta \sum_{i=1}^{2} \eta_i (u - u^n)_{t-i} + \varepsilon_t.$$

Price inflation, π, is expressed as:

(4) $$\pi_t = \pi_t^w + g_t,$$

where g is the real growth rate of oil prices.

The degree in which oil price shocks affect wage inflation depend on the degree in which inflation expectations are anchored to the central bank's medium run inflation target, π*. To see this, suppose inflation expectations evolve as:

(5) $$\pi_t^e = \chi\pi^* + (1 - \chi) \sum_{i=1}^{4} \gamma_i \pi_{t-i}, \qquad 0 \le \chi \le 1, 0 \le \gamma \le 1.$$

Inflation expectations depend on a level of inflation desired by the central bank, π*, and four lags of inflation. χ represents the degree of central bank credibility. When the central bank is fully credible, χ equals 1 and the public's expectations are equal to π*. When the central bank completely lacks credibility, χ equals 0 and expectations depend on past observed inflation.

How might oil price shocks affect wage inflation under different eras of credibility? Consider the wage inflation equation given in (3). Substituting (4) and (5) into (3) gives:

(6) $\pi_t^w = \alpha + \chi\pi^* + (1-\chi)\sum_{i=1}^{4}\gamma_i(\pi_{t-i}^w + g_{t-i}) - \beta\sum_{i=1}^{2}\eta_i\,(u-u^n)_{t-i} + \varepsilon_t.$

As (6) shows, the degree in which oil price shocks affect wage inflation depends on degree in which expectations are anchored, which is given by χ. Oil price shocks will not affect wage inflation if expectations are perfectly anchored (χ equals 1 in this case). More specifically, regressions of wage inflation on lagged wage inflation, lagged unemployment gaps, and lagged oil price shocks will see larger coefficient estimates on oil price shocks during periods of low credibility, and smaller coefficient estimates on oil price shocks during periods of high credibility.

The authors run several different regressions with different specifications to test whether the decline in oil price pass-through can be explained by an improved anchoring of inflation expectations. The authors first look at the behavior of wage inflation by estimating (7) below:

(7) $\pi_t^w = \alpha + \sum_{i=1}^{4}\beta_i\pi_{t-i}^w + \sum_{i=1}^{2}\gamma_i UGAP_{t-i} + \sum_{i=1}^{4}\phi_i OIL_{t-i} + \delta NIXON_t + \varepsilon_t.$

The authors regress wage inflation on 4 lags of wage inflation, 2 lags of the unemployment gap (UGAP), 4 lags of oil price shocks (OIL), and dummy variables representing the Nixon wage and price controls (NIXON). This equation is analogous to (6). The authors check the stability of the oil price coefficients and see if a break occurs around the early 1980s, as found by Hooker. If inflation expectations became better anchored in the 1980s, oil prices should have a large, positive effect on wage inflation in the 1970s and a negligible effect afterwards.

A second way to check if inflation expectations have become better anchored is to estimate a Phillips-curve like equation with measures of inflation expectations on the left-hand side. This can be expressed as (8) below:

(8) $\pi_t^e = \alpha + \sum_{i=1}^{12}\beta_i\pi_{t-i} + \sum_{i=1}^{2}\gamma_i\, UGAP_{t-i} + \sum_{i=1}^{4}\phi_i OIL_{t-i} + \delta NIXON_t + \varepsilon_t.$

π^e is a measure of inflation expectations based on survey measures, π is the inflation rate, UGAP is the unemployment gap, and OIL is a measure of exogenous oil shocks. The authors check for the stability of the oil shock coefficients. If inflation expectations have become better anchored, a break in the oil coefficients should occur around 1980/81 as Hooker found. Oil shocks should have a larger effect on expectations before 1980 and a negligible effect afterwards.

SECTION 3: WAGE INFLATION ESTIMATION

The authors begin the empirical analysis by estimating the wage inflation Phillips curve as expressed in (7) above. Wage inflation is measured at the year-over-year annual rate by

splicing together the hourly earnings index (HEI) and the employment cost index (ECI) as constructed by the Bureau of Labor Statistics. The unemployment gap is measured as the difference between the unemployment rate and the Congressional Budget Office's estimate of the short-run natural rate of unemployment while oil prices are measured as the growth rate of the PPI crude oil measure adjusted by the growth rate of core PCE price index. The observations are quarterly and the sample period runs from 1966:I to 2007:IV. The authors purposely exclude observations after 2007 to avoid deflationary environment that came about due to the 2007-08 financial crisis.

The authors chose the ECI as our wage measure due to its superiority in measuring actual wage compensation to workers over more popular wage measures such as the non-farm business compensation per hour (BCH) or average hourly earnings (AHE). This is because the ECI measures the actual change in wages and salaries and excludes the effects of labor mobility among industries and occupations with different wages. It also excludes the effects of overtime compensation. The AHE and BCH simply divide the total wages and salaries of production workers by the total number of hours worked. This type of measuring introduces two types of biases in wage changes. First, if the number of overtime hours worked increases, BCH and AHE wages will increase making the appearance of an acceleration of wage inflation. Second, if workers leave a low wage industry and enter a high wage industry, it will also increase BCH and AHE wages, even if the wage level remains constant in both industries. The ECI corrects for both problems.

A limitation of the ECI is that it does not begin until 1975. This is problematic for the analysis since the focus is how the behavior of wage inflation changed before and after the 1970s. The series is spliced together with the HEI. The HEI also gives a more accurate estimate of the actual wage compensation received by workers. It takes the average hourly earnings from business surveys and adjusts the series to account for overtime compensation and employment movements into and out of high and low wage industries. These adjustments correct the biases that occur in the regular AHE and give a more accurate reflection of true wage movements.

Column 1 in table 1 show the results of estimating (7). The row Σ OIL gives the estimates of the sum of the oil price coefficients. The heteroscedasticity- and autocorrelation-consistent (HAC) standard errors are given in parentheses. The oil coefficients sum to 0.06 and are insignificant, revealing that over the entire sample period oil price shocks show no effect on wage inflation. Of course, the interest lies in whether oil price shocks affect wage inflation differently in the 1960s and 1970s compared the 1980s and after. To check for any differences, the authors check for the stability of the oil price coefficients by implementing the Andrews (1993, 2003) test across the middle 70 percent of the observations. Figure 2 plots the F-statistics from the Andrews test. There is a noticeably large spike in 1981:III. This date matches the date found by Hooker (2002) who found a similar spike with core inflation. See Figure 2 and Table 1 in the Appendix.

The authors use the date of the maximum F-statistic and modify (7) by including a dummy variable D associated with the break date $\hat{\tau}$ and interact it with the oil shock variable. The dummy variable D is defined as:

$$D = \begin{cases} 0, & t < \hat{\tau} \\ 1, & t \geq \hat{\tau} \end{cases}.$$

That is, the dummy-variable takes on the value of 0 before the break date and 1 in the year of the break and afterwards. Equation (7) then becomes:

$$(9)\ \pi_t^w = \alpha + \sum_{i=1}^{4} \beta_i \pi_{t-i}^w + \sum_{i=1}^{2} \gamma_i UGAP_{t-i} + \sum_{i=1}^{4} \phi_i OIL_{t-i} + \theta D + \sum_{i=1}^{4} \delta_i D * OIL_{t-i} + \rho NIXON_t + \varepsilon_t.$$

This dummy-interaction specification acts to split the equation into two time periods. The ϕ coefficients on the OIL term show the effects of oil shocks during the period prior to the break;

the sum of ϕ and δ coefficients on the OIL and D*OIL terms show the effects of the oil shocks during the post-break period.

Estimates of (9) are reported in column 2 of table 1. The sum of the oil price coefficients during the pre-break sample period are given in the Pre-Break Σ Oil row. The magnitude of the pre-break sum increases to 1.07 is significant. The post-break sum of the oil coefficients is given in the Σ Oil row. The magnitude is much smaller than in pre-break period at 0.05 and is not statistically significant. This result says that oil prices fed directly into wage inflation prior to 1981 but had no effect afterwards.

3.1 Alternative Oil Price Measures

The wage Phillips curve derived in (6) assumes that oil prices are exogenous to the U.S. economy. This assumption is crucial for a valid causal link of oil prices to wage inflation. However, not all oil price fluctuations can be treated as exogenous[1]. A long literature has emerged that tries to correctly identify exogenous oil prices and oil supply shocks. Papers by Hamilton (1996, 2003) and Lee, Ni, and Ratti (1995) argue that successful nonlinear transformations of oil prices can capture the exogenous components of oil price changes. Hamilton (1996, 2003) argues that oil price shocks will have a minimal impact on the economy if it is simply correcting for a recent price decline. He develops a non-linear transformation he calls the "net oil price increase" (NOPI). If the current quarter's oil price reaches a new three-year high (one-year high in his 1996 paper), the current quarter's oil price is calculated as the percent change from the previous three-year (one-year) high. If not, the current quarter's price becomes zero. Lee, Ni, and Ratti (1995) propose an alternative measure based on similar logic as the NOPI. They argue that oil price shocks will have a larger effect on the economy in a period when oil prices are stable as opposed to price shocks that are simply correcting previous price decreases. Their measure adjusts the oil price by dividing it by its conditional standard deviation.

Kilian (2009) argues that oil demand shocks are more important than oil supply shocks in understanding oil price movements and quantifies the arguments made in Barsky and Kilian (2002, 2004). He constructs a trivariate structural VAR that contains the percent change in global crude oil production, an index of global real economic activity based in international cargo shipping rates, and the real price of oil. He defines oil supply shocks as unpredictable innovations to global oil production. Aggregate demand shocks are defined as innovations to global real activity not attributable to oil supply shocks. Finally, movements in the price of oil not attributable to oil supply shocks or aggregate demand shocks are considered oil specific demand shocks. Intuitively, these can be thought of as precautionary oil demand based on uncertainty about future oil supply shortfalls. The importance of this paper is that Kilian finds that oil price shocks are largely a result of precautionary demand shocks, while oil supply shocks only cause small and short-lived movements in oil prices. This is counter to the conventional belief that oil price shocks are largely explained by oil supply disruptions.

The authors re-estimate (9) by replacing the oil price with exogenous measures of oil prices and other oil shocks with the 1981:III dummy variable . The results of Hamilton's NOPI,

[1] Hamiltion (1983, 1985) argues that oil prices were exogenous to the U.S. economy from 1948-72 since the U.S. was a net oil exporter and due to the strict regulatory environment of oil prices and oil production. Barsky and Kilian (2001) argue that oil prices became endogenous after 1972 once the U.S. became a net oil importer, leading regulatory agencies to lose their influence in stabilizing prices.

Lee et al.'s "variance-adjusted oil price shock" (VAOPI) and Kilian's "precautionary demand shock" (KPD) are presented in columns 3, 4, and 5 of Table 1, respectively. Notice how the general pattern is the same as estimates with the oil price. In the pre-break sample period, the sum of the oil coefficients is large and statistically significant. For each series in the post-break period, the oil coefficients sums fall drastically in magnitude and are insignificantly different from zero.

SECTION 4: INFLATION EXPECTATIONS

In this section, the authors look to see if inflation expectations have become better anchored over time by estimating Phillips curve-like equations with survey measures of inflation expectations on the left-hand side. The authors check to see if a break in the oil coefficients occurs and see if it matches the timing found in Table 1.

Economists have long recognized the importance of inflation expectations in the actual performance of inflation. The difficulty is that expectations are not directly measurable. Economists have since turned to surveys of consumers and of firms. A difficulty in using survey measures of inflation expectations is that long time series that include the 1970s are scarce. The University of Michigan's Survey of Consumers (SC) mean response survey is one series that does provide enough observations going back to the 1960s. The SC median response is arguably a more accurate series since it is robust to outliers, but the series does not begin until 1978. However, it is included it in the analysis for comparison purposes. The Survey of Professional Forecasters (SPF) 1-year forecasts of GDP deflator inflation also has observations going back to the 1970s. The authors include this series in the analysis as well.

The authors estimate the effects of oil price shocks on inflation expectations by estimating (8) from above. The initial estimates of contain real oil prices. Later comparisons are made to the exogenous oil shock series discussed earlier. All data are quarterly with the time periods varying depending on the availability of the data.

The odd-numbered columns in Table 2 display the results of estimating (8) for each of the survey measures of inflation expectations. The row Σ OIL gives the estimates of the sum of the oil price coefficients. The HAC standard errors are given in parentheses. Of the series reported, only the SC mean response shows a statistically significant effect of oil price shocks on expectations. The second to last row shows the sample period of each series. Notice the shorter sample of the SC median survey. The oil coefficients sum to a small number and the sum is not statistically significant. Based on the shorter sample period this provides evidence that expectations were well-anchored from the 1980s to the present. The SPF GDP deflator series begins in 1970, but shows no statistical significance between oil prices and expectations. See Table 2 in the Appendix.

The authors check for the stability of the oil coefficients by checking for a structural break across a sequence of possible break dates. Figure 3 plots the F-statistics across a range of break dates for the SC mean, SC median, and SPF GDP deflator. There is a distinct spike in 1980:II and in 1981:I for the SC mean survey. The SC median survey sees a large spike at 1983:I, the first date checked. The SPF GDP deflator sees several large F-statistics in the late 1970s, but also sees a large spike in 1981:I. These dates in the early 1980s are consistent with those found by Hooker. See Figure 3 in the Appendix.

Given the apparent instability in the oil coefficients, the authors modify (8) by including a dummy variable associated with the break date τ and interact it with the oil shock variable. The dummy variable takes the same form as used with the wage series in section 3. The modified equation is given in (10) below.

(10) $\pi_t^e = \alpha + \sum_{i=1}^{12} \beta_i \pi_{t-i} + \sum_{i=1}^{2} \gamma_i \, UGAP_{t-i} + \sum_{i=1}^{4} \phi_i OIL_{t-i} + \theta D + \sum_{i=1}^{4} \delta_i D * OIL_{t-i} + \rho NIXON_t + \varepsilon_t.$

The even-valued columns in Table 2 show the estimates of (10) with the dummy-interaction term. There is a noticeable difference for the SC mean and SPF GDP deflator surveys. The pre-break sum of the oil coefficients (given by the row Pre-break Σ Oil) both increase in magnitude by a large amount and are each highly significant. The post-break oil coefficient sums (given by the row Σ Oil) decreased in magnitude for both series and are insignificantly different from zero. These results show that oil shocks had a positive and significant effect on inflation expectations before 1980/81 but a negligible effect afterwards. This gives indication inflation expectations became better anchored somewhere around 1980/81.

The interaction term did not alter the results much for the SC median series. Although the pre-break oil coefficient sum was larger than the post-break sum, the large standard error shows that its value cannot be estimated with any great precision. This most likely can be attributed to fact that only five years of data are available for the pre-break portion. This leaves only two oil price spikes. The larger of the two in 1981 occurred while the SC median series was already declining.

The authors re-estimate (10) using the exogenous oil shock measures discussed previously. Table 3 shows the results for the SC mean survey. The pattern follows the one using real oil prices. The pre-break oil coefficient sums are larger in magnitude than for the post-break period for the RNOPI and VAOPI measures. Each pre-break oil coefficient sum and post-break coefficient sum is statistically significant for the RNOPI and VAOPI as well. This indicates that expectations remain sensitive to oil shocks, but has declined over time. For KPD, the pre-break coefficient sum is larger in magnitude than the post-break sum, but the coefficients are not significant. See Table 3 in the Appendix.

Table 4 reports the results for the SC median survey. Recall that since the sample period was small, the pre-break period only gave us a few observations and was difficult to find statistical significance. This same conclusion is found with the RNOPI. The pre-break and post-break oil coefficient sums are both relatively small and insignificantly different from zero. Remarkably the results for the VAOPI and KPD are different. In each case the pre-break oil coefficients sum to large, positive, significant values. The post-break coefficient sums are much smaller and insignificantly different from zero. See Table 4 in the Appendix.

The SPF GDP deflator survey in Table 5 reveals a similar pattern, but with somewhat weaker results. The pre-break oil coefficients are all significant and larger in magnitude than in the post-break samples, however, the RNOPI and KPD are marginally significant at the 10 percent level. The post-break coefficient sums are negative for each series and significant for the RNOPI. See Table 5 in the Appendix.

The results presented here are consistent with inflation expectations becoming better anchored over time. The timing of the structural break in the oil shock parameters matches those dates found by Hooker with core inflation and by me with wage inflation. Oil price shocks of the 1970s led to large and persistent effects on inflation expectations, while similar shocks afterwards show no significant response.

SECTION 5: CONCLUSION

The oil price shocks of the 1970s led to large and persistent movements in inflation. Similar sized shocks hit the economy during the 2000s, but inflation remained rather muted. Hooker (2002) found a one-time structural break in oil prices occurring in 1981 using a Phillips curve specification where oil prices fed directly into core inflation prior to 1981, but had no effect afterwards. In estimating a wage Phillips curve, a similar break in the oil price parameters is found that matches the timing found by Hooker. Oil prices fed directly into wage inflation prior to 1981, but had a negligible effect afterwards. The results are robust to alternative specifications of oil price shocks. Using surveys of inflation expectations, the authors find a similar break in the oil price parameters that matches the timing found with the wage inflation regressions. The findings support the hypothesis that improved anchoring of inflation expectations can explain the declining pass through of oil prices to inflation.

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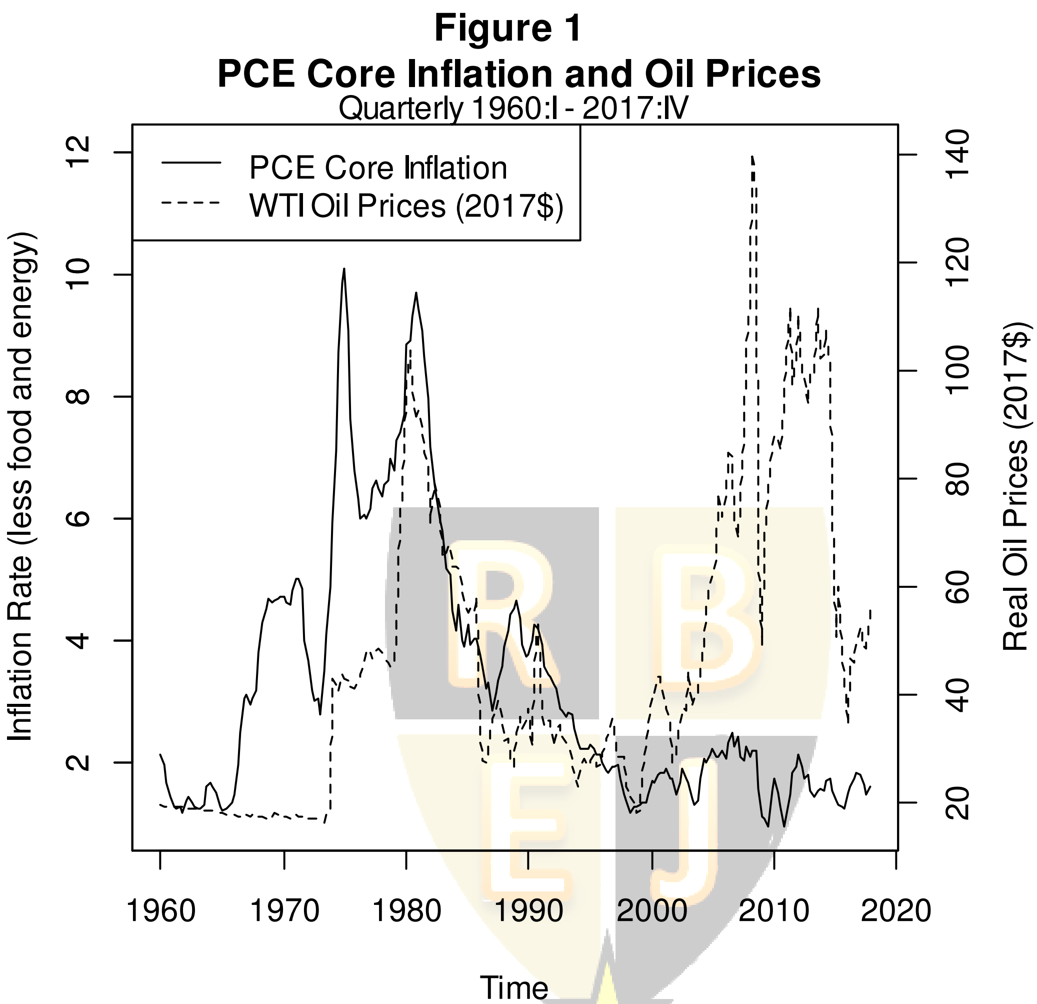
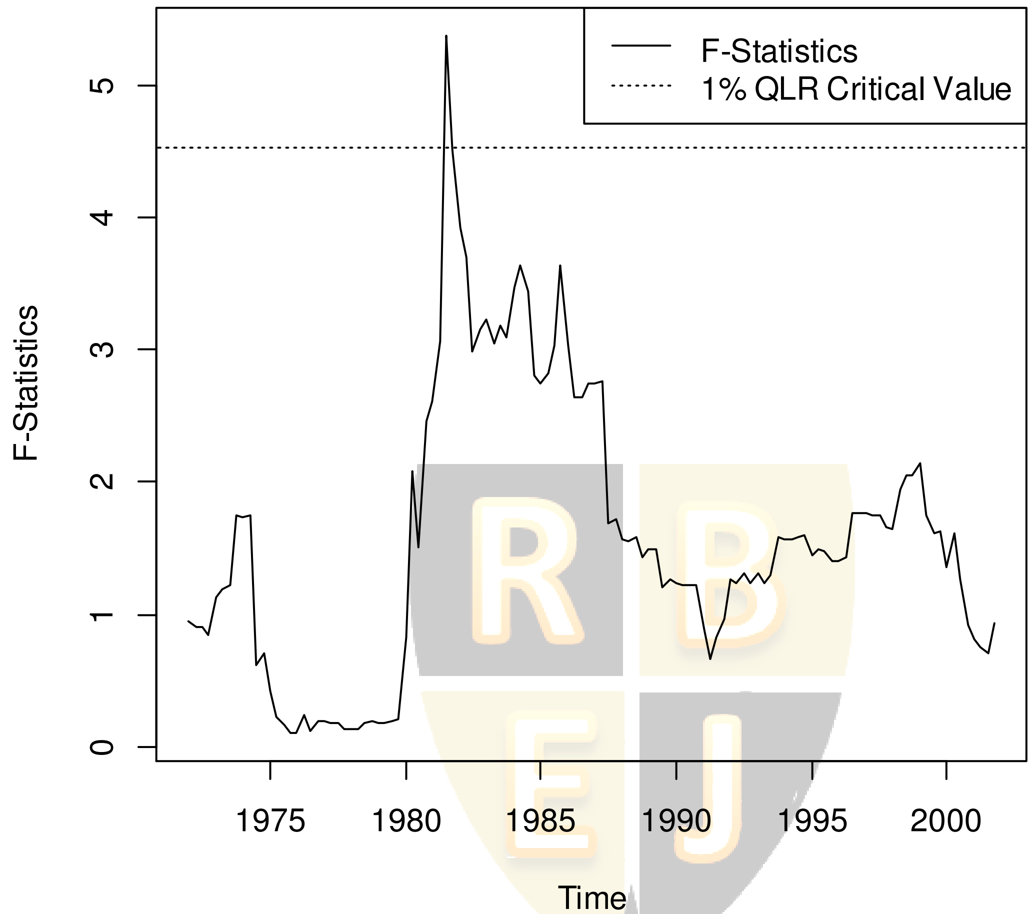
APPENDIX



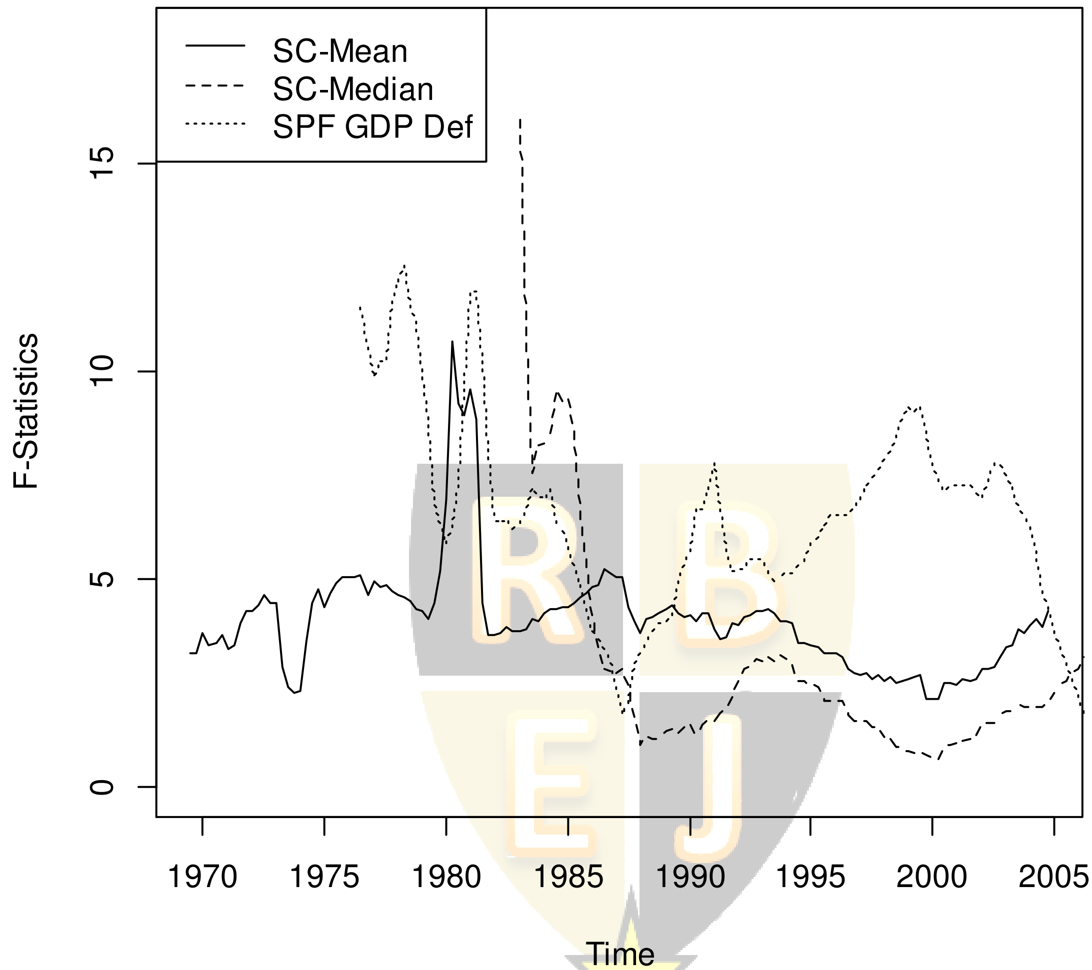
Notes: Figure 1 plots the core inflation rate against real oil prices. The inflation rate is measured as the growth rate of the PCE price index less food and energy. Real oil prices are expressed in 2017 dollars and are measured as the West Texas Intermediate spot price deflated by the PCE price index. Source: author's calculations.

Figure 2
F-Statistics



Notes: Figure 2 plots the F-statistics of the Andrews test for a structural break of the lagged oil price coefficients from estimating equation (3.1) using the HEI-ECI wage series.

Figure 3
F-Statistics



Notes: Figure 3 plots the F-statistics of the Andrews test for a structural break of the lagged oil prices from estimating equation (4.1) using the SC-mean, SC-median, and SPF GDP deflator inflation expectation series.

Table 1: HEI-ECI Wage inflation

	PPI Crude Oil		RNOPI	VAOPI	KPD
	(1)	(2)	(3)	(4)	(5)
Pre-Break		1.07***	5.53***	0.36***	1.14**
Σ Oil		(0.26)	(1.40)	(0.07)	(0.49)
Σ Oil	0.06	0.05	-0.44	0.06	0.07
	(0.06)	(0.07)	(0.80)	(0.06)	(0.13)
Break Date		1981:III			
AIC	87.2	71.4	75.9	58.9	47.2
Adj. R^2	0.98	0.98	0.98	0.98	0.98
SER	0.30	0.28	0.29	0.27	0..27
Sample Period	1966:I-2007:IV		1966:I-2007:IV	1966:I-2007:IV	1976:III-2007:IV

Notes: HAC standard errors are in parentheses, except for SupF statistics which contains the asymptotic p-values of the Andrews test as constructed by Hansen (1997). The initial results from column 1 regresses ECI-HEI wage inflation on 4 lags of wage inflation, 2 lags of the unemployment gap, and 4 lags of the oil price measure. Columns 2 through 6 include dummy interaction terms on the oil shock measure using the break date reported.

Table 2: Survey Measures of Inflation Expectations

	Michigan SC Mean Response		Michigan SC Median Response		SPF GDP Deflator	
	(1)	(2)	(3)	(4)	(5)	(6)
Pre-break Σ Oil		7.4*** (1.5)		0.38 (0.75)		4.78*** (0.66)
Σ Oil	0.50** (0.25)	0.24 (0.15)	0.00 (0.22)	-0.04 (0.14)	-0.04 (0.18)	-0.29 (0.31)
Break Date		1981:I		1983:I		1981:I
AIC	543.4	497.2	298.8	243.2	339.8	290.8
Adj. R^2	0.77	0.83	0.84	0.90	0.89	0.92
SER	1.01	0.88	0.78	0.61	0.69	0.58
Sample Period	1962:II-2007:IV		1978:I-2007:IV		1970:I-2007:IV	

Notes: HAC standard errors are in parentheses, except for SupF statistics which contains the asymptotic p-values of the Andrews test as constructed by Hansen (1997). Regressions in the odd-numbered columns regresses inflation expectations on 12 lags of inflation, 2 lags of the unemployment gap, and 4 lags of the oil shock measured as the growth rate of the PPI crude oil index relative to the core PCE index. Even-numbered columns include dummy-interaction terms with the oil shock measure for the break date given.

Table 3: Inflation Expectations UM Survey of Consumers Mean Response

	RNOPI (1)	VAOPI (2)	KPD (3)
Pre-break	0.41**	2.2***	2.1*
Σ Oil	(0.10)	(0.28)	(1.6)
Σ Oil	0.03**	0.26**	0.21
	(0.04)	(0.15)	(0.22)
Break Date	1981:I	1981:I	1981:I
AIC	509.9	498.1	276.1
Adj. R^2	0.82	0.83	0.91
SER	0.91	0.88	0.65
Sample Period	1962:II-2007:IV	1962:II-2007:IV	1976:I-2007:IV

Notes: HAC standard errors are in parentheses, except for SupF statistics which contains the asymptotic p-values of the Andrews test as constructed by Hansen (1997). Regressions in the odd-numbered columns regresses inflation expectations on 12 lags of inflation, 2 lags of the unemployment gap, and 4 lags of the oil shock measure. Even-numbered columns include dummy-interaction terms with the oil shock measure for the break date given.

Table 4: Inflation Expectations UM Survey of Consumers Median Response

	RNOPI (1)	VAOPI (3)	KPD (4)
Pre-break	0.00	0.75***	5.53***
Σ Oil	(0.04)	(0.25)	(0.79)
Σ Oil	0.01	0.06	0.05
	(0.02)	(0.13)	(0.13)
Break Date	1983:I	1983:I	1983:I
AIC	243.5	237.3	181.2
Adj. R^2	0.90	0.91	0.94
SER	0.61	0.59	0.47
Sample Period	1978:I-2007:IV	1978:I-2007:IV	1978:I-2007:IV

Notes: HAC standard errors are in parentheses, except for SupF statistics which contains the asymptotic p-values of the Andrews test as constructed by Hansen (1997). Regressions in the odd-numbered columns regresses inflation expectations on 12 lags of inflation, 2 lags of the unemployment gap, and 4 lags of the oil shock measure. Even-numbered columns include dummy-interaction terms with the oil shock measure for the break date given. Regressions using RNOPI, NNOPI, and VAOPI include dummy variables to account for the Nixon wage and price controls.

Table 5: Survey of Professional Forecasters: GDP Deflator

	RNOPI (1)	VAOPI (3)	KPD (4)
Pre-break	0.29***	1.09**	1.39*
Σ Oil	(0.07)	(0.14)	(0.84)
Σ Oil	-0.11***	-0.13	-0.27
	(0.04)	(0.13)	(0.18)
Break Date	1981:I	1981:I	1981:I
AIC	370.0	310.0	261.0
Adj. R^2	0.92	0.90	0.91
SER	0.54	0.62	0.61
Sample Period	1962:II-2007:IV	1962:II-2007:IV	1976:I-2007:IV

Notes: HAC standard errors are in parentheses, except for SupF statistics which contains the asymptotic p-values of the Andrews test as constructed by Hansen (1997). Each column shows results of regressing inflation expectations on 12 lags of inflation, 2 lags of the unemployment gap, and 4 lags of the oil shock measure along with dummy-interaction terms with the oil shock measure for the break date given. Regressions using RNOPI, NNOPI, and VAOPI include dummy variables to account for the Nixon wage and price controls.