ECONSTOR
Make Your Publications Visible.

A Service of
ZBW
Leibniz-Informationszentrum Wirtschaft
Leibniz Information Centre for Economics

Pollan, Wolfgang

Working Paper

Inflation Persistence or the Protracted Effects of Commodity Price Changes?

WIFO Working Papers, No. 451

Provided in Cooperation with:
Austrian Institute of Economic Research (WIFO), Vienna

Suggested Citation: Pollan, Wolfgang (2013) : Inflation Persistence or the Protracted Effects of Commodity Price Changes?, WIFO Working Papers, No. 451, Austrian Institute of Economic Research (WIFO), Vienna

This Version is available at:
https://hdl.handle.net/10419/128981

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

WWW.ECONSTOR.EU

Mitglied der Leibniz-Gemeinschaft

WIFO
ÖSTERREICHISCHES INSTITUT
FÜR WIRTSCHAFTSFORSCHUNG

WORKING PAPERS

Inflation Persistence or the Protracted Effects of Commodity Price Changes?

Wolfgang Pollan

451/2013

WIFO
ÖSTERREICHISCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG
AUSTRIAN INSTITUTE OF ECONOMIC RESEARCH

Inflation Persistence or the Protracted Effects of Commodity Price Changes?

Wolfgang Pollan

WIFO Working Papers, No. 451

June 2013

Abstract

This paper explores the question to what extent non-domestic factors provide an explanation of US inflation over the last three decades. Are lagged dependent variables – traditionally interpreted as proxies for inflation expectations – just proxies for oil and commodity prices? To answer this question a simple Phillips curve, which includes energy prices, is estimated for the USA. The results show that crude oil prices, which basically are world market prices, have exerted a strong influence on inflation, while the effects of domestic factors, such as the unemployment rate, have become weaker. These findings help to resolve a puzzle of recent years: given the sharp rise in unemployment, why has inflation not slowed down as much as predicted by the traditional Phillips curve analysis? Furthermore, the empirical results assign a much feebler role to expectations in the inflation process; if indeed inflation is a global phenomenon, the task of controlling inflation expectations by monetary policy may not be as crucial as implied by central banks statements pointing to the importance of anchoring inflation expectations. Are the actions of central banks nothing more than a sideshow?

E-mail address: Wolfgang.Pollan@wifo.ac.at
2013/235/W/0

© 2013 Österreichisches Institut für Wirtschaftsforschung
Medieninhaber (Verleger), Hersteller: Österreichisches Institut für Wirtschaftsforschung • 1030 Wien, Arsenal, Objekt 20 •
Tel. (43 1) 798 26 01-0 • Fax (43 1) 798 93 86 • http://www.wifo.ac.at/ • Verlags- und Herstellungsort: Wien
Die Working Papers geben nicht notwendigerweise die Meinung des WIFO wieder
Kostenloser Download: http://www.wifo.ac.at/wwa/pubid/46820

Inflation Persistence or the Protracted Effects of Commodity Price Changes?

By Wolfgang Pollan

Abstract

This paper explores the question to what extent non-domestic factors provide an explanation of US inflation over the last three decades. Are lagged dependent variables – traditionally interpreted as proxies for inflation expectations – just proxies for oil/commodity prices? To answer this question a simple Phillips curve, which includes energy prices, is estimated for the United States. The results show that crude oil prices, which basically are world market prices, have exerted a strong influence on inflation, while the effects of domestic factors, such as the unemployment rate, have become weaker. These findings help to resolve a puzzle of recent years: Given the sharp rise in unemployment, why has inflation not slowed down as much as predicted by the traditional Phillips curve analysis? Furthermore, the empirical results assign a much feebler role to expectations in the inflation process; if indeed inflation is a global phenomenon, the task of controlling inflation expectations by monetary policy may not be as crucial as implied by central banks statements pointing to the importance of anchoring inflation expectations. Are the actions of central banks nothing more than a sideshow?

Keywords: Commodity prices, expectations, inflation, monetary policy, Phillips Curve

JEL codes: D840, E120, E130, E310, E320, F410

Geographic Descriptors: U.S.

Inflation Persistence or the Protracted Effects of Commodity Price Changes?

By Wolfgang Pollan

Summary

The popular as well as the financial press has linked consumer price inflation in recent years to movements in crude oil prices, an interpretation supported by a large body of economic literature. Nonetheless, some US studies of inflation have persisted to focus on domestic cyclical factors to the neglect of world-wide developments, with implications for economic policy: The finding of strong inflation persistence, interpreted as inflation expectations, assigns an important role to monetary policy in anchoring inflation expectations. But if, at the empirical level, lagged dependent variables in the accelerationist version of the Phillips curve just pick up the effects of delayed oil/commodity prices, the task of controlling inflation expectations becomes less important.

There is great diversity in the course of oil/commodity prices over the last four decades: first, sharp rises to higher levels during the first and second oil price shocks; then the collapse of the oil price in 1986 and the subsequent tranquil period, called the Great Moderation, ending in 2005. This pattern suggests *prima facie* that oil/commodity prices played an important part, first in boosting inflation to the highest rates in post-war history, then in providing a rather stable environment on the cost side of inflation. Thus, the post-1970 years should be viewed as two different periods that have little in common.

If oil prices are introduced into the Phillips-curve as an explanatory variable their influence is found to be strong and to extend over several quarters. This influence comes at the expense of lagged dependent variables, which have been interpreted as proxies for inflation expectations. The sum of the coefficients of the expectations variables is far below unity, indeed close to zero if the periods of the first and second oil shocks are excluded from the analysis.

This result, if taken at face value, assigns a much feebler role to expectations in the inflation process. And as a consequence, the task of controlling inflation expectations by monetary policy may be not as important as implied by statements issued by central banks in the United States and in Europe which point to the importance of anchoring inflation expectations. Are the actions of the central bank nothing more than a sideshow? (pace, *Friedman,* 2009, p. 282)

The results of the empirical analysis assign a great role to factors that are external to the US economy and a small role to domestic factors such as the rate of unemployment. The strong impact of world economic factors on US inflation and economic activity raises the question

to what extent US monetary policy is still able to control inflation, limitations of national monetary policy recently acknowledged by *Bernanke* (2008): "Rapidly rising prices for globally traded commodities have been the major source of the relatively high rates of inflation we have experienced in recent years, . . .".

Inflation is a global phenomenon, with commodity prices as one of the main channels. Thus, national central banks, whether the Fed or the European Central Bank, will find it harder than in earlier periods to restrain inflation. The counterpart of the globalisation of inflation is the globalisation of deflation, with the reach of monetary policy also severely limited.

Introduction

The rapid rise in the price of oil and other raw material prices in 2008 and the steep decline at the beginning of 2009 and the corresponding rise and drop in the inflation rate in the OECD countries have made it obvious to most commentators and analysts that movements in the prices of raw materials exert a strong influence on inflation. References to the connection between, say, the current low inflation rate in the OECD and the drop of oil prices on a year-to-year basis can be found in any newspaper column commenting on inflation.

International organisations, such as the OECD, the IMF, the EU as well as national research institutes in Europe[1] have again and again pointed to the strong impact of the surge in commodity prices on economic activity and inflation. The title of an analysis by the IMF: "Is inflation back? Commodity prices and inflation" (*IMF,* 2008, pp. 83-128) well illustrates the concern about (continuing) inflation risks arising from large increases in commodity prices.

It seems that the economic profession is lagging behind in acknowledging the importance of raw material prices for inflation. To be sure, practitioners of economic analysis, with the two energy shocks (1974-75 and 1979-1981) and the collapse of the oil market in 1986 in mind, have paid close attention to forecasts of raw material prices[2]. Perhaps the tendency to incorporate world-wide developments into economic forecasts was more pronounced in Europe, where even the larger economies are seen as just a small part of the word economy, than in the United States, where the idea seemed to linger on that US economic events tend to influence economic developments in other economies but not vice versa.

Instead of focusing on external factors such as raw material prices and exchange rates, some US studies of inflationary phenomena persist on relying on domestic cyclical factors such as unemployment and the gap between potential and actual output and thus are unable to explain why the sharp rise in unemployment in recent years has not pushed the rate of

[1] Pain et al. 2008, European Central Bank (August 2010, November 2010, December 2011), Cechetti et al. 2008; IMF, 2008, Barrel, R., Pomeranz, O., 2008; *Álvarez et al.* (2010).

[2] See the *OECD, Economic Outlook* (2008, 2009, 2011, 2012).

inflation towards zero. At the economic policy level as well, the idea that the US economy is basically a closed economy still seems to inform policy makers' assessment of the appropriate course of monetary policy with regard to inflation[3].

In 2005, Kohn, vice-president of the FED, criticised the lack of attention to external factors:

One category of neglected factors is price shocks – changes in the level of key inputs, such as energy or imports. . . . Yet, despite their historical importance of aggregated inflation, energy prices, for example, are controlled for in only one of the structural models discussed at this conference. And this importance is not necessarily a concern of the past: Prices for oil and natural gas have soared since 2003, directly boosting the energy components of the consumer price index as well as raising the production costs, and ultimately to at least some degree the prices, of nonenergy goods and services. As a policymaker, I can assure you that any model of inflation that did not take account of these effects, and how they might or might not affects ongoing rates of inflation, would have been of little practical use to the FOMC over the past few years[4].

One of the standard economic constructs linking inflation to other economic factors is the Phillips curve and its derivative, the NAIRU, whose basis is the requirement of a one-for-one effect of inflation expectations on price and wage setting, ie., that the sum of the coefficients of inflation expectations sum to unity in a Phillips curve equation. It is perhaps here that the neglect of world-wide economic factors is most salient: Some contributions to the Phillips-curve and NAIRU literature have ignored the effects of oil price shocks on economic activity and inflation (recent papers include *Kamenik et al.,* 2013, *Ball – Mazumder,* 2011, *Cogley – Sbordone,* 2008, *Coibon – Gorodnichenko,* 2011, *Hall et al.,* 2009, *Hall,* 2011); if commodity prices are taken into account at all, they are introduced into the analysis in a simplistic manner via (real or nominal) import prices or by dummies (*Akerlof et al.,* 2000, *Batini et al.,* 2005, *Eickmeir – Moll,* 2009, *Fair,* 2000, *Fuhrer – Olivei,* 2010, *Fuhrer et al.,* 2012, *Moccero et al.,* 2011, *Pain et al.,* 2008).

[3] For example, *Bullard* (2012), president of the Federal Reserve Bank of St. Louis, argues "that the output gap in the U.S. is not as large as commonly believed . . . This helps explain . . . why U.S. inflation has remained close to target instead of dropping precipitously . . ." In the same context, Federal Reserve Bank of Atlanta President D. Lockhart (2012) infers from the persistently positive rate of inflation that slack in the economy cannot have been as high as estimated by some analysts.

[4] This criticism echoes a remark by *Nichols* (1982, pp. 153-155) made two decades earlier: "Analyses of U.S. inflation by American economists often surprise European observers by their lack of attention to international issues." See also *Meade – Thornton* (2012) who document the increasing skepticism of the members of the Federal Open Market Committee with regard to the Phillips curve and the frustration over the lack of an alternate inflation model.

The extended Phillips curve

According to the mainstream view of macroeconomics, the Phillips curve remains an important concept in business cycle models, both theoretically and empirically (*Ball – Mankiw,* 2002, *Blinder,* 1997). *Phelps* (1967) and *Friedman* (1968) challenged the idea that government faced a trade-off between inflation and unemployment and modern versions of the model contain an expected inflation term on the right hand side of an equation describing the current rate of wage or price inflation. The demand and supply of labour depends on changes in real wages and not money wages. In wage bargaining, workers, being only interested in real wage developments, will try to anticipate future price increases in order to protect their real wage.

Equilibrium can only be obtained when the inflation expectations of workers turn out to be correct. At the market clearing rate, all workers who are willing to take jobs at the prevailing real wage are employed. This rate has been termed the 'equilibrium' (*Phelps,* 1967) or 'natural rate of unemployment' (*Friedman,* 1968) or 'structural unemployment' or, in empirical applications, the 'non-accelerating-inflation rate of unemployment' or NAIRU. If the actual rate of unemployment is below this baseline rate, inflation tends to accelerate over time; if it is above this rate, inflation tends to slow down.

A standard formulation of the inflation – unemployment trade-off is an expectations-augmented Phillips curve of the form:

(1) $\Pi_t = \Pi^e + \alpha - \beta u_t + \gamma z_t + \varepsilon_t$

where t is the time period, Π_t and Π^e denote the realised and expected rate of inflation, u is the rate of unemployment, and z is a vector of supply shift variables (with a mean equal to zero), and ε_t is an error term. A key restriction of equation (1) is that the coefficient of the expected inflation term is unity, a condition called the dynamic homogeneity condition or Friedman's policy invariance proposition.

According to the adaptive expectations hypothesis (*Friedman*, 1968), inflation expectations are formed adaptively as a weighted average of recent inflation rates; in the simplest case, this process takes the following form:

(2) $\Pi^e = \Pi_{\tau-1}$.

A reformulation yields

(3) $\Pi_t = \Pi_{\tau-1} - \beta(u_t - u^*) + \gamma z + \varepsilon_t$

where $u^* = -\alpha/\beta$ *and* is termed the NAIRU.

Another approach argues that in the long run expectations are rational, i.e., forecasts are not systematically biased, or the average of expected inflation is equal to the average of actual inflation (*Lucas,* 1972, *Ball – Mankiw,* 2002, p. 118).

Inflation is negatively related to deviations of the unemployment rate from its natural rate: If the actual rate of unemployment is below this baseline rate, inflation tends to accelerate over time; if it is above this rate, inflation tends to slow down. The entire curve shifts one-for-one with changes in Π^e. Aside from short-term changes due to z_t and ε_t, the rate of inflation will not change ($\Pi_t - \Pi_{\tau-1} = 0$), if u equals u^*. In the long-run, the relationship between inflation and unemployment is vertical at the natural rate of inflation.

Purpose of study

This paper explores the question to what extent external factors can provide an explanation of the US inflation rate over the last three decades. In particular, to what extent are lagged dependent variables – traditionally interpreted as proxies for inflation expectations – just proxies for oil/commodity prices. For this purpose a simple Phillips curve, which includes energy prices as supply shocks, is estimated for the United States.

The results show that energy prices have exerted a strong influence on inflation, while the effects of domestic factors, such as the unemployment rate, have become weaker: Given the hike of energy prices in the years since 2005, there is no contradiction between a persistently positive rate of inflation and the high unemployment rate; this constellation is rather a mild manifestation of stagflation as experienced in the seventies.

Furthermore, the persistence of inflation found in several studies is largely due to the delayed effects of energy prices and not to the fact that inflation expectations are guided by past inflation rates. When prices of crude oil are introduced into the regression the sum of the coefficients of past inflation rates is far below unity. This result runs counter to the hypothesis that the Phillips curve is vertical, thus undermining the basis of the NAIRU analysis.

This paper is organised as follows. The first section reviews the literature of the impact of oil price shocks on inflation and economic activity: changes in oil prices on consumer price inflation are drawn out over time. The variables used in the empirical part are specified in the next section. The dependent variables are headline and core inflation according to the Consumer Price Index, with the lagged dependent variable as a four-quarter-moving average of rate of change serving as proxies for inflation expectations. Commodity and oil prices are represented by the spot oil price; a review of the development of crude oil prices draws attention to the difference in the time path during the first and the second oil price shock on the one hand and the subsequent years on the other, differences which can be expected to have repercussions on the impact of crude oil prices on inflation and on how inflation expectations were formed.

Section 3 contains the regression results of Phillips curves for headline and core inflation. These regressions which explore various specifications involving prices of crude oil are run for the period from 1973 (the year before the first oil shock) to 2010, for the period excluding the two oil price shocks (1982-2010) as well for the short period covering both oil shocks (1973-1981). Most of the equations are based on quarterly data, though some results based on yearly data are also presented. The final section contains conclusions and some suggestions as to carry out a more detailed and sophisticated empirical analysis.

The impact of oil price shocks on inflation and economic activity

Interest in this topic has been revived at the academic as well as at the level of international economic organisations in recent years (*Blanchard – Gali,* 2007, *Blinder – Rudd,* 2008, *Cecchetti – Moessner,* 2008, *Hamilton,* 2009, *Kilian,* 2008, 2009, *Lizardo – Mollick,* 2010; and the

literature cited in note 1.) and has produced a number of studies dealing with the impact of commodity price surges on economic activity and inflation. Economic historians will also remember the first and second oil price shocks, which were then analyzed under the heading of supply shocks (e.g. *Blinder – Rudd,* 2008, and the literature cited there).

The effects of commodity price changes on consumer prices can conveniently be characterised as direct and indirect effects (*ECB,* August 2010). The pass-through of changes in commodity price changes to retail prices take time. While the direct effects of oil price increases show up rather quickly in higher energy prices charged consumers, indirect effects that occur as a result of the impact of oil prices on productions costs (such as in the production of chemical, pharmaceutical goods, food stuff and transport services) are transmitted with a longer delay. According to *IMF* (2008) estimates, oil price changes are transmitted with an average lag of 9 to 12 months, while the propagation lag of food prices is considerably longer. And then there may be second-round effects as economic agents attempt to compensate for the loss of real income caused by past inflation[5]. Clearly, fossil fuel/commodity intensity as well as policy feedback rules matter a great deal in the transmission of commodity price changes to the consumer over time (*Barrel – Pomerantz,* 2008, *IMF,* 2008).

In sum, the literature on the macroeconomic effects of oil price shocks clearly establishes that these effects are drawn out over time; that is, a change in commodity prices at time t will not only affects consumer prices at time t, but also at time t+1, t+2, etc. As a result, if the basis of analysis are quarterly data, the change in retail prices in one quarter will be strongly correlated with the change in retail prices in subsequent quarters, effects that cannot be captured by simply introducing a quarter-on-quarter change in commodity prices into a Phillips-curve analysis[6].

Specification of variables

Price variables

This paper uses the regular series of consumer price indices in two variations, the headline index (Consumer Price Index, CPI) and the index excluding food and energy, the so-called core index (CPILFE). Other studies employ the PCE or a corrected consumer price index in the search for a good fit. But the use of indices that are not currently available seems to be misguided: Given the great importance that inflation expectations play in the extended Phillips curve and given that proxy variables for these expectations are constructed from consumer price indices, it seems important to use those price indices that are available to the public at the time expectations are formed, i.e. statistics that consumer, employers and

[5] *Nordhaus* (2007) puts the indirect effects at 80 percent of direct effects.

[6] This problem is, of course, less acute in a yearly Phillips-curve model.

employers' associations, wage earners and trade unions consider in their decisions, not some constructs put together by statisticians and economists *ex post*, such as the GDP deflator or the PCE[7].

The lagged dependent variable

In the Phillips curve literature it is standard practice to proxy inflation expectations with lagged values of inflation; indeed the focus of this paper is to investigate how the sum of the estimated coefficients of the lagged dependent variable change when commodity prices are included as explanatory variables. Rather than estimating many unconstrained coefficients, this paper follows Gordon's lead (*Gordon,* 1997, p. 20) and enters the lagged dependent variable as a series of four-quarter moving averages of rates of change[8]. This procedure will also be used in the construction of the oil price variable.

Explanatory variables

Commodity and oil prices

The basic time series used in this paper to represent world-wide phenomena are the price of oil as measured by the spot oil price: West Texas Intermediate as well as raw material prices according to the widely used HWWI index[9]. Other studies have used nominal and real import prices for this purpose[10].

There are two reasons for preferring raw material prices over import prices. First, if a country is autarchic, say, in crude oil supplies, i.e., does not import crude oil or oil products at all, movements in crude oil prices will not enter the import price index, save in an indirect way through imported energy-intensive products. Thus, the wide swings in oil prices will not be fully reflected in this explanatory variable. Nonetheless, in an economy which is open to international trade (and does not regulate prices of energy products in the fashion of, say, China or Egypt) domestic oil prices will rise and fall *pari passu* with prices in international

---

[7] Even farther removed from the CPI or core inflation is a statistic used by *Ball – Mazumder* (2011) to measure core inflation: a weighted median of consumer price inflation across industries. And supply shocks are measured by total CPI inflation minus median inflation.

[8] A similar procedure is employed by *Akerlof et al.* (2000).

[9] *HWWI Consult GmbH,* 2010. The HWWI (total, all commodities) employs the following weighting of commodity groups: food 5,5 percent, industrial raw materials 15,4 percent, energy raw materials 79,2 (of which coal 4,5 percent, crude oil 74,6 percent).

[10] Real import prices: While real, i.e., relative prices, are the proper variables in the input decision in production, they have no role to play in the explanation of inflation,which is a nominal variable. In practice, the choice of nominal versus real variables (nominal import or commodity prices deflated by some aggregate price index such as the GDP deflator or the CPI) makes very little difference, because commodity prices fluctuate a great deal relative to the deflator used.

markets even if oil and oil products are not imported at all[11]. If oil market prices are truly world market prices the 'Law of one price' applies: Except for transportations costs, traded commodities must sell for the same price within the United States as outside.

Second, the import share of oil products may change over a time period of several decades; as a result, the import price index, unless corrected for this compositional effect, may indicate a rising or falling impact of world market prices on domestic inflation.

Econometric issues

Many Phillips-curve analyses employ quarterly models, with the dependent variable and the independent variables transformed by taking quarter-on-quarter relative changes. This transformation eliminates longer-term trends. This does not matter much when the variable in question is a slow-moving variable, such as the consumer price index, but this transformation may create a rather erratically fluctuating variable, when medium/long-term fluctuations are pronounced. This is the case with oil/commodity prices: eliminating the medium/long-term trend eliminates exactly that feature to which the delayed effects on the price index are due.

When the oil price series is transformed by taking quarter-on-quarter relative changes a completely different picture emerges: the spike of the first oil price shock (1974:1) is just slightly larger than the downward spike (in absolute value) produced by the (short-lived) collapse of the oil price at the end of 2008; and the spike produced by the second oil price shock (1979:3) is smaller than the price hike produced by the first Iraq war (1990:3).

The approach used here to incorporate the longer-term swings in oil/commodity prices into the explanatory variable follows the procedure used by *Gordon* (1997, p.20) to estimate the impact of past inflation rates (as proxies for inflation expectations): the oil price variable is represented by 4-quarter averages of past quarterly inflation rates (where quarterly inflation rates are defined as quarter-on-quarter (logarithmic) changes). As noted, the same procedure is also applied to the consumer prices index to generate lagged dependent variables.

Unemployment

The procedure of estimating a time-varying natural unemployment rate has been pioneered by R. Gordon and applied by many economists estimating a Phillips-curve, with the goal of extract long-term shifts in the unemployment-inflation relation from the data. In view of the many discretionary choices to be made in estimating a time-varying unemployment rate and in view of the reported decrease in the reagibility of inflation to changes in economic activity

[11] There is also a demand effect that in addition to the cost effect of rising oil prices will tend to raise domestic prices. Domestic producers of energy will reap windfall gains from the price hike and will be inclined to expand investment in energy production, adding to aggregate demand. This is effect is likely to be more pronounced in energy-autarkic economies than those relying strongly on energy imports. The reverse effects will hold when energy prices decline.

(instability issue)[12], a simpler approach, that has been suggested by *Ball – Mankiw* (2002), has been chosen in this paper: to extract the long-term trend from actual unemployment data the Hodrick-Prescott filter (*Hodrick – Prescott,* 1997) has been employed (with a smoothing parameter of 1600);[13] this trend is then used as the NAIRU or U*. Deviations from U* are then entered into the Phillips curve (unemployment – U*). *Ball – Mankiw* (2002, pp. 122-123) suggests that the H-P trend is close to the path of the time-varying natural unemployment rate. A similar result is reported by *Claar* (2006). The H-P approach also has the advantage of easy replicability.

Notation

M4CPI: 4-quarter moving average of quarter-on-quarter logarithmic change = $\frac{1}{4}*(\Delta lnCPI_t + \Delta lnCPI_{t-1} + \Delta lnCPI_{t-2} + \Delta lnCPI_{t-3}) = \frac{1}{4}*(lnCPI_t - lnCPI_{t-4})$, where ΔlnCPI is the quarter-on-quarter logarithmic change

M4CPI(-4): $M4CPI_{t-4}$

similarly for

M4CPILFE: $\frac{1}{4}*(lnCPILFE_t - lnCPILFE_{t-4})$,

M4CPILFE(-4): $M4CPILFE_{t-4}$

M4WTI: $\frac{1}{4}*(lnWTI_t - lnWTI_{t-4})$

M4WTI(-4): $M4CPI_{t-4}$

UNCYC: UNRATE – U* (Unemployment rate minus the unemployment rate smoothed by the Hodrick-Prescott filter with a smoothing parameter of 1600 for quarterly data, and of 100 for yearly data. The H-P filter was computed over the period 1970 to 2010).

Data Sources

FRED, Federal Reserve Economic Data, Federal Reserve Bank of St. Louis, http://research.stlouisfed.org/:

UNRATE: Civilian Unemployment Rate (UNRATE), U.S. Department of Labor: Bureau of Labor Statistics;

CPI: Consumer Price Index for All Urban Consumers: All Items (CPIAUCNS), U.S. Department of Labor: Bureau of Labor Statistics;

CPILFE: Consumer Price Index for All Urban Consumers: All Items less Food and Energy (CPILFENS), U.S. Department of Labor: Bureau of Labor Statistics;

WTI: Spot Oil Price: West Texas Intermediate, (OILPRICE), Dow Jones & Company,

FRED accessed February 23, 2011.

HWWI Consult GmbH, 2010:

HWWI: HWWI (total, all commodities).

---

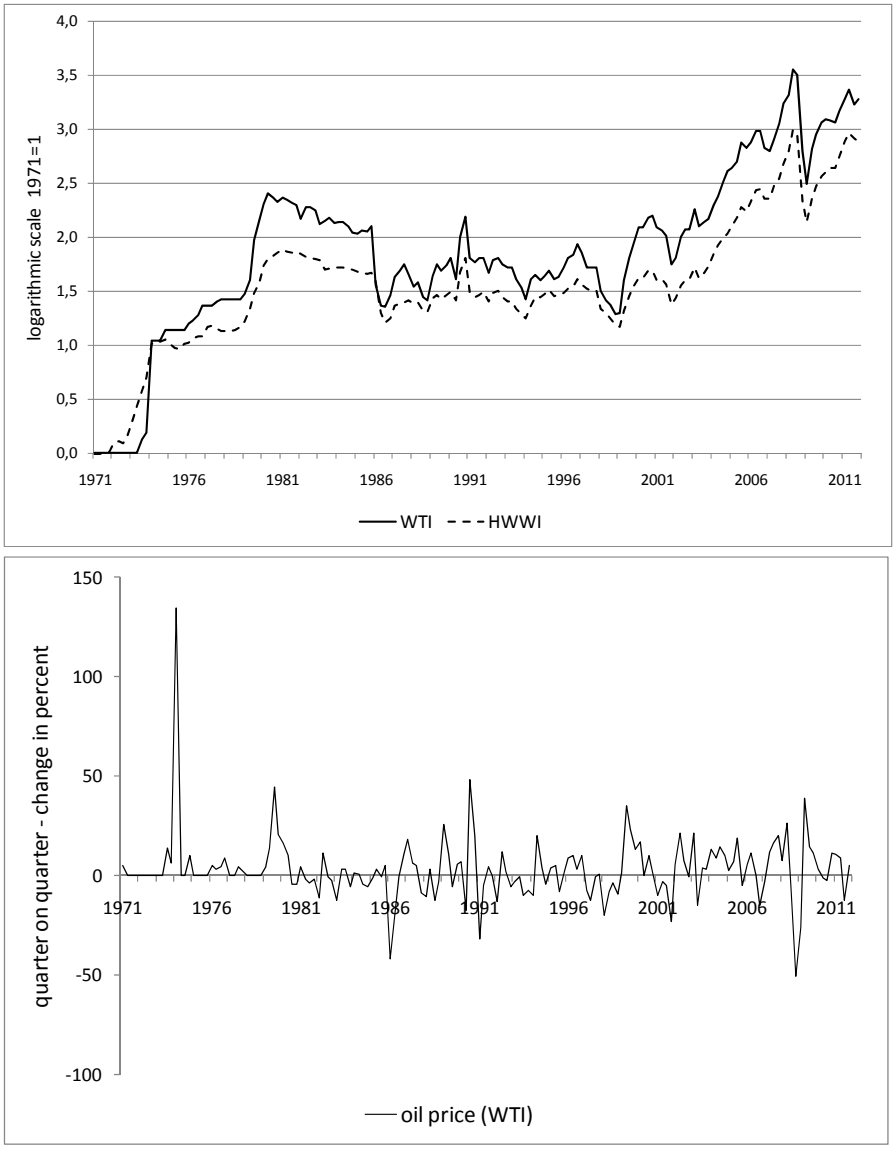
[12] *Pain et al.* (2008), *Vogel et al.* (2009), *Milani* (2009).

[13] While the procedure employed by *Ball – Mankiw* (2002) presupposes knowledge of the parameter linking unemployment to inflation, no such assumption is made here.

A look at the development of oil and raw materials prices

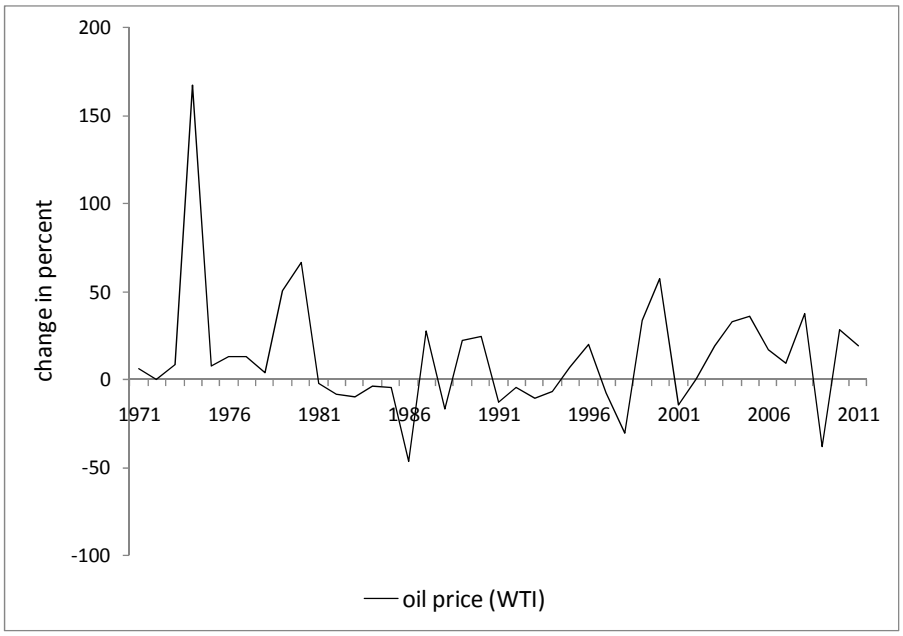
As *Smith* (2009, p. 146) points out, oil exports (crude oil plus refined products) have been a leading commodity in world trade – comprising 13 percent of total commodity trade by value in 2006, some $ 4 billion per day. Automobile exports amount to only about one-third as much, and iron and steel to about one-quarter. Nearly all nations are significantly affected by developments in oil markets, either as producers or consumer – or both (*Smith,* 2009, p. 147). Another characteristic of oil prices is their high volatility, the highest of all goods investigated by *Smith* (2009).

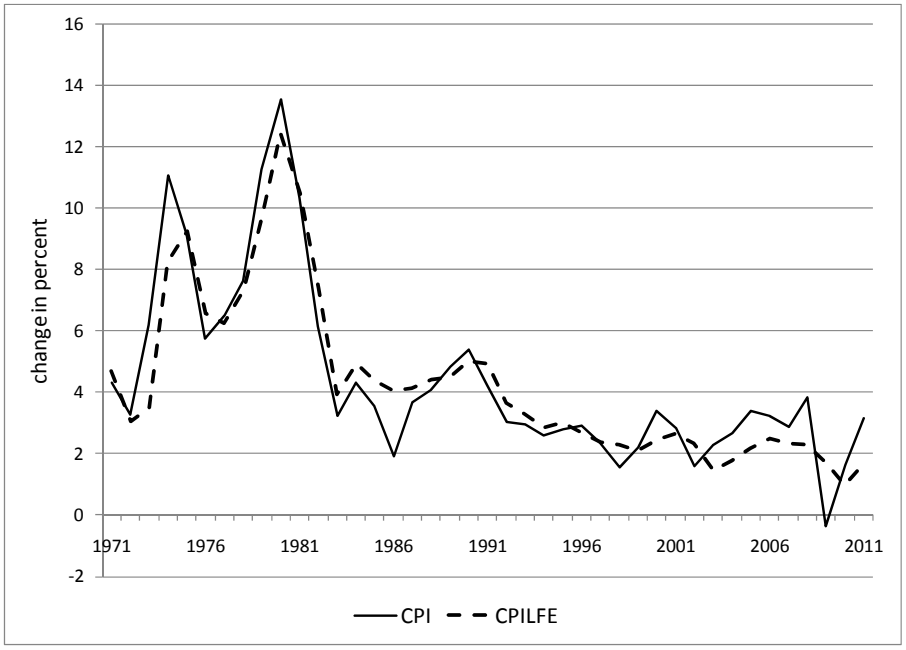
Figure 1: WTI and HWWI-(total) in levels, quarterly data



2. panel: quarter-on-quarter relative change

Figure 2: yearly inflation rates, WTI, CPI, CPILFE





CPI . . . headline index, CPILFE . . . core index, Consumer price index excluding food and energy

In nominal terms, oil prices (as measured by West Texas Intermediate) increased sharply in the years 1973-74 and from that level continued to increase at a more modest pace. The second oil price shock produced another steep increase in the price of oil during the years 1979-80;

this price hike was followed by a slow retrenchment of oil prices. In 1986 oil prices collapsed and reached a level just below that attained before the second oil price hike.

Except for a short-lived spike of 1991 (first Iraq war), oil prices fluctuated around the price established in1986 into the first years of the new millennium, then prices increased steeply, with a high point in 2008 followed by a sharp reversal.

The first and the second oil price shocks stand out through two characteristics: first, the strength of the price increase, and, second, by the persistence of the new price level. During the first shock, the higher price level was maintained for about 6 years, during the second shock for about 5 years. By contrast, the following years exhibited great fluctuations, and peak or bottom levels were never maintained for long. Even the most recent oil price hike, reaching its peak in 2008:2, was a short-term event, with the price dropping to a level less than half in 2008:4. A similar picture is provided by the development of an aggregate index of raw materials prices (HWWI; see Figure 1 and 2).

During the period covering the first and second oil price shock, the movement of headline and core inflation are almost parallel, with core inflation lagging behind headline inflation. It is remarkable that during the second oil price shock core inflation was almost as high as headline inflation (and considerably higher than during the first oil price shock), even though, as measured by the yearly inflation rates of the price of crude oil, the second oil price shock was milder than the first oil price shock. This is *prima facie* evidence that a strong price-wage-price spiral got underway in the second half of the seventies and that inflation expectations along the lines suggested by adherents of the NAIRU hypothesis were formed and were a major force in generating inflation. Thus, the value of the coefficients of the lagged inflation terms estimated over the period of the oil price shocks from should differ from those estimated over years that were characterised by short-term fluctuations[14].

Regression results

The period investigated covers the years beginning just before the first oil price hike and ending in 2010. The whole period is broken up into two subperiods: the period of the oil pirce shocks (1973:1-1981:4) and the period 1982:1-2010:4; the second subperiod covers the years known as the period of "Great Moderation", which ended around 2005. The results differ greatly.

[14] The difference in the characteristics of inflation between the period before 1973 , the period of the two oil price shocks and the period thereafter puts doubts on the usefulness of estimation results covering very long periods (see *Fair,* 2008, whose model covers the years 1954 to 2006)

Table 1: Headline inflation, quarterly data

	1973: 1 to 2010:4							1973:1 to 1981:4		1982:1 to 2010:4						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:																
Δ ln CPI																
Explanatory variables:																
M4CPI	0.977	0.704	0.687	0.891	0.818	1		0.782	0.684	0.843	0.245	0.217	0.560	0.642	1	
	10.6	*5.1*	*4.9*	*7.3*	*11.4*			*8.7*	*6.5*	*5.2*	*1.0*	*0.9*	*2.7*	*4.3*		
M4CPI(-4)	–0.142	0.019	–0.011	0.020						–0.097	0.176	0.059	0.147			
	–1.7	*0.2*	*–0.1*	*0.1*						*–0.8*	*1.2*	*0.4*	*0.9*			
UNCYC	–0.090	–0.122	–0.118	–0.107	–0.123	–0.093	–0.180	–0.315	–0.294	–0.026	–0.084	–0.045	–0.049	–0.046	0.000	–0.047
	–1.8	*–2.4*	*–2.3*	*–2.0*	*–2.9*	*–2.2*	*–3.8*	*–5.5*	*–5.1*	*–0.4*	*–1.3*	*–0.7*	*–0.7*	*0.8*	*0.1*	*–0.9*
Time Trend	–0.204	–0.320	–0.363		–0.222		–1.08			–0.090	–0.366	–0.547		–0.174		–0.766
	–1.8	*–2.6*	*–2.7*		*–2.0*		*–12.4*			*–0.6*	*–2.2*	*–2.7*		*–1.2*		*–6.2*
M4WTI		0.017	0.018	0.010		0.006	0.047		0.013		0.028	0.033	0.019		0.009	0.039
		2.6	*2.7*	*1.7*		*1.4*	*9.5*		*1.7*		*3.3*	*3.7*	*2.5*		*1.6*	*6.6*
M4WTI(-4)			0.004	–0.002			0.023					0.012	0.001			0.017
			0.8	*–0.4*			*4.9*					*1.7*	*0.2*			*2.8*
Δ ln WTI (-1)					0.007									0.010		
					2.9									*3.3*		
∑Coeff of lagged dependent variables	0.835	0.723	0.676	0.911	0.818	1	0.000	0.782	0.684	0.746	0.421	0.276	0.707	0.642	1	0.000
$\bar{R}^2$	0.76	0.76	0.76	0.753	0.76	0.75	0.70	0.78	0.79	0.30	0.36	0.37	0.33	0.36	0.31	0.37
SE	0.416	0.408	0.408	0.417	0.408	0.418	0.462	0.328	0.319	0.425	0.407	0.404	0.416	0.404	0.421	0.404
D-W	1.7	1.7	1.7	1.6	2.1	1.6	1.4	1.9	2.1	1.8	1.9	1.9	1.8	2.1	1.7	1.9

Values of constant not listed. Numbers in italics below coefficients are t-statistics. The coefficients of the time trend are given as the coefficients multiplied by 10,000. The coefficients of UNCYC are given as the coefficients multiplied by 100.

Headline inflation

The following paragraphs comment on the regression results for the period 1982:1 – 2010 in more detail than for other periods, for which similar results were obtained.

Adding the oil price variables to the regression lowers the sum of the coefficients of the lagged dependent variables considerably: the sum of the coefficients falls from 0.746 to 0.421 and 0.276, and the coefficients of the oil price variables (as well as the statistical significance) are much higher than for the whole period[15]. These results indicate a trade-off between the value of the coefficients of the oil price variable and the lagged dependent variable, suggesting along the lines of the Koyck transformation[16] that the lagged dependent variable captures to a great extent the delayed effects of changes in the oil price. Interpreted as proxies for inflation expectations, the low value of the sum of coefficients puts into considerable doubt the validity of the NAIRU hypothesis, which requires the sum to be equal to unity.

In some Phillips-curve studies the oil/commodity price variable is entered in the form of a quarter-on-quarter relative change, lagged one quarter; this practice of restricting the effects of oil/commodity price changes to a lag of just one quarter biases the estimates of the oil price variable towards zero: the coefficient of the oil price variable is still positive but its value is about one fourth the value in a specification when the medium-term impact of commodity prices on inflation is allowed to work for the period 1982-2010 (Table 1, 1982-2010, compare equ. 3 to equ. 5), about one half for the period 1973-2010 (Table 1, 1973-2010, compare equ. 3 to equ. 5).

The effect of cyclical unemployment variable on inflation is moderate, but is markedly stronger when the oil price variable is added. The effect of cyclical unemployment rate for the years 1982-2010 is much weaker than for the whole period, a finding that is in line with results reported by several studies (*OECD,* 2008, *IMF,* 2008) according to which the short to medium-term response of inflation to domestic cyclical output variations declined over the past decades.

Most regression equations contain a time trend. In the literature, an abundance of factors has been proposed that can be interpreted as resulting in a negative trend in the inflation rate. *Gordon* (1997, p. 29-30) points to the contrast between labor militancy, relatively strong unions, a relatively high minimum wage in the late 1960s and the 1990s that were characterised by labor peace, relatively weak labor unions, a relatively low minimum wage.

---

[15] Note that leaving the lagged dependent variables out altogether (Table 1, 1982-2010, equ. 7) does not worsen the fit of the regression.

[16] In terms of the Koyck transformation (*Theil,* 1971, pp. 259-263) lagged endogenous variables can be thought as representing the protracted influence of exogenous variables.

Other factors that may have decreased inflationary pressures include the increase in global competition and immigration of unskilled labor (*Gordon,* 1997, p. 39).

Increasing intensity of foreign competition is also cited by the OECD (*Pain et al.,* 2008, p.16) as an important factor in changing the response of inflation to cyclical domestic factors, making the economy more sensitive to measures of foreign economic slack.

Perhaps the most easily tractable change over the years has been the sharp decline in energy intensity in the advanced economies since the 1970s, reducing the indirect first round effects of commodity price shocks (*IMF,* 2008, *Blanchard – Galí,* 2010, *Edelstein – Kilian,* 2007). The trend variable seems to capture to a great extent the decline in energy intensity: Omitting the trend variable (Table 1, 1973-2010, equ. 4; 1982-2010, equ. 4) reduces the coefficients of the energy variable and increases the value of the coefficients of the lagged dependent variable.

Of course, there may be other factors at play, interacting with the pass-through of energy prices into consumer prices. As *Barrel – Pomeranz* (2008, p. 32) and others have noted, second round effects of oil shocks are much smaller than they were thirty years ago, owing to a more flexible labor market and a credible monetary policy (*Blanchard – Galí,* 2010, *ECB,* 2010, *Hamilton,* 2012). As the *IMF* (2008, p. 109) put it: "The transmission of commodity price shocks into expected inflation appears to depend crucially on the conduct of monetary policy."

The results of the Phillips-curve equations which include oil prices indicate that the sum of the coefficients of the lagged dependent variables is considerably less than unity[17]. Still, several papers continue to make exactly this assumption and impose the unity requirement on the form of the regression (*Batini – Greenslade,* 2006, *Fuhrer – Olivei,* 2010, *Fuhrer et al.,* 2012, *Ball – Mazumder,* 2011, *Kamenik et al.,* 2013). As *Akerlof – Shiller* (2009, p. 46-47) argue, given the central role of natural rate theory, "the theory should have been tested, and retested, and tested some more." Thus, it is instructive to investigate the effects of such a restriction (i.e., the unity requirement) on the regression results.

For the whole period, imposing the unity constraint reduces the value of the coefficients of the oil price variable to a value close to zero; for the period 1982:1-2010:4 this constraint has a similar effect: the values of the coefficients of the oil price variable are about one third the size of the coefficients in the unconstrained equations. Thus, in this form of the Philipps Curve,

[17] Other studies that find that the sum of the coefficients of lagged inflation rates is much below unity include *Franz* (2005) and *Pollan* (2012). See also *Hall et al.* (2009) who show that the coefficients of measures of inflation expectations are close to unity, but that the coefficients of lagged inflation are near zero; note, however, that commodity prices are not included in the analysis.

the practice of constraining the sum of the coefficients of the lagged dependent variable has the effect of biasing the coefficients of the oil price variable towards zero[18].

Core inflation

Core inflation is the rate of change of the Consumer Price Index less energy and food. The regression results are presented in Appendix A, Table 2. Core inflation excludes direct effects of oil price hikes, but includes indirect and second round effects. Thus, the effects of including the oil price variable are much weaker, only showing up strongly when the lagged dependent variable is excluded from the right hand side of the equation.

During the years of the first and second oil price shocks the path of core inflation was almost identical to that of headline inflation; this similarity ended in the early eighties when core inflation followed a smooth path (Figure 2). This contrast is also evident in the regression results: For the period 1982:1 to 2010:4, the sum of the coefficients of the lagged dependent variables is markedly lower and (as in the equations with headline inflation) the unemployment term becomes less important. The value of the coefficient of the negative time trend is about as large as in the regressions for headline inflation, even though the impact of energy on core inflation is much lower, indicating that the time trend, in addition to the drop in energy intensity, picks up the influence of other variables.

Phillips curves based on yearly data

Regression results based on yearly data (see Appendix A, Tables 3 and 4) in general confirm the results from those based on quarterly data: For headline inflation as well as for core inflation, the coefficients of the lagged dependent variable are much smaller in the period excluding the oil price shocks. The time trend plays an important role; without the time trend, the coefficients of the lagged dependent variable are considerably higher, both in the whole period and in the subperiod. This is also true for the coefficients of the rate of unemployment.

Conclusions

The popular as well as the financial press has linked movements in the inflation rate (as measured by the Consumer Price Index) in recent years to movements in crude oil prices. This interpretation is supported by a large body of economic literature which has studied the impact of oil price shocks on inflation and economic activity. Nonetheless, a number of US studies of inflation have persisted to focus on domestic cyclical factors to the neglect of

[18] Note that this procedure turns the coefficients of the unemployment positive and close to zero. In this specification the time trend is not significant.

world-wide developments. One area where the neglect of external factors extends into the realm of economic policy is the Phillips curve and the NAIRU: The finding of strong inflation persistence, interpreted as inflation expectations, assigns an important role to monetary policy in anchoring inflation expectations. But if, at the empirical level, lagged dependent variables in the accelerationist version of the Phillips curve just pick up the effects of delayed oil/commodity prices, the task of controlling inflation expectations becomes less important.

A look at the course of oil/commodity prices (Figure 1) reveals great diversity over the last four decades: first, sharp rises to higher levels during the first and second oil price shocks, then the collapse of the oil price in 1986 and the subsequent tranquil period, called the Great Moderation, which ended in 2005. This pattern suggests *prima facie* that oil/commodity prices played an important part, first in boosting inflation to the highest rates in post-war history, then in providing a rather stable environment on the cost side of inflation. Thus, the post-1970 years should be viewed as two different periods that have little in common.

If oil prices are introduced into the Phillips-curve with the inflation rate according to the consumer price index as an explanatory variable their influence is found to be strong and to extend over several quarters. This influence comes at the expense of lagged dependent variables, which have been interpreted as proxies for inflation expectations. The sum of the coefficients of the expectations variables is far from unity, indeed close to zero if the periods of the first and second oil shocks are excluded from the regression analysis. Closely related to the effect of oil prices on inflation is the effect of a negative time trend. This trend variable largely embodies the trend towards a less energy efficient economy and thus reflects a structural feature of the economy and may not be due solely to the course of monetary policy, as claimed by the 'trend' literature (*Cogley – Sbordone,* 2008, *Coibon – Gorodnichenko,* 2011), though monetary policy may be one of many factors contributing to a downward trend in inflation. Other factors cited for making a lower inflation rate include weaker labor unions, a relatively low minimum wage, the increase in global competition and immigration of unskilled labor.

The introduction of the oil price variable into the Phillips curve sharply lowers the sum of the coefficients of the lagged dependent variable; if the sum of the coefficients is interpreted as indicating the importance of inflation expectations, this result, if taken at face value, assigns a much feebler role to expectations in the inflation process[19]. And as a consequence, the task of controlling inflation expectations by monetary policy may be not as important as implied by statements issued by central banks in the United States and in Europe which point to the

[19] As illustrated in this note by the price of crude oil, the lagged dependent variables may just stand for the lagged effects of exogenous variables; this is a question that needs to be pursued in a more sophisticated analysis going beyond the effects of oil prices.

importance of anchoring inflation expectations. Are the actions of the central bank nothing more than a sideshow? (pace, *Friedman,* 2009, p. 282)[20].

The results of the empirical analysis assign a great role to factors that are external to the US economy and a small role to domestic factors such as the rate of unemployment or other indicators of domestic economic activity[21]. The strong impact of world economic factors on US inflation and on economic activity raises the question to what extent US monetary policy is still able to control inflation. The limitations of national monetary policy were acknowledged by B. Bernanke in 2008 (July): "Rapidly rising prices for globally traded commodities have been the major source of the relatively high rates of inflation we have experienced in recent years, . . .".

Inflation is a global phenomenon, with commodity prices as one of the main channels. It matters little where demand pressures for raw materials come from, from emerging or developed countries, or where constraints on the supply of these materials are exercised, hence the importance of forecasting the price of oil (*Bernanke,* 2008, *Alquist et al.,* 2011). Thus, national central banks, whether the Fed or the European Central Bank, will find it harder than in earlier periods to restrain inflation.

The counterpart of the globalisation of inflation is the globalisation of deflation: central banks might find it harder to fight deflation and to directly stimulate the economy, particularly when short-term interest rates are at the zero bound. In globally interconnected financial markets, an increase in liquidity in one market will find its way to other markets where the demand for loans is high (e.g., Brazil) or to countries which serve as safe havens, such as Switzerland, and unless sterilised, will generate a surge in the price level in the receiving countries and thus stimulate world-wide demand. Large scale purchases of financial assets by central banks might also reduce international long-term interest rates and lower the value of the foreign exchange rate, and thus, in a round-about way stimulate the domestic economy (*Glick – Leduc,* 2011, *Neely,* 2010).

---

[20] There seems to be consensus that the restrictive monetary policy initiated under Volcker in 1979 engineered a recession and finally brought inflation under control. One might even attribute the collapse of crude oil price in 1986 to the restrictive stance of US monetary policy. But this was more than 30 years ago, when the US economy played a much larger role in the world economy than now.

[21] The finding that commodity prices exert a strong influence on inflation may also suggest a revision of the view of how inflation expectations are formed. In Friedman's model of adaptive expectations economic agents extrapolate past inflation developments into the future. However, when aware of the connection between commodity prices and inflation economic agents are unlikely to persist in following this routine. Rather, they will take commodity inflation into account in forming inflation forecast (see e.g., OECD and IMF projections) and expectations (*Trehan,* 2011, *Anderson et al.,* 2011).

Extensions

This paper has followed the practice of examining the overall consumer price index (headline and core CPI), but better insights into the inflation process can be gleaned by breaking up the CPI into its components (see various country reports by the IMF, OECD, European Central Bank and national research institutes); obviously, service prices are influenced by different factors than prices of manufactured goods, food stuff, housing and energy[22].

Other extensions concern commodity prices; this paper employed prices of crude oil (WTI) to represent commodity prices. Here, too, a differentiation between industrial materials, food and energy prices is called for. Moreover, foreign exchange rates, which have fluctuated strongly since the early seventies, have to be incorporated into the analysis. Another question that should be clarified concerns asymmetric effects: are the effects of increases different from decreases in commodity prices?

The results in this paper, in line with the findings of other studies, show that the impact of unemployment has weakened with time; the variable chosen to represent cyclical economic activity was a simple detrended unemployment rate. A more comprehensive study would also take account of the changing composition of the labour force to construct a modified version of the unemployment rate as well as use other cyclical variables such as the output gap to estimate the impact of domestic forces on the course of inflation or the various subcomponents of inflation.

Then there is the question of the exogeneity of the explanatory variables. Clearly, unemployment is an endogenous variable within the economic system; it makes sense to treat unemployment as exogenous if his variable is thought to be determined by monetary policy, but as *Hamilton* (2009) and others have argued, commodity prices have a strong impact not only on prices but also on economic activity; thus, unemployment and the output gap are functions of commodity prices. Here again, at a deeper level, there are competing views about to what extent the oil price shocks of the seventies and of recent years were driven by demand factors. These are questions that need to be tackled in a more comprehensive analysis.

[22] Studies reaching back to the seventies would also consider the effects of the Nixon price controls. In a preliminary analysis, inclusion of dummies for the Nixon controls did not turn out to be important, if the oil price was among the explanatory variables.

Appendix A

Table 2: Core inflation, quarterly data

	1973: 1 to 2010:4				1973:1 to 1981:4		1982:1 to 2010:4			
	(1)	(2)	(3)	(4)	(1)	(2)	(1)	(2)	(3)	(4)
Dependent variable:										
Δ ln CPILFE										
Explanatory variables:										
M4CPILFE	0.978	0.928	0.947		0.951	0.871	0.761	0.763	0.737	
	15.7	*14.1*	*13.1*		*9.4*	*8.6*	*7.7*	*7.7*	*7.4*	
M4CPILFE(-4)	–0.110	–0.076	–0.079				–0.140	–0.143	–0.150	
	–1.8	*–1.2*	*–1.3*				*–1.9*	*–0.9*	*–2.0*	
UNCYC	–0.131	–0.122	–0.122	–0.119	–0.304	–0.254	–0.047	–0.044	–0.036	–0.073
	–4.8	*–4.5*	*–4.4*	*–2.9*	*–4.6*	*–3.9*	*–1.9*	*–1.7*	*–1.4*	*–3.0*
Time Trend	–0.175	–0.188	–0.175	–1.125			–0.286	–0.293	–0.346	–0.860
	–2.4	*–2.6*	*–2.3*	*–14.9*			*–3.6*	*–3.6*	*–3.9*	*–15.1*
M4WTI		0.006	0.005	0.022		0.018		0.094	0.002	0.005
		2.2	*1.8*	*5.1*		*2.3*		*0.5*	*1.1*	*1.7*
M4WTI(-4)			–0.002	0.019					0.003	0.008
			–0.6	*4.6*					*1.5*	*2.9*
∑Coeff of lagged dependent variables	0.868	0.852	0.868				0.621	0.620	0.587	0.000
$\bar{R}^2$	0.88	0.89	0.89	0.68	0.73	0.76	0.80	0.80	0.80	0.69
SE*100	0.244	0.241	0.242	0.402	0.377	0.355	0.149	0.150	0.149	0.187
D-W	1.6	1.7	1.7	0.9	1.8	2.1	1.8	1.8	1.9	1.4

Values of constant not listed. Numbers in italics below coefficients are t-statistics. The coefficients of the time trend are given as the coefficients multiplied by 10,000. The coefficients of UNCYC are given as the coefficients multiplied by 100.

Table 3: Headline inflation, yearly data

	1973-2010			1982-2010		
	(1)	(2)	(3)	(1)	(2)	(3)
Dependent variable: π^h						
Explanatory variables:						
π^h (-1)	0.676	0.621	0.818	0.196	0.419	0.599
	4.6	9.2	13.6	1.3	5.9	7.4
π^h (-2)	–0.111			0.162		
	–0.9			1.5		
UNCYC	–0.444	–0.529	–0.619	–0.400	–0.337	–0.377
	–2.7	–3.7	–3.5	–3.1	–3.4	–2.8
Time Trend	–0.080	–0.072		–0.076	–0.066	
	–4.2	–4.3		–4.4	–4.7	
Δ ln WTI	0.038	0.039	0.039	0.029	0.029	0.025
	7.1	7.5	6.2	6.4	6.4	4.4
Δ ln WTI (-1)	0.001			0.010		
	0.0			1.5		
$\bar{R}^2$	0.917	0.918	0.877	0.840	0.834	0.694
SE	0.832	0.827	1.013	0.499	0.504	0.683
D-W	1.7	1.7	1.3	2.1	2.5	1.7

Values of constant not listed. $\pi^h = \Delta$ ln CPI. Numbers in italics below coefficients are t-statistics. UNCYC = Unemployment rate – Hodrick-Prescott Filter (100) of the unemployment rate, computed over 1970-2010. The coefficients of UNCYC and of the Time Trend are given as the coefficients multiplied by 100.

Table 4: Core inflation, yearly data

	1973-2010			1982-2010		
	(1)	(2)	(3)	(1)	(2)	(3)
Dependent variable: π c						
Explanatory variables:						
π^c (-1)	0.849	0.657	1.001	0.548	0.519	0.691
	6.3	6.2	6.5	3.8	5.7	4.3
π^c (-2)	–0.237		–0.117	–0.37		0.67
	–1.8		–0.8	–0.9		0.5
UNCYC	–0.277	–0.490	–0.428	–0.269	–0.300	–0.459
	–1.9	–2.9	–2.5	–2.3	–3.1	–3.9
Time Trend	–0.074	–0.072		–0.064	–0.060	
	–3.8	–3.2		–3.1	–3.3	
Δ ln WTI	0.17		0.20	0.002		–0.003
	3.2		3.2	0.4		–0.6
Δ ln WTI (-1)	0.010	0.015	0.010	0.006	0.006	0.002
	1.7	2.5	1.4	1.5	1.6	0.4
$\bar{R}^2$	0.900	0.854	0.858	0.889	0.892	0.840
SE	0.823	0.994	0.981	0.457	0.465	0.535
D-W	2.1	1.8	1.8	2.6	2.5	1.9

Notes: See Table 3. $\pi^c = \Delta$ ln (CPILFE).

References

Akerlof, G.A., Dickens, W.T., Perry, G.L., "Near-Rational Wage and Price Setting and the Long-Run Phillips Curve", Brookings Papers on Economic Activity, 2000, 31(1), pp. 1-60.

Akerlof, G.A., Shiller, R.J., Animal Spirits: How Human Psychology Drives the Economy and Why it Matters for Global Capitalism, Princeton University Press, Princeton–Oxford, 2009.

Alquist, R., Kilian, L., Vigfusson, R., "Forecasting the Price of Oil", Bank of Canada, Working Paper, (2011-15), June, 2011.

Álvarez, L.J., Hurtado, S., Sánchez, I., Thomas, C., "The impact of oil price changes on Spanish and euro area consumer price inflation", Elsevier, Economic Modelling, 2011, 28(1-2), pp. 422-431.

Anderson, S.T., Kellog, R., Sallee, J.M., (2011). "What Do Consumers Believe About Future Gasoline Prices?", NBER Working Paper, April 2011, (16974), Cambridge, MA.

Ball, L., Mankiw, N.G., "The NAIRU in Theory and Practice", Journal of Economic Perspectives, 2002, 16(4), pp. 115-136.

Ball, L., Mazumder, S., "Inflation Dynamics and the Great Recession", Brookings Papers on Economic Activity, Spring 2011, 42(1), pp. 337-381.

Ball, L., Mankiw, N.G., "The NAIRU in Theory and Practice", Journal of Economic Perspectives, Fall 2002, 16(4), pp. 115-136.

Barrel, R., Pomeranz, O., "Oil Prices and World Inflation", National Institute Economic Review, (203), January 2008.

Batini, N., Brian, J., Stephen, N.I., "An open-economy new Keynesian Phillips curve of the U.K.", Journal of Monetary Economics, September 2005, 52(6), pp. 1061-1071.

Batini, N., Greenslade, J.V., "Measuring the UK Short-Run NAIRU", Oxford Economic Papers, January 2006, 58(1), pp. 28-49.

Bernanke, B.S., "Outstanding Issues in the Analysis of Inflation", speech delivered at the Federal Reserve Bank of Boston's 53rd Annual Economic Conference, June 2008, Chatham, Massachusetts.

Blanchard, O.J., Galí, J., 2007. "The Macroeconomic Effects of Oil Shocks: Why are the 2000s So Different from the 1970s?", NBER Working Paper, (13368), Cambridge, Massachusetts.

Blinder, A.S., "Is There a Core of Practical Macroeconomics That We Should All Believe?", American Economic Review, May 1997, 87(2), pp. 240-243.

Blinder, A,S., Rudd, J.B., "The Supply-Shock Explanation of the Great Stagflation Revisited", NBER Working Paper, 2008, (14563), Cambridge, Massachusetts.

Bullard, J., The Global Economy and the European Sovereign Debt Crisis, OMFIF Golden Series Lecture, London, July 10, 2012, http://research.stlouisfed.org/econ/bullard/Bullard_OMFIF_10July2012_final.pdf.

Cecchetti, S.G., Moessner, R., "Commodity prices and inflation dynamics", BIS Quarterly Review, December 2008.

Claar, V.V., "Is the NAIRU more useful in forecasting inflation than the natural rate of unemployment?", Applied Economics, 2006, 38(18), pp. 2179-2189.

Cogley, T., Sbordone, A.M. "Trend Inflation, Indexation, and Inflation Persistence in the New Keynesian Phillips Curve", American Economic Review, 2008, 98(5), pp. 2101-2026.

Coibon, L., Gorodnichenko, Y., "Monetary Policy, Trend Inflation, and the Great Moderation: An Alternative Interpretation", American Economic Review, 2011, 101, pp. 431-370.

European Central Bank (2010A), "Oil Prices – Their Determinants and Impact on Euro Area Inflation and the Macroeconomy", Monthly Bulletin, August 2010, pp. 75-92.

European Central Bank(2010B), "Drivers of Recent Inflation Development", Monthly Bulletin, November 2010.

European Central Bank (2011), "Prices and Costs", Monthly Bulletin, December 2011.

Edelstein, P., Killian, L., "Retail Energy Prices and Consumer Expenditures", CEPR Discussion Paper, 2007, (DP6255).

Eickmeir, S., Moll, K., "The Global dimension of inflation – evidence from factor-augmented Phillips curves", ECB Working Papers, February 2009, (1011).

Fair, R.C., "Testing price equations," European Economic Review, 2008, 52(8), pp. 1424-1437.

Franz, W., "Will the (German) NAIRU Please Stand Up?" German Economic Review, 6(2), pp. 131-153.

Friedman, M., "The Role of Monetary Policy", American Economic Review, 1968, 58(1), pp. 1-17.

Friedman, B., "Comments and Discussion on Hamilton, J.D. 'Causes and Consequences of the Oil Shock of 2007-08'". Brookings Papers on Economic Activity, Spring 2009, 40(1), p. 282.

Fuhrer, J.C., Olivei, G.P., "The role of expectations and output in the inflation process: an empirical assessment", Federal Reserve Bank of Boston, Public Policy Brief, 2010, (10-2), pp. 1-39.

Fuhrer, J.C, Olivei, G.P., Tootell. G.M.B., "Inflation Dynamics When Inflation is Near Zero", Journal of Money, Credit and Banking, 2012, 44(s1), pp. 89-122.

Fuhrer, J.C., Olivei. G.P., Tootell, G.M.B., "Empirical Estimates of changing Inflation Dynamics", Federal Reserve Bank of Boston, Working Papers, 2009, (09-4).

Glick, R., Leduc, S., "Are Large-Scale Asset Purchasing Fueling the Rise in Commodity Prices?", FRBSF Economic Letter, April 4, 2011.

Goodfriend M., "Inflation Targeting in the United States?" in: Bernanke, B.S., Woodford, M. (Eds.), The Inflation-Targeting Debate, NBER, Universtiy of Chicago Press, Chicago, London, 2005, pp. 311-337.

Gordon, R.J., "The time-varying NAIRU and its implications for economic policy", Journal of Economic Perspectives, 1997, 11(1), pp.11-32.

Groen, J.J.J., Pesenti, P.A., "Commodity Prices, Commodity Currencies, and Global Economic Developments", National Bureau of Economic Research, Working Paper, 2010, (15743), Cambridge, Massachusetts.

Hall, R.E., "Clashing Theories: Why is Unemployment So High When Interest Rates Fall to Zero?", Hoover Institution and Department of Economics, Stanford University, November 4, 2011.

Hall, S.G., Hondroyiannis, G., Swamy, P.A.B., Tavlas, G.S., "The New Keynesian Phillips Curve and Lagged Inflation: A Case of Spurious Correlation?", Southern Economic Journal, October 2009, 76(2), pp. 467-481.

Hamilton, J.D., "Causes and Consequences of the Oil Shock of 2007-08," Brookings Papers on Economic Activity, 2009, pp. 215-261.

Hamilton, J.D. 2012. "Oil Prices, Exhaustible Resources, and Econnomic Growth", National Bureau of Economic Research, Working Paper, 2012, (17759), Cambridge, Massachusetts.

Hodrick, R., Prescott, E.C., "Postwar U.S. Busines Cycles: An Empirical Investigation," Journal of Money, Credit, and Banking, 1997, (29), pp. 1-16.

HWWI Consult GmbH, Hamburg, 2010, http://hwwi-rohindex.de/index.php?id=7946&L=1.

International Monetary Fund (IMF), "Is Inflation back? Commodity Prices and Inflation", World Economic Outlook, October 2008, Chapter 3, pp. 83-128.

Kamenik, O., Kiem, H., Klyuev, V., Laxton D., 2013. "Why Is Canada's Price Level So Predictable?", Journal of Money, Credit and Banking, 2013, 45(1).

Kilian, L., "The Economic Effects of Energy Price Shocks", Journal of Economic Literature, 2008, 46(4:871-909).

Kilian, L., "Not all Oil Price Shocks are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market." American Economic Review, 2009, 99(3), pp. 1053-1069.

Kohn, D.L., "Inflation Modeling: A Policymaker's Perspective", Journal of Money, Credit and Banking, 2007, 39(s1), pp. 181-186.

Lizardo, R.A., Mollick, A.V., "Oil price fluctuations and U.S. dollar exchange rates", Energy Economics, 2010, 32(2), pp. 399-408.

Lockhart, D., "The Debate Over Further Monetary Action", Mississippi Economic Council, Federal Reserve Bank of Atlanta, 2012, http://www.frbatlanta.org/news/speeches/120713_lockhart.cfm

Lucas, R.E., "Expectations and the Neutrality of Money", Journal of Economic Theory, 1972, 4(2), pp. 103-124.

Meade, E.E., Thornton, D.L., "The Phillips curve and US monetary policy: what the FOMC transcripts tell us", Oxford Economic Papers, 2012, 64(2), pp. 197-216.

Milani, F., "Does global slack matter more than domestic slack in determining U.S. inflation?" Economic Letters, 2009, 102(3), pp. 147-151.

Moccero, D., Watanabe, Sh., Cournède, B., "What drives inflation in the major OECD economies?", OECD Publishing, OECD Economics Department Working Papers, 2011, (854).

Neeley, Ch.J., "The Large-Scale Asset Purchases Had Large International Effects", Federal Reserve Bank of St. Louis, Working Paper, 2010, (2010-018D), revised April 2012.

Nichols, D.A., "Comment on Gordon, R.J. 'Inflation, Flexible Exchange Rates, and the Natural Rate of Unemployment'", in: Workers, Jobs, and Inflation, Bailey, M.N. (Ed.), 1982, pp. 153-155.

Nordhaus, W.D. "Who is Afraid of a Big Bad Oil Shock?", Brookings Papers on Economic Activity, 2007, (2), pp. 219-238.

OECD, Economic Outlook, 2008, 2008/1(83).

OECD, Economic Outlook, 2009, 2009/2(86).

OECD, Economic Outlook, 2011, 2011/1(89).

OECD, Economic Outlook, 2012, 2012/1(91).

Pain, N., Koske, I., Sollie, M., "Globalisation and OECD Consumer Price Inflation", OECD Economic Studies, 2008/1(44).

Phelps, E.S., "Phillips Curves, Expectations of Inflation and Optimal Unemployment Over Time", Economica, New Series, 1967, 34(135), pp. 254-281.

Schreiber, S., "Estimating the natural rate of unemployment in euro-area countries with co-integrated systems", Applied Economics, 2012, 44(10), pp. 1315-1335.

Smith, J.L, "World Oil: Markets or Mayhem?", Journal of Economic Perspectives, 2009, 23(3), pp. 145-164.

Stock, J.H., Watson, M.W., "Modeling inflation after the crisis", NBER Working Paper, 2010, (16488), Cambridge, MA.

Theil, H., Principles of Econometrics, John Wiley & Sons, New York, 1971.

Trehan, B. "Household Inflation Expectations and the Price of Oil: It's Déjà vue All Over Again", FRBSF Economic Letter, 2011, (2011-16).

Vogel, L., Rusticelli, E., Richardson, P., Guichard, S., C. Gianella, C., 2009. "Inflation responses to recent shocks: do G7 countries behave differently?", OECD Economics Department Working Paper, 2009, (689).