Oil and the Macroeconomy: Lessons for Monetary Policy

PROCEEDINGS OF THE U.S. MONETARY POLICY FORUM 2009

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Foreword

The U.S. Monetary Policy Forum (USMPF) is an annual conference that brings academics, market economists, and policymakers together to discuss U.S. monetary policy. A standing group of academic and private sector economists (the USMPF panelists) has rotating responsibility for producing a report on a critical medium-term issue confronting the Federal Open Market Committee (FOMC).

The 2009 USMPF panel includes private-sector members David Greenlaw (Morgan Stanley), Jan Hatzius (Goldman Sachs), Ethan Harris (Bank of America Merrill Lynch), Peter Hooper (Deutsche Bank), Bruce Kasman (JP Morgan Chase), and Kermit Schoenholtz, as well as academic panelists Anil Kashyap (Chicago Booth), Frederic Mishkin (Columbia), Matthew Shapiro (Michigan), Hyun Song Shin (Princeton), and Mark Watson (Princeton).

This volume reports the results of the third USMPF conference, held on February 27, 2009 in New York, N.Y. The meeting, attended by over 100 central bankers, academics, business economists, and journalists, began with a presentation of this year's report, followed by a luncheon address delivered by Christina Romer (Chair of the President's Council of Economic Advisors), and ended with a panel discussion.

The third USMPF report, Oil and the Macroeconomy: Lessons for Monetary Policy, authored by Harris, Kasman, Shapiro and West, focuses on the relevance of oil price movements for central banking. Following the authors' presentation, James Bullard, President of the Federal Reserve Bank of Saint Louis, and Janet Yellen, President, Federal Reserve Bank of San Francisco offered their comments.

This year's policy panel was entitled "Making Monetary Policy During a Financial Crisis." The discussion featured presentations by Charles Plosser and Eric Rosengren Presidents of the Federal Reserve Banks of Philadelphia and Boston, respectively, as well as by panel member Mishkin.

The USMPF is sponsored jointly by the Initiative on Global Markets at the University of Chicago Booth School of Business and the Rosenberg Institute for Global Finance at the Brandeis International Business School.

Anil K Kashyap and Frederic S. Mishkin, Co-Directors

Chicago, Illinois, and New York, New York, December 2009

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In addition to institutional support, there were a number of people whose help was essential to our success. First, there are all of the members of the USMPF panel, who offered comments and encouragement. Second, we thank the FOMC members, who attended the meeting and spoke on the record. We extend a special thanks to Charles Evans and Gary Stern, the Presidents of the Federal Reserve Banks of Chicago and Minneapolis respectively, who accepted our invitation to attend the meeting. Finally, there were several people behind the scenes who deserve special mention. These include Peggy Eppink, Allan Friedman, and Janice Luce of the University of Chicago Booth School of Business and Matthew Parillo and Nancy Allen at the Brandeis International Business School. We owe a special thanks to Jennifer Williams for organizing the conference and overseeing all the conference operations.

Finally, Stephen G. Cecchetti was a co-founder of this conference. He resigned from the panel upon taking a leave from Brandeis to work at the Bank for International Settlements. His energy and vision were critical in establishing the USMPF. With his departure Brandeis will no longer be a co-sponsor. We thank Steve and all his colleagues at Brandeis for their many contributions to the USMPF.

Oil and the Macroeconomy: Lessons for Monetary Policy

Executive Summary by Ethan S. Harris, Bruce C. Kasman, Matthew D. Shapiro, and Kenneth D. West

Much ink has been spilled on the big oil shocks of the past. This paper analyzes the latest run-up in oil prices and the monetary policy response to that rise. Our focus is on US policy. But to properly frame the discussion, we also describe global developments in oil markets and the economy.

In the 1970s, oil price movements occurred in the context of increasing inflation punctuated by supply shocks: sudden drops in actual or expected supply due to a geopolitical event. The oil price increases of the 2000s were driven, at least initially, by persistently high demand—particularly from emerging market economies—and a stubbornly weak supply response. The final doubling of oil prices in the first half of 2008 was more like past supply shocks—it clearly was not due to strong demand because the global economy was weakening and oil consumption growth was slowing.

The impact of rising oil prices on the global economy has been uneven, suggesting different challenges for different central banks. Some nations have benefited strongly from the recycling of petro-dollars (most notably Asian emerging markets) while others have benefited very little (e.g. the United States and Japan). Inflation pressures have also varied, with the strongest pressure in the United States and many emerging market economies.

How should central banks respond to oil price movements? A standard new Keynesian framework suggests central banks should target "sticky prices" (like the core CPI) and ignore flexible prices (like oil). Stepping outside this simple framework, however, there are good reasons for policymakers to pay attention to oil. In particular, they should worry about oil if high headline inflation—the overall rate of inflation as reported in official statistics and highlighted in press reports—can change inflation expectations (that is, if inflation expectations are not perfectly anchored). Indeed, based on an econometric study of measures of inflation expectations and a simulation of the new Keynesian model, we find that oil prices can be important for inflation expectations.

Policy makers faced some very tough choices in the last decade and it is important to evaluate those choices with the minimum possible 20-20 hindsight. Nonetheless we have some mild criticisms of the Fed responses to oil prices. We believe the Fed was a bit too eager to dismiss the trend-like rise in oil prices as it continued into 2005 and 2006. It is understandable that even after a long price run-up the Fed was reluctant to extrapolate ever rising prices ahead. However, by that point the Fed had already "forgiven" a substantial amount of "one-time" inflation and since they were relying on oil price futures to predict future inflation they had no expectation that the extra inflation would be reversed. Moreover, the boom in oil prices coincided with booms in two other asset markets—credit and housing—and the combination of strength in all of these markets should have been a warning sign. The Fed found comfort in the continued moderate readings from their preferred measures of inflation expectations, but waiting for measures of inflation expectations to pick up was a risky tactic, given that once these expectations rise, the problem is likely to be very hard to reverse. Perhaps the Fed should have recognized that slow, perfectly predictable rate hikes were not imposing adequate restraint.

We are more sympathetic to Fed actions in the fall of 2007 and into 2008. Clearly the Fed was gambling a bit with its anti-inflation credibility as it hesitated to tighten even as inflation expectations inched higher. However, the Fed decisions need to be considered in the context of the considerable downside risks to growth. The capital markets crisis had eased back only slightly by summer 2008 and while consensus forecasts called for only a mild "growth recession," most forecasters saw major downside tail risks. Anti-inflation credibility is a form of "capital" and it has no value if it is never used. It made sense for the Fed to use some of its hard won anti-inflation credibility when there was a high risk of a major recession in 2008; it made much less sense to risk it when the going was good in 2005 and 2006.

While oil prices have been pushed to the background by the capital markets crisis, when that crisis ends the challenges of the last decade will return.

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1. INTRODUCTION

This paper examines the role of oil in the macroeconomy with the aim of evaluating and guiding central bank responses to oil price movements. Oil prices increased steadily and substantially this decade. They rose from a low of about $20 per barrel at the end of the 2001 recession to highs of $140 in mid-2008. The seven-fold increase of oil prices rivals the oil shocks of the 1970s in the size of the price increase. The experience this decade, however, is strikingly different from the 1970s. First, the oil price increase this decade was gradual—unfolding over the six years from the recovery from the 2001 recession to the middle of 2008. Second, macroeconomic performance was very different than in the 1970s. Though inflation was creeping up this decade, it did not spike as it did in the 1970s. Correspondingly, this decade has not seen the sharp episodes of tight money that were forced by the inflation of the 1970s.

Of course, much has changed since oil prices peaked in July of 2008. Output has collapsed world-wide and with that collapse, oil prices have dropped sharply, to under $40 per barrel. In the summer of 2008, prior to the financial market meltdown and the sharp onset of the world-wide recession, there was substantial uncertainty about the course of oil prices. The forward price of oil was flat for many years ahead at the peak levels. There were forecasts of declining prices, but there were also forecasts of oil prices going to about $200 per barrel. Firms such as airlines were locking in forward delivery of oil prices at peak prices. Hence, though oil prices have now collapsed, it is important to bear in mind the situation looked very different before the financial crisis.

This paper analyzes the latest run-up in oil prices and the monetary policy response to that rise. Our focus on monetary policy distinguishes our paper from recent studies such as Kilian (2008) and Hamilton (2009a, 2009b).

Sections 2 and 3 in the paper cover various analytical and empirical aspects of oil prices and the macroeconomy. Section 2 reviews some standard approaches for studying oil prices and embedding them in a macroeconomic model. Section 3 discusses a number of microeconomic and macroeconomic aspects of the behavior of oil prices. Not all of the detail in sections 2 and 3 is used in our monetary policy discussion; one of the purposes of sections 2 and 3 is to summarize important developments in oil and the economy even if some aspects of those developments are not central to our monetary policy discussion.

Sections 4 through 6 and the Appendix present analytical and empirical analysis of the relationship between oil prices and monetary policy. U.S. policy in recent years is the center of the analysis. In section 4, we focus on core versus headline, or overall, inflation. In the section 5 of the paper, we take a close look at inflation expectations. In section 6, we discuss recent monetary policy in response to oil price movements in the context of the core/headline distinction. An Appendix analyzes a benchmark new Keynesian model modified to include an external oil sector.

In section 7, our final section, we summarize our findings and offer conclusions.

Before moving forward, we should present a series of disclaimers. We are not experts in the oil market, neither in the microeconomics of oil supply and demand nor the macroeconomics of the effects of oil on economic aggregates. The aim of this paper is to analyze the monetary policy response to oil shocks, especially during the 2000s. To do so, we need to take stands on the sources of the movements in oil and their likely macroeconomic consequences. Though we hope we bring some fresh insights, we have not attempted a definite or exhaustive survey of the causes and effects. Instead, we aim to elaborate the macroeconomic and oil market context that frame recent monetary policy actions.

2. ANALYTIC FRAMEWORK

The analytic framework we use in this paper draws on two strands of literature. First, we need a framework for discussing the determinants of oil prices. By way of background, we present the standard Hotelling (1931) model as a baseline where price net of costs grows at the rate of interest. This model, however, as we will discuss, makes it hard to rationalize short-run movements in prices in response to temporary shocks.[1] Accordingly, we augment the model (informally) to consider factors that create temporary wedges between the long-run Hotelling path for energy and the short-run flow supply and demand equilibrium price. This approach underlies the microeconomic analysis in the paper.

Second, we need to embed the oil market into a macroeconomic model in order to address the central question of the paper—how should monetary policy respond to oil prices? For our baseline model, we use the new Keynesian model that is now the workhorse for analyzing monetary policy—modified in a simple way to account for oil price shocks. Like the Hotelling model, the baseline new Keynesian model omits important features that appear to be pivotal in understanding the policy response to oil. Again informally, we will discuss extensions to the baseline model that appear to be central for understanding policy responses to oil. This approach underlies the monetary policy analysis in the paper.

2.1 EQUILIBRIUM IN THE OIL MARKET: LONG-RUN AND SHORT-RUN ARBITRAGE CONDITIONS

The starting point for understanding oil prices is Hotelling's idea that in equilibrium oil owners must get a price that makes them indifferent between selling today or holding back and selling tomorrow. Specifically, the scarcity rent—the difference between the price of oil and its cost of production—should rise with the rate of interest, that is,

$$(2.1)\quad P_{t+1} - MC_{t+1} = (1+r_t)\,(P_t - MC_t),$$

where P is the real price of oil, MC is the marginal cost of extraction, and r is the real required rate of return.

If the expected future scarcity rent is too high today, producers will have an incentive to hold back production to take advantage of the high return, causing current prices to rise enough to restore balance. Of course in a multi-period world, this arbitrage condition must hold into the indefinite future. Integrating the expression forward, would give an expression for the level of the real price of oil.

There are broad lessons to learn from this stylized model. Expression (2.1) says that oil prices (net of extraction costs) will have the random walk behavior of asset prices. That means that price

1 Many others have made arguments similar to the ones that we are about to make on the adequacy of the Hotelling model. See, for example, Hamilton (2009a), which also contains some references to additional literature on this model.

changes should be largely unpredictable. Moreover, they should not move much in response to current conditions unless changes in current conditions imply permanent changes about market conditions.

The asset price character of oil prices also means that one should expect them to be quite volatile and to move for reasons that are hard to explain. Such volatility can arise either from rational revaluation of the prospects for the market, or be noise or bubbles that can characterize asset markets.

While the Hotelling model is the natural benchmark for the price, especially for the long-run (i.e., the forecast of the price into the future), it does not capture all the features of the market for oil. In particular, there are features of the market where current flow demand and supply have effects on the price that could lead to important divergence of the spot price from the Hotelling path. It is critical to take these features into account, for example, in understanding the collapse of prices in late 2008.

What breaks the link between the pricing condition for oil in the ground and the value of oil available for immediate delivery for industrial use? A similar arbitrage condition holds once the oil is above the ground,

$$(2.2) \quad P_{t+1} = (1+r_t)\,(P_t + S_t - CY_t),$$

where S_t is the storage cost per period and CY_t is the convenience yield from holding oil above ground (refiners, distributors and end users find it useful to have some readily available inventory).

These arbitrage conditions have some important implications. Normally the futures curve should slope upwards gradually (in industry jargon: *in contango*). In practice the futures curve can slope upwards steeply or slope downward (in industry jargon: *backwardation*) with futures prices below current prices.

A steeply upward sloping curve occurs during periods of unusually low spot prices. For example consider a sharp temporary drop in demand during a recession. The arbitrage conditions imply that sellers should hoard inventory rather than sell today, restoring the normal gradual upward slope of the futures curve. However, two things seem to limit this arbitrage behavior. First, there is a limit on the size and flexibility of storage capacity. Second, many producers may be reluctant to withhold supply due to ongoing income needs. In fact, at the extreme the supply curve could bend backward for national oil companies. If oil funds much of the national budget, then there is a strong incentive to increase production to make up for lower prices.

Backwardation (a downward sloping futures curve) occurs when there is a sudden shortage of oil and it is difficult to boost production immediately. When supply drops abruptly (or less likely, demand surges abruptly) prices jump to clear the market and given the extreme inelasticity of supply and demand the jump can be dramatic. Futures prices jump much less on the assumption that long-run supply and demand responses will end the shortage. During these periods we would expect inventories to get very lean, but not go to zero due to the rising marginal "convenience yield."

Now, there is an apparent problem in this line of analysis. The same P_t appears in equations (2.1) and (2.2)! Hence, they both cannot independently describe the equilibrium for oil prices. In the next section, we address this point by distinguishing between the value of oil in the ground and oil above the ground immediately available for use.

2.2. *q* FOR OIL

There is potentially a significant difference between the value of oil in the ground versus the value of oil available for immediate delivery.[2] While the following dichotomy is a simplification, it is a useful point of departure.

- Oil in the ground is an asset. It is priced according to the Hotelling exhaustible resource arbitrage condition where price net of extraction costs rises at the rate of interest. Consequently, oil in the ground has an asset value that is related to the present discounted value of current and future spot prices. As with other asset prices, movements in the asset value of oil should be largely permanent—arising from revisions in expectations about the present value of future demand, supply, and cost.

- Oil ready for delivery is an industrial commodity used for current energy supply and for production of processed industry materials. The price of delivered oil is determined by *flow* supply and demand conditions that are only loosely connected to the long-run asset value of oil in the ground.

The ratio of the current spot price of oil to its asset value in the ground is *Tobin's q for oil*. Why is this ratio not always equal to one? In the *q* theory of investment (e.g., Hayashi (1982)), the answer is that adjustment costs keep the desired capital stock from equaling its actual value period-by-period. The technology for converting oil in the ground to oil delivered introduces a number of factors that can create a wedge between the Hotelling intertemporal arbitrage condition and the spot price of oil.

Extraction costs, short run. The technology for extracting oil from the ground is subject to increasing marginal cost, in some instances very steeply so. There are a fixed number of wells sunk at a point in time. There is limited scope for increasing the flow from them, and increases in flow can come at the cost of future recovery. There are also marginal sources of supply (e.g., stripper wells) that are increasingly costly on the margin.

Extraction costs, new capacity. Drilling new wells are subject to increasing marginal cost, gestation lags, etc., just like conventional investment projects. If new capacity means exploiting new fields, the gestation lags could run in the decades.

Transportation bottlenecks. Pipelines have limited capacities. Supertanker transportation rates are subject to wide fluctuations depending on demand (Kilian 2009).

Storage. Storage above the ground can serve to affect the gap between the asset value of oil in the ground and the spot value of delivered oil. Storage costs will vary depending on supply and demand conditions.

Official intervention. Historically, oil prices have been the subject to substantial official intervention. In the 1960s, the price of oil was set by the Texas Railroad Commission. In the 1970s, there were controls on the price of domestic oil in the United States. In the recent episode, government purchases of strategic reserves may have affected spot prices.

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2 Barsky and Kilian (2001) make this point by stressing that marginal cost in expression (2.1) may be upward sloping and therefore subject oil prices to changes in flow demand.

While this list is surely incomplete, it makes clear that there may be large and prolonged deviations of spot from asset value of oil in the ground.

In Section 3 of this paper, we will present evidence on the value of delivered oil versus oil in the ground. It is a critical ingredient in distinguishing hypothesis about the short-run determinants of movements in the price of oil.

2.3. EMBEDDING OIL IN A MACROECONOMIC MODEL

This simple framework does not have a mechanism for exploring the policy response to oil prices. We need an expanded model to assess how central banks should adjust policy in general, and how policy should have responded to oil prices this decade in particular. Robert Solow (1980) called his article on this question, "What to do (Macroeconomically) When OPEC Comes." While OPEC is not at the centerpiece of our discussion, it is worth noting how closely the model and the implied policy prescription remains. Absent sticky prices and wages, there is no clear course for monetary policy to act in response to a price shock. Relative prices will change. Real wages will fall. And output will remain at its possibly lower full-employment equilibrium level.

Sticky prices, of course, change this picture substantially. Shocks to relative prices have real effects. In the Appendix, we present a benchmark new Keynesian macroeconomic model modified to include an external oil sector. While the apparatus of this model is different, the lessons are quite similar to the ones that Solow drew in 1980. Recall first some terminology conventionally used in the literature on inflation.

> *Headline inflation* is overall inflation, typically measured by the overall CPI or PCE deflator.
>
> *Core inflation* is a measure that strips movements in headline inflation that come from movements in volatile food and energy prices before computing inflation.

The distinction between the two measures of inflation is vital for policy. In Section 4, we discuss how the benchmark model supports a policy that targets core rather than headline inflation. That inference is closely related to Solow's prescription to "accommodate" supply shocks, though most new Keynesian models express this policy in terms of the response to inflation rates rather than price level shocks.

In an important sense, we use the model as foil. A central question—one to which we devote substantial attention in the paper—is whether oil shocks feed into inflation expectations. If so, inflation expectations can become unanchored, potentially leading to a drift in the target for policy or a costly disinflation. In the context of the model, it makes a substantial difference whether persistently high inflation is just a series of positive residuals or a shift in the constant.

Another feature of the story that is brought into resolve by its omission from the model is the role of other external factors—notably world demand and inflation and the prices of other assets and commodities. In Section 3, we discuss the importance of these features. Clearly, a complete model would take them into account, and perhaps endogenize oil prices. Instead, we take the shortcut of modeling oil as exogenous to the United States, and then discuss informally world factors that both affect the price of oil and would also enter as shocks in the new Keynesian model.

3. OIL AND THE ECONOMY: THE 2000S

In this section, we explore macroeconomic and microeconomic aspects of oil and the economy. Our focus is on the recent episode: the steady increase in oil prices beginning with the recovery from the 2001 recession, the rapid increases in 2007 and 2008, and the even more rapid decline in 2008.

A complete account of the determinants of oil price is beyond the scope—both of this paper and the authors' expertise. Indeed, the very substantial variance across expert opinions on the determinants of the price of oil is an important fact of this market. Oil, like many goods determined in asset markets, is subject to price movements that are nearly impossible to predict and often difficult to rationalize fully *ex post*.

That said, the following summarizes salient features of the behavior of oil prices recently.

From the early 1970s through the start of this decade, oil price increases have tended to come in sharp and short bursts. These bursts have generally not lasted longer than eighteen months and have been associated with geopolitical events—the Yom Kippur war (1973), the Iranian revolution (1979) and the first Gulf War (1990). These price spikes also followed an extended period of strong global growth and building inflation pressures. Thus, a healthy debate continues to rage about the relative role of demand and supply in determining oil price movements. See Barsky and Kilian (2001) for the revisionist view that inflationary pressure and aggregate demand were important causal features of the 1970s oil price shocks; see Blinder and Rudd (2008) for a defense of the view that they were exogenous geopolitical events superimposed on a period of world-wide inflation.

We are not, in this paper, revisiting the debate over the 1970s. The picture we will paint for the 2000s, however, has more resonance with the Barsky-Kilian perspective on oil markets than the supply shock one. That is, oil prices in the 2000s were driven by high world aggregate demand operating against tightening supply, but not supply shocks.

We also need to be clear under what circumstances the particular source of oil price change matters. In the new Keynesian model that we analyze below and that is the basis for much of central bank policy, it does not matter for policy whether the change in prices is from supply or demand. On the other hand, it is important to understand the role of these factors because it provides the context for the change in oil prices. In particular, if oil prices are high because of good economic times, one will not see a negative correlation of oil prices and economic activity that arises if oil prices increase because of supply disturbances.

Regardless of the explanation favored for past episodes, this decade's run up in oil prices is different in its dynamics. For more than four full years—from early 2002 through mid-2006—the dollar price of oil (adjusted for inflation) moved steadily higher. Prices never rose more than 30% over a two quarter period, but cumulatively increased more than three-fold (Figure 3.1). Alongside this increase, global

GDP accelerated into mid-decade and unemployment rates moved steadily lower across the globe. Global consumer price inflation excluding food and energy remained broadly stable over this period (Table 3.1, Figure 4.2).[3]

Following a modest retreat in oil prices during the second half of 2006, oil ascended much more rapidly. In the year ending in July 2008, oil prices had more than doubled reaching a record high above $140 per barrel. During this period, global growth remained solid, but global CPI inflation took off, rising above 5% on a year ago basis, its highest level since 1991. Soon after oil prices peaked the global economy fell into a deep and synchronized economic downturn. And oil prices have collapsed, reversing more than half their earlier rise. Our analysis of events during this period suggests the following. Sections 3.1 through 3.4 make the following points.

1. The rise in oil prices this decade seems to be a consequence of rising global aggregate demand and sluggish supply. Oil has become closely aligned with movements in global growth and other cyclical indicators. As a result, oil prices are behaving much more like other commodities whose relative price moves up and down with global growth.

2. Although energy price increases lifted US headline CPI inflation, global headline and core inflation remained stable from 2002 through 2006. Globally, both headline and core inflation rose sharply over 2007-8. This rise appears to be linked in part to cyclically high levels of resource utilization.

3. Oil has had an important impact on relative growth performance. A large income transfer to oil producing nations appears to have reinforced a rotation in growth from developing market (DM) to emerging market (EM) countries this decade.[4] Non-oil producing EM countries appear to have been large beneficiaries of trade recycling from oil producing countries.

4. In the US, rising energy prices has weighed on real consumption by depressing real purchasing power and through other channels. The impact on consumption was partially offset by a combination of a weaker dollar and strong demand from emerging markets (from oil and non-oil exporters), which significantly spurred US export performance.

Sections 3.5 through 3.9 focus on microeconomic and market determinants of oil prices. These sections make the following points.

5. Supply and demand elasticities are low, meaning small shocks can lead to big changes in prices.

6. Various approaches to computing the long run value of oil have been proposed. None have been particularly successful.

3 Global GDP and CPI are GDP-weighted averages of national data, where GDP weights are determined via relative sizes of economies in US dollars. National GDP is converted to USD using annual averages of market exchange rates (not PPP-adjusted). Countries in global variables are United States, Japan, Canada, Australia, Euro area, Norway, New Zealand, Sweden, Switzerland, United Kingdom, Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, Venezuela, China, Hong Kong, Indonesia, India, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, Czech Republic, Hungary, Poland, Romania, Russia, South Africa, and Turkey.

4 Throughout the paper, data from EM countries refers to data from JP Morgan's list of over 20 emerging markets. This list excludes OPEC countries. See previous footnote for a list of the countries.

7. A novel application of q theory that we propose here suggests that oil prices were overshooting by 2008.

8. Futures prices tell a somewhat different story, since they typically forecast "no change."

9. We have no direct evidence on the role of speculation in the oil market. But we do note that conditions were ripe for a bubble in 2008.

3.1. OIL IN THE GLOBAL BUSINESS CYCLE

The close alignment of oil prices with key cyclical variables this decade argues strongly for viewing oil price movements as an endogenous element of this decade's global business cycle. In particular,

- Oil has moved closely with other commodities. For example, industrial metals prices have risen almost as much as oil over this period (Figure 3.2). They also seemed to "lead" oil in the final rise. This underscores the point that the rise in oil prices was not unique to supply and demand conditions in the oil market, but reflected factors common to all commodities: strong demand from commodity-intensive users combined with limits on new supply.

- Oil is positively correlated with GDP growth. As Figure 3.3 shows, West Texas Intermediate (WTI) oil prices have generally traced the ups and downs of global GDP growth over the last decade or so.[5] This positive correlation has strengthened in the last decade. It contrasts starkly with the negative correlation of GDP growth and oil prices during the stagflationary period of the 1970s to early 1980s.

There has been a litany of regional disruptions to oil supply in recent years—including the start of the Iraq war and Hurricane Katrina—but there has been no global supply-side disturbances that can explain this decade's oil price run-up. A restrained trend growth in supply (discussed below) may be a factor. The absence of a significant geo-political trigger helps explain why the rise in prices up to 2007 contrasted with previous price spikes.

While there is considerable circumstantial evidence suggesting that oil price movements have aligned with global demand, outsized cumulative increases in oil prices were not matched by unusually strong global oil consumption. Indeed Hamilton (2009a, 2009b) describes the final years of this period as one of rising demand meeting stagnating global production. Figure 3.12 below documents such stagnation for non-OPEC production. From 2002-2007 global oil consumption grew at a 1.6% pace, roughly similar to the 1.5% growth recorded during the 1990s expansion (Figure 3.4). Beneath this aggregate, the composition of global demand has changed dramatically. In 1999, emerging market economies accounted for less than 45% of global crude oil consumption, but the share had risen to 51% in 2007. Over this period emerging market oil consumption accelerated, while consumption for developed nations ground to a halt (Figure 3.5). This rotation was likely caused by three factors:

5 We follow the standard practice of using West Texas Intermediate (WTI) as the benchmark for oil prices. WTI is also the underlying commodity of futures contracts discussed below.

(1) a shift towards more energy intensive production and consumption in emerging market economies,
(2) more rapid growth in these countries (Figure 3.6), and
(3) government programs that tended to subsidize energy consumption in EM economies.

3.2. OIL AND GLOBAL INFLATION

Global core and headline inflation remained broadly stable through 2006, though both rose substantially in 2007-08 (Figure 3.7). To an important degree the rise in core inflation aligned with the rise in global resource utilization rates above the 1990s cyclical peak during 2007, highlighting the role of the business cycle in global price setting this decade (Figure 3.8). As well, the pattern may reflect a delayed reaction; Kilian (2008) argues that shocks to oil demand have a slow cumulative effect on headline CPI in the US. Whether or not core inflation in the US and elsewhere is contained in the face of rising energy prices depends jointly on how the economy responds to inflation and how policy responds to it.[6] The modest increases in core inflation in the face of energy shocks may indicate the credible and appropriateness of monetary policy (e.g., Blinder (2006)). But it is important to consider inflation expectations along with actual inflation, and in any event initial stability may presage a delayed response. Global inflation did rise significantly as the expansion matured and as oil prices continued to rise. Headline inflation spiked above 5% in 2008, its highest level in nearly two decades. Core inflation also rose by more than a full percentage point over 2007-8.

3.3. RECYCLING OF OIL REVENUES: EMERGING MARKET COUNTRIES ARE THE WINNERS

The sustained rise in oil prices since 2002 provides a useful laboratory for examining how a major income transfer is transmitted in an increasingly connected global economy. In short, this decade's rise in oil prices proceeded in tandem with a significant shift in spending towards emerging market economies—both those that are oil consumers and oil producers. To provide context and background, we document this shift in detail. The essential point is that because of the recycling, different countries face a different "net shock" from oil prices. Readers not interested in the details of the shift can skip to section 3.4 without loss of continuity.

The sustained rise in the price of oil this decade has generated a massive transfer of wealth from the oil producing countries to oil consuming countries. In 2007, world spending on oil was roughly $5.9 trillion, an amount that was roughly three times as large as in 2002 (Table 3.2). Comparing actual spending on oil to what would have been spent if consumption had been flat at 2001 levels, there was a cumulative $8 trillion in extra global spending on oil over this five year period. OPEC countries received almost half of the revenues from this consumption ($2.9 trillion). The big losers were developed economies ($2.7 trillion) and emerging Asia ($1.0 trillion). In terms of exposure to oil, by 2007 the net cost of oil as a share of GDP had risen to the 2 to 3 percent range in each of the major developed economies, but the exposure in some countries in emerging Asia was twice as high.

6 Research using backwards looking Phillips curves has also found that energy prices seem not to feed into core inflation in the US (Hooker (2002), Cavallo (2008)), though they appear to in Europe (Cavallo (2008)). The US pattern could be because there is a low structural response of inflation to energy prices, or because expectations of inflation were very well anchored because of the Fed was expected to offset inflationary shocks.

While the oil exporters' gain is a net loss to oil importers, the wealth transfer gets recycled through international transactions. With their wealth gains, oil exporters purchase goods and services from oil importing nations, helping to offset some of the drag of higher oil prices on importers' GDP. In addition, the portion of oil revenues that is saved tends to be recycled to the oil importing economies through financial markets. This, in turn, stimulates growth by lowering borrowing costs and raising other asset prices.

The lack of quality national product account data from OPEC nations makes it difficult to do a full accounting of the recycling of oil revenues. Looking at national account data through a somewhat different lens—the net commodity exporters (NCE) that do provide GDP account data—does provide some indication of how this process has worked. Real net exports subtracted about 2% points annually from growth in the major net commodity exporting (NCE) countries from 2003 to 2007. Domestic demand growth in the NCE countries soared to nearly 8% annualized over this period, or nearly three times the average during the previous decade. As the group makes up about 10% of global GDP, this suggests real net trade with the NCE group alone added almost 0.5%-point per year to the remainder of global real GDP growth.

A closer examination of the oil producing countries is possible, through nominal trade data. On this score, our analysis of OPEC's trade flows reveals three keys points. Table 3.3 shows the marginal propensity to import out of export revenue (MPI). Table 3.4 shows the raw data on merchandise trade with OPEC over the recent period of rapid increase in oil prices.

Low short-term spending elasticities. The short-run MPI is estimated as the annual change in imports divided by the annual change in exports (both in US dollars). Over the past two and a half decades, OPEC's MPI within one year has been roughly $0.34 to the dollar. As shown in Table 3.3, this estimate varies across countries, with Kuwait spending the smallest share and Bahrain and the UAE spending the most.

Rising long-run elasticities. The long-run MPI is estimated as the ratio of the 5-year change in imports to the 5-year change in exports. OPEC spent on imports roughly one-half of every dollar in export revenue. Again, the results vary by country with the UAE spending dollar-for-dollar. Over the most recent 5-year period (2002-07), the long-run MPI has moved up considerably to $0.71. The rise has been fairly broad-based.

Emerging markets take the lion share of recycling. In the 2002-07 period, exports from OPEC jumped $446 billion and roughly $325 billion was recycled back to the rest of the world in the form of imported goods. These petrodollars were not returned in proportion to each country's share in oil expenditures. Rather, much of the windfall reflects a transfer of income from developed to emerging markets. Emerging market exports to OPEC rose $186 billion from 2002 through 2007 compared to a $181 billion increase in import, a ratio of imports to exports of 103%. For developed markets, this ratio was just 52%.

Within the EM, the offset was almost two for one in Latin America, versus a near one-for-one offset in CEEMEA (Central Eastern Europe, Middle East and Africa) and EM Asia. To be sure, the value of trade between OPEC and Latin America and CEEMEA is relatively low partly because Latin America and CEEMEA each contain major oil exporters. As a result, most of OPEC's trade with the EMs occurs with EM Asia. Within EM Asia, China, India, and Singapore all ran a trade surplus with OPEC in 2007. They also experienced a greater rise in the value of exports to OPEC than in the value of imports from OPEC over the 2002-07 period. No doubt, these countries also import oil from non-OPEC sources and so their net gain in the oil for goods trade is unclear. However, China also ran a trade surplus with Russia and Canada in 2007, suggesting that trade with oil exporters more broadly has also resulted in a net export gain.

Among the G-3, the variation in the degree of OPEC oil-revenue recycling is striking. For the 2002-07 period, the rise in US exports to OPEC offset only 34% of the rise in imports. Japan's offset was fairly similar, with export growth equal to 30% of import growth. By comparison, the Euro area fared much better. The level of Euro area exports rose $58 billion from 2002 to 2007, versus a $66 billion increase in imports: a ratio of 88%. The Euro area's advantage may owe to its specialization in the production of capital goods, especially Germany's. However, a portion of the gain also reflects the collapse in Euro-US dollar exchange rate over this period.

Clearly many emerging economies felt a different kind of oil shock than many developed countries. Not only did these countries drive a relatively price inelastic surge in demand for oil, but they benefited disproportionately from the recycling of petro-dollars. Revenue recycling means each country faces a different overall shock from the rise in oil prices. For countries with high levels of recycling—such as EM Asia—the rise in oil prices is probably best viewed as an indicator of strong aggregate demand, with relatively little supply shock in terms of income transfer. By contrast, countries which did not benefit significantly from recycling—such as the US and Japan—the energy shock felt like an exogenous supply shock, even if those countries contributed to the general surge in oil demand and the rise in oil prices.

As this discussion makes clear, oil revenues do not recycle necessarily to the countries with large oil import bills. Indeed, since the aggregate balance of payments for a nation is determined jointly with the difference between its domestic saving and domestic investment, the amount of recycling back to the US will be limited by its aggregate trade deficit. Likewise, it is not surprising that the EM countries are the net exporters to the oil exporting countries. These countries, led by China, have had substantial external surpluses over the period.

The impact of rising energy prices on the US economy needs thus to be viewed against the backdrop of broader global macroeconomic developments. Rising oil prices was a negative income shock which reduced both household purchasing power and corporate earnings for the non-energy producing sector. As noted in both Kilian (2008) and Hamilton (2009a), the key mechanism whereby energy price shocks affect the economy are through a drag on consumer and business spending on goods and services other than energy. But there may have been significant positive effects on US growth from the strength in global demand that has contributed to rising oil prices as well as from the direct effects of recycling surpluses from oil producing nations. Kilian (2008) also finds offsetting effects when oil prices rise because of a shock to demand, though he concludes that in the long run the effect on the US economy is negative.

The impact of these developments is clear in relative performance. Across countries, this decade has seen an enormous shift in relative growth performance between the US and EM countries. In the next subsection, we further elaborate on the US performance.

3.4. US CONSUMERS FEEL THE PAIN

Within the US there has been a significant change in the composition of US growth (Figure 3.9). Since the end of the 2001 recession exports have trended sharply upward as a share of GDP. Yet during this period, the external balance remained substantially negative. This figure shows that Americans were not as spendthrift as the large external balances or the very low personal saving rate might suggest. We note in the next section that energy demand is highly inelastic. Rising energy prices thus are associated with rising expenditures on energy. In the US in recent years, such rising energy expenditures were accomplished at least in part by squeezing non-energy consumption, which declined from 67 to 66 percent since the start of the decade—a sharp reversal of the upward trend. Similarly, an increasing share of the external imbalance is attributable to paying the energy bill. We focus on the consumer rather than firms because energy makes up a relatively large share of spending—about 7% at its peak—than it does for cost share in private industries which generally average less than 2%.[7]

Table 3.5 shows an estimated response of aggregate US consumption growth to changes in oil prices. The estimates are based on a non-structural regression, so the correlations it uncovers need to be interpreted with caution. The regression includes, among other controls, current and lagged real disposable personal income (DPI) growth. Since the direct income effect of oil prices is reflected in the deflator for personal income, the regression is meant to capture the incremental price effect. Broadly, these results support the view in the literature that there are multiple channels through which energy price changes affect consumption (Kilian (2008)). In addition to reducing discretionary income, higher energy prices may create uncertainty about the future and prompt a rise in precautionary saving. In addition, consumption of durables that are complementary in use with energy (notably autos) will tend to decline more than spending on other goods. Using our estimated consumption relationship that allows energy prices to influence consumption in two ways—directly and indirectly through depressing real disposable income—we can estimate the size of the drag on consumption from rising energy prices this decade.

Figures 3.10 and 3.11 show the estimated effects of oil prices on consumption growth based on the estimates in Table 3.5. In Figure 3.10, the solid line measures the effect of oil price movements on consumption through changes in real DPI, i.e., by isolating the contribution of gasoline prices to overall PCE deflator movements. The dashed line is the incremental effect of oil prices based on the estimated coefficient. Figure 3.11 sums these effects. The results suggest that the oil price drag on consumption has been substantial this decade. It is also interesting to note that the boost to consumption lift from the collapse in oil prices in 2009:1 is estimated to be the largest on record. Of course, these results (both the drag 2002-08 and the rebound in 2009) may overstate the effects of oil price movements; as noted above, there are offsetting effects when oil price movements are driven by demand.

7 Moreover, oil is unique among commodity prices in how it passes through to finished consumer goods prices. Note that consumption of fresh food makes up a larger share of US consumption than gasoline. However, commodities make up far less of the value added in retail food than crude oil does for retail motor fuel. To wit, whereas crude oil accounts for roughly 70% of the value added in a gallon of gasoline, milled field corn makes up less than 2% of the cost of a box of corn flakes cereal (despite being roughly 70% of the volume). The remainder reflects packaging, processing, advertising, transportation, and other costs. Thus, changes in the input cost of food tend to be absorbed by a multitude of other margins.

3.5. SUPPLY AND DEMAND EQUILIBRIUM

The previous subsections have focused on the demand side. To summarize, the period since the 2000s was one of strong world aggregate demand, especially in emerging markets. Despite brief disruptions such as the war in Iraq, supply shocks do not appear to be a precipitating factor in the run-up in prices in this period. Strong world demand alone cannot explain movements in price. There needs to be consideration of the supply-demand balance both in the period in question and over time.

Demand is highly inelastic, especially in the short run; supply has also been constrained as well (Hamilton (2009a, 2009b)). On the demand side, the surge in oil prices in the 1970s caused a shift in consumption towards less energy intensive activities, leaving the remaining consumption more price inelastic. And in many emerging market economies such as China, energy price subsidies insulated local demand from global price increases.

While our narrative has focused on the role of strong demand in driving up prices, supply also played a role. On the supply-side, capacity constraints have developed at each stage of production until the economic collapse in the second part of 2008: OPEC had been running at close to its productive capacity since 2004, refinery capacity was tight, storage facilities were and are limited, and tanker capacity was tight. As Figure 3.12 shows, despite the surge in oil prices in the past decade, the annual growth in oil supply has been steadily falling outside of OPEC. In the early part of the decade the Former Soviet Union (FSU) was increasing its average daily supply by about 1 million barrels per day (roughly 10% growth)) and while choppy, supply from other non-OPEC producers was rising. By contrast, in the last several years, the annual change in non-OPEC oil output has turned negative. Some of this can be traced to supply disruptions, but the more fundamental story seems to be that oil is getting harder and harder to extract.

The upshot is that a relatively small shock can cause a major change in prices.

3.6. WHAT IS THE LONG-RUN EQUILIBRIUM PRICE OF OIL?

There is remarkably little agreement in the industry about how to calculate the long-run equilibrium price of oil, or fair value. Industry experts generally adopt five approaches (Ahn and Morse (2008)). We describe these, and then in the next subsection, propose another approach.

> *Accounting.* One approach is an elaborate adding up of current and expected supply and demand. On the supply side, this includes detailed analysis of the speed of depletion of key fields, analysis of geopolitical events affecting the market, estimates of the cost of bringing new fields on line, etc. On the demand side, it generally involves estimating growth and price elasticities for a wide range of consumers.
>
> *Marginal cost.* Another approach is to calculate the marginal cost of production. This requires identifying the most expensive current supply source and assuring that the source has enough spare capacity to remain the marginal source in the face of rising demand. The favorite example of this seems to be the Canadian tar sands. "Industry experts generally believe these tar sands are economical at $85-$95/bbl [barrel] and the barrier should trend lower as technology improves and economics of scale are exploited" (Ahn and Morse (2008)).

Rule of thumb. A popular industry rule of thumb is that the retail price should be 3 to 4 times finding and development costs. A survey of 50 top oil companies found these costs averaged $17.46/bbl (Ahn and Morse (2008)). That implies a fair value of $52 to $70 per barrel.

Peak oil. Sitting in the background is the idea that as a finite resource, oil will run out some day (Ahn (2008)). This may or may not coincide with technological breakthroughs that sharply reduce the demand for oil. Thus if there is some terminal price beyond which zero oil is consumed, current prices should be determined by working back to the present on a price path that satisfies the Hotelling conditions. The problem with this is that small wags of the future "tail" can cause today's equilibrium oil price to move dramatically. Peak oil seems to come back every 20 years or so.

Cost regression. A more elaborate approach is to regress oil prices on a variety of cost variables. For example, Ahn and Morse (2008) use data from December 2003 to October 2007 and regress the five-year forward price on a variety of measures of the cost of oil production. The results suggest the equilibrium price in August 2008 was $80/bbl in the equation without the exchange rate and $88/bbl using the equation with the exchange rate.[8] Presumably there is some reverse causation going on here with the hot oil market bidding up the price of oil production.

3.7 MEASURING *q* FOR OIL

Here we describe an application of the familiar *q* approach to measuring asset values. Our novelty is the use of data in which there is unusually little ambiguity about whether value is determined by oil or other assets—namely, mergers and acquisitions of firms whose principal asset is oil reserves.

3.7.1. STOCK MARKET VALUE

The value of the numerator of *q* for oil, the spot price, is straightforward to measure. The value of the denominator, the value of oil in the ground, is more complicated to measure. One approach we considered would be to use the stock market value of oil companies. But large oil companies, in addition to owning oil reserves, have interests in distribution, refining, and sales of petroleum products, as well as lines of business not closely related to oil. While it might be possible to separately value these lines of business, errors in doing so might well be of the same order of magnitude, so we have not pursued that exercise in detail. Nonetheless, a quick look at the stock of two large, integrated oil companies is revealing. Figure 3.13 shows how little the stock price of Exxon and BP responded to the dramatic run-up in oil prices from the beginning of 2008 to their peak in mid-year. The prices were down for much of the first half of 2008. They started down before the peak in oil prices in mid-year and were down substantially by the time the stock market meltdown related to the financial crisis hit in late September. Hence, despite the record profits of the oil companies during the run-up in oil prices, their asset values had a very damped response to oil prices—precisely what a *q* theory of the spot market price of oil would predict.

8 The exchange rate was Bloomberg's DXY dollar index, with is based on six major world currencies: the euro, the Japanese yen, the British pound, the Canadian dollar, the Swiss franc, and the Swedish krona.

3.7.2. USING MERGERS TO ESTIMATE THE VALUE OF OIL IN THE GROUND

An alternative methodology for valuing oil in the ground is to use the market price of reserves.[9] Occasionally, individual oil wells are sold, but this market is likely to be far from representative (e.g., stripper wells). Mergers and acquisitions of firms whose principal asset is oil reserves, however, provide a financial market assessment of the value of oil in the ground. Daniel Ahn has done such a calculation based on data for mergers and acquisitions of oil companies provided by John S. Herold, Inc. The financial market value of a barrel of proven reserves is calculated by taking the market value of a merger or acquisition of a firm whose principal asset is proven reserves net of other assets of the company divided by the quantity of proven reserves. An obvious complication is the valuation of assets other than oil in the ground. These assets get valued as part of the M&A process. While there are clear difficulties in doing so, these values are presumably more reliable than done in conventional q calculations, which reflate book value of historical investments, because they are part of a financial transaction. Moreover, the calculations are based on mergers and acquisitions where the value of the proven reverses account for at least half of the value of the transaction.

Figure 3.14 shows the financial market value of proven reserves in the ground (black line). The above-ground price of oil—measured as the average of oil and gas forward prices—is shown for comparison (gray line). The ratio of the above ground price to the value of oil in the ground (ratio of gray line to black line) is a measure of q. For the period from 2002 to the beginning of 2006, except for some temporary fluctuations in the value of oil in the ground, the market value of oil in the ground and oil for above-ground delivery trend together closely. Beginning in 2007, they diverge persistently, with the value of oil in the ground being relatively flat and the value of delivered oil persistently higher. There is some volatility in the M&A data but two points are fairly clear. First, there was a persistent negative valuation gap from the middle of 2006 until the end of 2008. Second, the value of proven reserves was not following the pattern of above-ground prices. Like the stock price of the oil companies shown in Figure 3.13, the price of oil in the ground did not move at all in response to the sharp escalation in oil prices in early 2008. These results are quantitatively very significant. By the middle of 2008, q for oil, measured as the ratio of the two series in Figure 3.14, was 1-3/4. By the end of 2008, it was back to one.

The evidence from the stock market value of large oil companies and from the M&A value of smaller ones suggests that the price of oil was (a) warranted from 2002 to the beginning of 2006 (because prices and asset values moved commensurately), but (b) temporarily high from mid-2006 through early 2008 (because the increases in prices were not reflected in the asset value of oil). This evidence points to flow supply and demand factors as the explanation of the high and spiking oil prices. For reasons discussed above, flow supply and demand equilibrium price is not necessarily tightly linked to asset values because of a wide range of adjustment costs.

9 The authors would like to thank Daniel Ahn of Barclays Capital for supplying data and advice on this section.

3.8. FUTURE PRICES

Futures prices provide another window into long-run versus short-run equilibrium in the oil market. Surprisingly, in 2008 they tell a different story than do our q calculations. Figure 3.15 shows that, for most of 2008, the forward price of oil was essentially equal to the current spot price. For example, in January 2008, the spot price was $93 dollars per barrel and the 10-year ahead forward price was $87 per barrel. As spot prices spiked in the first half of 2008, the forward prices moved up essentially one-for-one. In June the spot price was $134 per barrel, and the forward price at all horizons was essentially equal to the spot price. Thus the forward oil market was consistent with the hypothesis that the changes in the spot price of oil were essentially permanent. Hence, the futures market does not tell the same story as the stock market valuation of the large oil companies or the M&A-based estimates of the q for oil. These markets did not appear to perceive the increase in oil prices during 2008 as permanent.

The decline in oil prices in 2008 also shows an interesting story. As oil prices started to decline from their peak in mid-year, the entire forward curve shifted down with the spot price. By September, the price for immediate delivery had fallen over 30% to levels just about $100 per barrel. The forward curves for August and September, like the ones during the run up in prices in the first half of the year, are essentially flat. Alquist and Kilian (2008) document that this flat pattern has been pervasive over the last 20 or so years.

The situation changed dramatically in the final quarter of 2008, when the financial crisis was in full swing and there was a clear understanding that there would be a sharp and perhaps protracted world-wide recession. Spot prices fell by almost $20 per month through the remainder of the year—reaching $40 per barrel at the end of the year. Instead of moving one-for-one as it had for the first 8 months of 2008, the forward curve remained somewhat anchored at the long end with future valuation in the $80s. By the end of the year, the long-futures price had fallen to $72 per barrel, but this value was almost twice the spot price.

Indeed, the premium of the futures price over the spot price at the end of 2008 was as large as it has ever been in the available data. Figure 3.16 shows the spot price and its difference with the 1- and 2-year ahead futures prices for data since 1987.[10] The positive slope of the yield curve—$21 dollars over the 2-year horizon in December 2008—is the largest positive forward premium (*contango* in the language of futures markets) exhibited in the sample. This outcome is completely consistent with the view that the world was temporarily awash in flow supply of oil relative to demand that had collapsed owing to the financial crisis. It points toward a current (January 2009) market assessment of the long-run price of oil somewhat above $70, and that the very recent declines in spot price reflect the world-wide slump.

What is striking is the complete absence of negative forward premium (*backwardation*) in the earlier part of 2008.

10 Futures prices at greater than 2-year horizons have been available only recently. The long futures prices are thinly traded (see Alquist and Kilian 2008).

To summarize, consider how the *q* for oil results of Section 3.7 and the evidence from the forward price of oil in this section relate to each other and shed light on equilibrium in the oil market in 2008. As discussed in Section 2, changes in the flow demand for oil can have sharp effects on the price of delivered oil even if they are temporary. Costs of extraction, delivery, and storage can detach the spot price of oil from its long-term asset value. The high worldwide demand for oil in the first half of 2008 and the collapse in demand in the second half of 2008 accordingly could account for the sharp increase and decrease of oil prices in 2008. The evidence from the *q* for oil calculations and the stock price discussed in Section 3.7 support this view. Likewise, the sharp upward slope in the forward curve for oil prices in late 2008 suggest strongly that the market perceived demand to be temporarily low. It remains a puzzle, however, that the forward curve for oil was quite flat when oil peaked in mid-2008. The results on *q* for oil and the stock prices suggest that such expectations of continued high oil prices had not been capitalized in the market value of petroleum companies or the value of oil in the ground.

3.9. SPECULATION

Proving whether there was a bubble or not is beyond the scope of this paper, but it is worth noting that the market was ripe for a bubble in 2008. Data on oil market fundamentals are very poor: for example, there is no publicly available data for judging the amount of inventories held in the ground or in many of the rapidly growing EM economies. It is our impression that oil was increasingly viewed as a "hot"new asset class. Indeed, with the collapse in housing, credit, stocks, etc., it could be argued that commodities were the only hot asset. Many investors were new to the market and may have seen the surge in buying as a signal of fundamental value. Experts were widely divided over what fair value was, so there was not an obvious counterparty to a bullish trade.

While it appears that oil prices were overshooting in 2008, the markets were not convinced and the futures curve remained relatively flat as oil prices surged. As we will see, most central bankers chose to accept the prices in forward markets.

4. INFLATION METRICS AND MONETARY POLICY: FACTS AND THEORY

In this section we explore the distinction between headline and core inflation. Headline inflation is overall inflation; core inflation excludes inflation in energy and food (though the fact that it excludes food is not important for our analysis). Section 4.1 summarizes recent inflation developments. Through much of the 2000s, rising oil prices lead to headline inflation rates distinctly higher than core inflation rates. Section 4.2 then reviews some theoretical literature on which measures of inflation are appropriate targets for a central bank. In particular, it considers the question: in the presence of shocks to oil prices that cause headline and core inflation to deviate, what inflation metric should the central bank target?

4.1 HEADLINE AND CORE INFLATION FROM 2002 TO 2007

We begin with a word on patterns of oil price movements. Hamilton (2009a) and Alquist and Kilian (2008) conclude that a good model for real oil prices is a random walk, though in statistical terms the random walk cannot be distinguished from a stationary but very persistent process. This persistence manifests itself in a spiky pattern (Figure 3.1). Oil prices either jumped to a new level and stayed there for a long time as in 1974-75, 1979-80 and 1986 (to the downside) or they spiked up and came down quickly as in 1990-91. The last decade witnessed a new kind pattern: a sustained upward trend. As Blinder and

Rudd (2008) point out, "an *ever-increasing* relative price of energy is fundamentally illogical; but recent events have shown the world that such a path can persist for a long time" (p. 12).

Headline inflation ran ahead of core inflation for much of the period of persistent oil price increases. See Figure 4.1 for the United States. In the United States from December 2001 to December 2007, the cumulative gap between US headline and core PCE inflation was 3.9 percentage points (almost 0.7% per year). Suppose that the Fed wants to on average keep core inflation at 1.75%.[11] Relative to that rate of inflation, the cumulative "overshoot" of core prices was 1.5 percentage points and of headline inflation was 5.4 percentage points. These are relatively big numbers: the average 0.9 percentage point overshoot of headline inflation was 50% above the "target."

Table 4.1 shows similar calculations for the UK and Japan, as well as the United States and Euro area. For the period as a whole, headline inflation has overshot the ECB target by about twice as much as the Fed, but the core has actually been below target. On average headline inflation has been right in the middle of the Bank of England's 1 to 3% range. Headline inflation in Japan has been below the midpoint of the 0 to 2% target range (which only was officially announced in March 2006).

Inflation developments outside the major economies were also instructive.[12] Here we focus only on regional aggregates. As in a number of developed economies, both core and headline inflation were well behaved in emerging markets through the end of 2006. As Figures 4.2 and 4.3 show, both unit labor costs and core inflation fell over this period and headline inflation was subdued.

Unfortunately, other things were not so calm. The long boom in emerging market growth, was putting increasing pressure on capacity in emerging market economies—for example, a simple gauge of resource utilization rose above its 1993-2000 average in 2004, peaking at 2 standard deviations above trend in 2008 (see below, Figure 6.4). Policy makers adopted a number of measures to dampen inflation expectations—rising policy rates, reserve requirements and exchange rates, imposing capital controls and price controls—without curbing the pressure. Throughout 2007 and 2008, emerging market inflation accelerated significantly. By the end of the period, core inflation had surged in emerging markets and picked up slightly in developed economies as a group.

4.2 THEORY: OIL PRICES AND MONETARY POLICY IN NEW KEYNESIAN MODELS

In this section we review a literature that uses a certain class of formal models to consider how monetary policy should respond to inflation when there are alternative measures of inflation. These models take as given that inflation expectations are anchored; that is, the public correctly perceives the inflation target of the central bank. The basic conclusion of these models is that variability of core inflation is a better measure of economic welfare than is variability of headline inflation. Hence core inflation is a more appropriate target than headline inflation. After outlining the logic of these models, we return to note the dependence of the models on the assumption that inflation expectations are anchored.

11 The assumption here is that this is the midpoint of the comfort zone of the committee. This seems to be the case both from public comments and from the initial 3-year ahead forecast of FOMC members in October 2007. A few FOMC members may favor a lower band.

12 This discussion draws heavily on Hensley et al. (2008).

The theoretical approach that we review has come to dominate both academic and central bank analyses of monetary policy. This is the so-called new Keynesian approach, exposited quite thoroughly in Woodford (2003). Our appendix develops a new Keynesian model that incorporates oil prices. We use it below to illustrate some of our arguments and conclusions about recent US monetary history.

In the new Keynesian model, optimal government policy includes a role for monetary policy because of price and wage stickiness. This stickiness is feasible because of imperfect competition in product and labor markets. Staggered setting of prices and wages leads to relative price distortions that can be ameliorated by monetary policy.

We begin first by reviewing results on the form of the loss function for optimal policy, and then turn briefly to the form of policy rules. Consider a baseline version of this type of model—closed economy, all prices and wages set according to scheme originated by Calvo (1983), labor the only factor of production—that appears in textbooks such as Woodford (2003) and Galí (2008). In such a model, to maximize the expected utility of the representative household, the central bank should target a weighted sum of variation in (sticky) wage inflation, (sticky) price inflation and the output gap. The weights depend on the parameters of tastes and technology. That is, optimal monetary policy trades off variability in inflation and real activity, with the terms of the tradeoff determined by parameters of tastes and technology. See, for example Woodford (2003, ch.6) or Erceg et al. (2000).

The parenthetical "sticky" was inserted in the previous paragraph to emphasize that the goal is to ameliorate effects of sticky wages and prices. Aoki (2001) shows that if there is a competitively produced consumption good, optimal monetary policy ignores fluctuations in the price of this good. This result holds regardless of the volatility of the price of such a good. The intuition is that fluctuations in the price of a competitively produced good are market signals that serve to appropriately direct resources. In other words, Aoki's result, and the related results in Mankiw and Reis (2003), suggest that variability of core rather than headline inflation is a better target for monetary policy, if the difference between the two is due to inflation in competitively produced consumption goods.

Of course, Aoki's (2001) result further implies that core inflation itself might not be a good target, if some products that are included in the core inflation index are sold in competitive markets. (This point has been made, for example, by Wynne (2008).) It would take us too far from our topic to pursue this point. So we take as given that with respect to choice of price index, the question is whether to target core or headline inflation. For the purpose of our present discussion of new Keynesian models, we assume that the sole difference between the two inflation measures is inflation in the price of oil.

To consider the possible role of oil requires extensions of the model described above. The first two extensions follow from the fact that oil is not only consumed but is a factor of production. This has two implications. A direct implication is that exogenous increases in oil prices have effects similar to an exogenous fall in productivity: we require more resources to produce a given amount of output. In the jargon of new Keynesian models, the efficient level of output changes when oil prices move exogenously (Bodenstein et al. (2008), Nakovy and Pescatori (2009)). Policy should therefore recognize that many of the real effects of oil prices are ones that reflect desirable reallocation of resources, just as policy should recognize that technology shocks lead to desirable reallocations.

A second implication is more subtle. Bodenstein et al. (2008) extend the baseline model described above to allow for oil that is consumed and used in production. They conclude that insofar as oil feeds into decisions made by producers with market power, optimal monetary policy will depend in part on variation in oil use. But they also conclude that as a practical matter, energy shares are sufficiently small in the US that the resulting policy will be very similar to one that ignores oil use variation. Hence they conclude that the measure of consumer price inflation variability that is appropriate for monetary policy is variability of core rather than headline inflation.

Third, oil prices are determined in a global economy, with the US market arguably taking oil prices as given. This raises the question of how monetary policy should operate in open economies. To our knowledge, and even limiting ourselves to literature that builds closely on the framework described above, there is not a consensus how open economy considerations affect policy. One vein of research (Clarida et al. (2002)) argues that optimal monetary policy is essentially the same in open and closed economies. More recent research (Engel (2009)) finds that optimal policy in an open economy may be quite different than that in a closed economy if sticky prices lead to divergences in prices of a given good across countries. In open economies, then, this class of models does not deliver a clear guideline as to appropriate measures of inflation.

But even Engel's (2009) results imply quantitatively large effects only if the import and export sectors are large. It is our sense that the US remains sufficiently insensitive to world factors that the closed economy advice is probably a good starting point. For example, we noted in section 3 that although growing global demand boosted U.S. exports, the most visible effect of rising energy prices was an increase in energy expenditure and a squeezing of non-energy expenditures. We thus summarize our review of results on the form of the loss function for optimal monetary policy as: in closed or nearly closed economies, and in the class of models that have come to dominate academic and central bank thinking on monetary policy, the measure of consumer price inflation variability that is relevant is core rather than headline inflation.

What form of policy rule will allow the central bank to achieve its goals of appropriately trading off variability in core inflation against variability in real activity (and variability in wage inflation, when wages are sticky)? Under some simplifying assumptions about dynamics and commitment, an interest rate rule that sets the interest rate in response to real activity and to actual or expected inflation can achieve the optimal tradeoff. Under dynamics rich enough to well mimic actual behavior, the optimal interest rate rule might implicitly or explicitly respond to various signals about the state of inflation and real activity, and not take a simple textbook form. Hence one might want to look to headline inflation, or to inflation in oil prices, as a signal, even if the goal is to achieve a desired level of variability of core inflation. We acknowledge this possible role for oil prices, but use our limited time and space to focus on other issues.

Let us now step outside this class of models to note the possible crucial dependence of the model's results on the assumption that inflation expectations are model consistent and therefore by assumption anchored as long as the central bank follows a stabilizing policy. Bean (2006) agrees that logic such as that spelled out above calls for targeting core inflation. But he also notes that if we accommodate oil price increases, there is substantial risk:

> Can we be sure that households and firms will behave appropriately and that medium-term inflation expectations will remain anchored? At present, that is not something the literature helps us answer. But given the potential costs of restoring credibility once it is lost, it may be better to err on the side of caution.

Hence a key question in our analysis of US monetary policy is whether a focus on core inflation might have let inflation expectations drift upwards. We focus on this question—both in the data and with simulations of the new Keynesian model—in the next section. The workhorse new Keynesian model presumes that inflation expectations stay anchored. In Section 5 we explore the validity of this presumption. In Section 6 we evaluate monetary policy in the 2000s—policy that was implemented under the presumption of anchored inflation expectations.

5. INFLATION EXPECTATIONS: ARE THEY ANCHORED?

In Section 5.1 we examine various measures of inflation expectations. In Section 5.2 we study whether they remain anchored following oil price shocks. In Section 5.3 we use a version of the new Keynesian model to see how stable inflation will be in response to a five year, persistent escalation of oil prices such as we saw in the 2000s.

5.1. INFLATION EXPECTATIONS IN THE 2000S

In recent years central bankers can with considerable justification point to changing inflation dynamics as evidence of improved anchoring of inflation expectations. For example, in a speech in March 2007, Fed Governor Mishkin argued that central bank credibility had helped alter inflation dynamics. He noted that inflation had become less persistent, with a sharp decline in the sum of coefficients on lagged inflation in a simple autoregression. More sophisticated tests of persistence from Stock and Watson (2007) and Cecchetti et al. (2007) confirm an anchoring of trend inflation not just in the United States, but in a number of developed economies. Moreover a number of studies have shown that inflation had become less sensitive to the unemployment gap and to energy price shocks (e.g., Hooker (2002), Carlstrom and Fuerst (2008)).

Mishkin (2007) argues that given the importance of expectations in the standard new Keynesian Phillips curve model, "a natural first place to look for explanations of changing inflation dynamics is a possible change in the expectations-formation process." He argues that the anchoring in the inflation trend is due to anchoring of inflation expectations. He points to low and stable measures of inflation expectations. "With expectations of inflation anchored, any given shock to inflation—whether it is from aggregate demand, energy prices or the foreign exchange rate—will have a smaller effect on expected inflation and hence on trend inflation."

The Federal Reserve monitors three measures of inflation expectations: surveys of consumers, surveys of economists, and market-based measures (there is no survey of firms' inflation expectations in the United States).[13] Each measure is only a noisy proxy for the underlying economic concept that ultimately matters: businesses' price-setting behavior.

13 This section draws heavily on Harris and Pandl (2008a, 2008b).

Both the University of Michigan and the Conference Board compile consumer surveys, but judging from Fed speeches and meeting minutes, the Fed puts much more weight on the former. The Michigan one-year expectation spiked to 5.2% in May 2008, up almost two percentage points from the same month a year earlier. More importantly, consumers' long-run expectations—the amount they expect prices to rise over the next five to ten years—rose to 3.4%, from an average of about 3% over the prior five years (Figure 5.1). Given the stability of this series in prior years, this seemed like a plausible sign of deteriorating inflation expectations.

The Fed monitors two main surveys of economists: the Philadelphia Fed's Survey of Professional Forecasters (SPF) and confidential surveys of primary dealers. We discuss the SPF. The 10-year CPI forecast from the SPF, after dipping slightly in 2007, in the first half of 2008 rose to the same level it held at for most of the past decade (again see Figure 5.1). While the Fed put significant weight on this measure—it appears in its large-scale forecasting model FRB/US, for example—this survey too has disadvantages. It appears perhaps too stable, indicating forecast inertia rather than a super-credible central bank.

Finally, the Fed tracks measures of inflation expectations derived from the bond market by comparing nominal interest rates with rates on securities that are inflation protected. The 5-year, 5-years forward "breakeven rate" is its preferred benchmark (Figure 5.2). Breakeven rates carry two key advantages over surveys: they are timely, and they are based on market-transaction where substantial sums are resting on the implied forecasts. Deriving true inflation expectations from breakevens requires adjusting for premiums for liquidity, convexity, and inflation risk.[14] The 5-year breakeven estimate increased relatively sharply during the first quarter of 2008. Yet, as of mid-June, the 5-year breakeven estimate of expected inflation was about 2.5%, only slightly above their average since 2004. A big problem for the Fed was that it could not be sure how much of this move to the middle was due to expectations of rate hikes.

Outside the United States, what data are available suggest a pattern similar to the United States: expectations were well contained for most of the oil price run-up, but inched up in the summer of 2008. The UK breakeven estimate (Figure 5.2) had a steadier, and in 2008, a more considerable increase. Most countries have surveys of economists, many have surveys of consumers and least common are market-based measures of inflation expectations. For example, in the Euro area, a qualitative measure of consumers' 1-year inflation expectation is compiled monthly by the European Commission, but the answers generally track current headline inflation. The ECB asks economists to provide both inflation forecasts and the probability of inflation exceeding 2% for four or five years ahead. In the summer of 2008 the median long-term inflation forecast was stable at 1.9-2.0%—i.e. exactly matching the ECB's target of "below, but close to, 2%." However, the probability that inflation could be at 2.0% or above was rising: from 46.8% a year earlier, to 50.4% in the Q2 2008 survey to 56.9% in the Q3 2008 survey. Finally, the ECB publishes a seasonally adjusted 5y5y breakeven rate in its Monthly Bulletin. The rate moved above its long-term average (2.25%) at the end of 2007 and to above 2.50% in the summer of 2008.

14 In October 31, 2008, the Cleveland Fed suspended posting its liquidity-adjusted inflation forecasts based on TIPS. According to announcement on its WWW page, "We have discontinued the liquidity-adjusted TIPS expected inflation estimates for the time being. The adjustment was designed for more normal liquidity premiums. We believe that the extreme rush to liquidity is affecting the accuracy of the estimates."

5.2. DO OIL PRICES MOVE EXPECTED INFLATION: EMPIRICAL RESULTS

In this section, we present some direct evidence on the inflation expectations-oil price linkage. To do so, we estimate a simple time series model of expected inflation, actual inflation, and oil prices. We consider four different measures of expected inflation. From the University of Michigan Survey of Consumers, we use the median values of the annual percent change of expected price at 1-year and 5- to 10-year horizons. From the US nominal and inflation-protected Treasury yield curves, we use the implied breakeven inflation rates for 5-year ahead, 5-year inflation (horizon 5 to 10 years) and 10-year inflation (horizon 0 to 10 years). We do not perform an econometric analysis of the Survey of Professional Forecasters because it has so little movement.

The statistical model is specified as a recursive vector autoregression with core inflation ordered ahead of the expected inflation measure. The change in log nominal oil prices is treated as exogenous. The VAR is estimated with three lags. It is estimated using monthly data over the sample periods indicated in Table 5.1. The 1-year Michigan inflation expectations go back to 1978, but we started the estimation in 1983 so that it applies to the post-Volcker deflation regime. The estimation period of the other series begins at different dates according to availability of data.

The first column of numbers in Table 5.1 shows the *p*-value for the test of the hypothesis that the coefficients of oil price change are jointly zero in the regression of expected inflation. The second column of numbers gives the results of the same test for the coefficients of core inflation. Oil prices are strongly significant in explaining the Michigan 1 year inflation expectations and moderately significant in explaining the Michigan 5-10 year inflation expectations and the 10-year TIPS implied inflation. They are not significant for the 5-year ahead, 5-year TIPS implied inflation, for which there is only a short sample. Core inflation also moves the Michigan expectations, though not too much should be made of this result because the estimated effects are quite small.

Figure 5.3 shows the historical contribution of oil price changes to the measures of expected inflation based on the estimated VAR and the historical series for oil prices. There are very significant moves down in the 1-year Michigan expected inflation coming from the collapse in oil prices in 1987 and the spike in oil prices at the time of the first Iraq war. The results thus illustrate that there is non-trivial response of this series to oil prices. In the 1990s, oil was on average a negative factor for inflation expectations. Toward the end of the decade, the drop in oil prices was an important contributor to the falling inflation expectations.

Our focus is the 2000s. Oil price changes significantly raised inflation expectations on average throughout the decade. Their effect on inflation expectations is not that persistent, so the volatility of oil price changes—despite the fairly persistent increases, there were some declines—shows up in Figure 5.3. The response to oil price changes of the longer-horizon measures of inflation expectations have a similar pattern as the 1-year expectations, but the response of long-term expectations is much more muted. It is not surprising that the long-run inflation expectation measures move less than short-term ones. Nonetheless, it is important to note that long-term inflation expectations measures are not entirely anchored with respect to movements in oil prices.[15]

15 Using the Michigan survey data, Huang and Trehan (2008) conclude that inflation expectations are well anchored. Their setup and method of calibrating stability of expectations are quite different from ours, with one notable distinction that we include oil prices in our regressions and they do not.

For the 5-year ahead TIPS expectation, the Fed's confidence that expectations were relatively well anchored has some justification. The 10-year TIPS expectation does suggest some persistent pass through of oil to headline inflation expectations. It is as if the markets are expecting—for the next five years that there would be more of the same experience as recently—that headline inflation would run high, but there was no longer-term shift in the inflation target.

The Fed tends to discount the Michigan inflation expectations result, in part because they are well known to react sharply to oil price changes in the way we document. One interpretation of these reactions is that household respondents put too much weight on prices they see frequently, e.g., gasoline. And that the boost that energy prices give to the survey measures of expectations subside once the price shock passes. We caution, however, against being overly dismissive of the household expectations data. While it is true that the 1-year expectations move up and down with oil, the 5- to 10- year expectations are smoother. The persistent increase in oil prices in the 2000s pushed up this longer-run measure of inflation expectations persistently. Moreover, Figure 5.3 shows that the consumers' survey responses and the 10-year TIPS estimate moved very similarly in response to the accumulation of oil price increases since 2002.

Thus, in a period such as we saw from 2002 to mid-2008, where oil prices caused headline inflation to run persistently ahead of core, there is a risk of expectations becoming unanchored. In the next section, we simulate a new Keynesian model to evaluate this concern.

5.3. PERSISTENT OIL PRICE INCREASES: SIMULATED RESPONSE

The findings of the previous section suggest that oil prices have a special role in inflation expectations and therefore the Fed, notwithstanding the implications of the benchmark model, might want to take into account oil prices directly, or headline inflation rather than core inflation, when setting interest rates. The results in the previous section are strictly empirical. The new Keynesian model presented in the Appendix also suggests to us that expectations about core inflation might become unhinged if there is a long sequence of positive shocks to energy. To explain this result requires that we briefly describe the model and some results.

Our model takes as its starting point a new Keynesian model found in texts such as Galí (2008, ch. 3) and Walsh (2003, ch. 5.4). In this starting point model, there is a composite consumption good. Labor is the only factor of production. The economy is closed. Our extension adds "energy" as a second consumption good and second factor of production. We assume that all energy is imported. Part of the good that we produce is used to pay for imported energy, with the remainder consumed. Trade is balanced every period. The real price of energy is exogenous. Households consume a Cobb-Douglas aggregate of energy and the good that we produce; firms produce with a Cobb-Douglas production function that requires labor and energy.

Most of the Appendix is devoted to documenting that this model strongly argues for targeting core rather than headline inflation. That is, when we make the domain of our analysis similar to that of earlier studies such as Bodenstein et al. (2008), Dhawan and Jeske (2007) and Duval and Vogel (2008), we find results similar to ones found in those studies. Let us first summarize this traditional domain, and then move to a non-traditional domain that involves a long sequence of positive energy price shocks. To make sense of the discussion requires introduction of a few elements from the model. The Appendix contains a complete discussion.

In our model, core inflation, which we denote π_{qt}, is simply inflation in the price of our produced good. Headline inflation is inflation in the market basket purchased by consumers. This market basket has a weight θ on energy, a weight 1-θ on our good. US data suggests that a plausible value of θ is low, perhaps as low as .02 if one interprets energy narrowly as direct purchases of oil and gas, but in any case not higher than .06 even if one interprets energy more broadly.

In any event, whatever the value of θ, headline and core inflation are related via

(5.1) $\pi_{ht} = (1-\theta)\times\pi_{qt} + \theta\times$(inflation in the price of energy).

We assume a simple monetary policy rule in which the interest rate responds only to a measure of inflation, with both core inflation π_{qt} and headline inflation π_{ht} considered candidate measures. If i_t is the interest rate, our two monetary policy rules are:

(5.2A) "target core": $i_t = 1.5\pi_{qt}$

or

(5.2B) "target headline": $i_t = 1.5\pi_{ht}$

These rules obviously are quite simple, but are adequate for our purposes. One novelty of our analysis relative to studies cited above is that we allow for a rich set of possible assumptions about stickiness and persistence of prices and wages; we experiment with 10 different sets of parameters in all. These various assumptions lead to similar conclusions. We noted in section 4.2 above that models such as ours suggest that welfare, measured as expected utility of a representative household, is a weighted sum of variances of measures of inflation and real activity. Smaller values imply higher expected utility. Which variances are appropriate depend on assumptions about price and wage stickiness. But in all 10 of our specifications all the relevant variances are smaller under core (equation 5.2a) than headline (5.2b) inflation targeting. Hence expected utility is higher under core than under headline inflation targeting: our model finds results found using similar models in the past. See the Appendix for details.

We bury the (lengthy) development and presentation of these results in the Appendix (sections A.1 through A.4), because the salient point of such results is that we are working with the type of model that has been used in the past to endorse a core rather than a headline inflation target. We now ask a question that, to our knowledge, has not been addressed with this class of models: What happens if there is a long series of generally positive shocks to energy prices?

To answer this question, we assume core inflation targeting (equation (5.2a)), on the presumption that core inflation has been the target for US monetary policy. One of the implicit maintained assumptions of the model is that expectations are model consistent and policy is credible; the public correctly understands the monetary rule and the inflation target (normalized to zero). In our view, that maintained assumption is called into question if core inflation is above target for an extended period of time. So, our question is: can a plausible series of energy price shocks push core above target for an extended period of time?

We constructed our series of energy price shocks as follows. We fit an AR(1) in the real oil price, quarterly (last month of quarter), 1983:2-2008:2. We used the 26 quarterly residuals, 2002:1-2008:2, as shocks. As one might imagine, the residuals in this deliberately chosen period tend to be positive, with an average value of 7.4% (or about 30%, at an annual rate); 18 of the 26 residuals were positive, while only 8 were negative. We assume that we begin in the steady state of the model. We fed in this series of 26 shocks and ask how core inflation responds, for each of our 10 parameter sets.

The results varied somewhat across parameter sets. But in every parameter the response of core inflation was positive in every quarter. That is, core inflation was above target; the core price level (relative to the trend implied by the target inflation rate) rose monotonically through the 26 quarters. None of the 8 negative shocks to energy prices sufficed to move core inflation back to or below its target (steady state) value of zero for even a single quarter.

The actual numerical value of the rise varied from parameter set to parameter set. But the annual rate of core inflation was typically about 2%-4% above target. This range applies even if we truncate our sample a year or two prior to 2008:2. See Appendix section A.5 for more details.

Of course, the United States did not see core inflation at this level (2% to 4% above a target presumed to be around 1.75%) in the actual data. We noted above that core inflation remained stable (Figure 4.1 and associated discussion). Obvious reasons that our simulations say otherwise include that we start off the exercise with all variables (including core inflation and real activity) at steady state, that we are shutting down other shocks—no collapse in credit markets at the end of the sample in our exercise!—and that the model itself makes simplifying assumptions. But we take as the lesson of this calculation that even when expectations are well anchored, core inflation can and will accelerate if there is a long series of positive energy shocks. And in our view, such an event can plausibly be precisely the trigger for inflation expectations becoming unanchored, as indicated in the results in Section 5.2 and as noted in the quotation from Bean (2006) in Section 4.2.

6. MONETARY POLICY AND OIL PRICES, 2002 — 2008 AND BEYOND

6.1. SURGING OIL PRICES AND MONETARY POLICY 2002 TO 2007

The surge in headline inflation documented in the previous section provided a series of challenges to policy makers. Here we first consider the response to the steady rise through 2007 and turn to the boom into the summer of 2008. As we will see each stage of the oil price rise posed a unique challenge to central banks. Of course, we attempt to look at the episode with the information at hand in real time rather than 20-20 hindsight. Note that while we discuss the actions of other central banks, the Fed is at the center of our narrative and other banks are brought into the picture mainly for comparative purposes.

The chronically high headline created a problem for central banks regardless of whether their official target was core or headline inflation. An effective inflation target should be "transparent"—easily understood by the public—and achievable—so the public has confidence that deviations from plan are corrected in a reasonable period of time. The experience of this period illustrates that there is no "right" policy rule. On the one hand, chronic high headline inflation makes a core targeter look increasingly incredible. Hence as the commodity boom continued, a growing refrain in the press was that inflation was low as long as you didn't drive, heat your house or eat.

The Fed was on the defensive, explaining why the core was the right measure (and not some kind of dodge to avoid responsibility) and explaining why a growing list of inflation indicators—the dollar, oil and gold prices, real interest rates, etc—might not be good indicators of the underlying inflation risk. As we saw in the previous section, measures of inflation expectations suggest the Fed had not completely won the public relations battle. While most FOMC members seem to favor average inflation of less than 2%, economists, markets and the general public all expected, to varying degrees, that the Fed will on average overshoot its "target" in the decade ahead.

It is also worth considering the Fed's focus on the core in the context of the broader policy environment during this period. By the end of this period not only were there concerns about the persistence of headline inflation, but there were growing signs of a potential bubble in the housing and credit markets. None of these booms was unique to the United States—home prices boomed in many countries and the surge in oil prices seemed more correlated with the strength of emerging markets than the United States. Nonetheless, with its high sensitivity to oil and with a weak dollar, a case can be made that the Fed was too sanguine about the ongoing low core inflation. It seemed that the Fed was relying too much on its anti-inflation credibility and not enough on actual policy tightening.

Of course, with the collapse in oil prices and the jump in global spare capacity, we now know that much of the overshooting of headline inflation in the United States and Euro area is being reversed as of this writing (January 2009). The collapse of oil prices and of world-wide aggregate demand, however, was not built into the expectations of central bankers even at the end of this period (summer of 2008). In forecasting oil prices, the Fed and many other central banks were assuming futures markets were as good as any forecast model, suggesting the prices of oil and other commodity prices would level off—not fall—in the years ahead. The committee wrote,

> Rates of both overall and core inflation were expected to decline over the next two years, reflecting a flattening out of the prices of oil and other commodities consistent with futures market prices, slack in resource utilization, and longer-term inflation expectations that were expected to remain generally well anchored.[16]

The Fed and other central banks were also predicting only a modest rise in spare capacity, and that headline inflation would converge to a core level still at the upper end of their formal or informal targets (see Table 6.1 for FOMC projections). It remains an open question how the Fed and other central banks would have responded had inflation not collapsed as a result of the financial crisis.

In sum, the Fed may have overplayed its hand in trying to focus public attention on core rather than headline inflation. It ended up forgiving a significant stretch of above "target" inflation. As we will see, this legacy of persistently high headline inflation, added to the policy challenges in 2008.

It is worth asking: if the Fed was too complacent about high headline inflation, what should they have done differently? Some economists argue that the Fed should not have cut rates to 1% in 2003. But given the deflation risks at the time, this seems like an appropriate application of "risk management." A more appropriate criticism is that the Fed stuck to its "measured pace" tightening in the face of persistently high headline inflation, the signs of "froth" across the capital markets and the housing market, and the persistent increase in oil and other commodity prices. The slow and steady rise in rates from emergency

16 Monetary Policy Report to Congress, July 15, 2008 www.federalreserve.gov/boarddocs/hh/2008/july/fullreport.htm.

low levels did not provide real restraint on the economy or asset markets. So our advice—based, we believe, on information available at the time rather than with hindsight—is that they should have put a bit of "fear of the Fed" into the market. Possibilities include mixing in a few 50 basis points hikes, speeding up the tightening process, and having a somewhat higher target rate at the end of the series of rate increases.[17, 18]

6.2. OIL AND MONETARY POLICY IN 2008

The final blowout boom in oil prices in 2008 provided an even bigger challenge to policy makers. How would the new generation of policy makers, with their commitment to targets and transparency, respond to the worst stagflationary environment since the 1970s? The oil surge not only added to building inflation pressure, but also added downside risks to a global economy already facing extreme economic and capital markets stress. At the time there was a hot debate among energy economists about how much of the increase was "fundamental"—limited supply and concerns about "peak oil"—and how much was "speculative"—driven by either investment flows or simply price-trend extrapolation. (See our discussion of oil valuation in section 3.) Regardless of the exact cause, the fact that the surge in oil prices was accompanied by a sign of weaker energy demand in the United States (and stable demand elsewhere) means that the shock clearly was not a signal of strong global demand.

Which risk was greater in the summer of 2008: an "ungluing" inflation expectations or an "ungluing" of the economy? More precisely, was there a greater risk that inflation expectations would rise and "reglue" at a stubbornly high level or that negative feedback loops would build, causing a "low growth equilibrium" or a "nonlinear break" in the economy. Furthermore, how did central banks handle the possibility of a bubble in the oil market?

In light of the collapse in capital markets, the economy and oil prices following the Lehman bankruptcy the correct policy choice in the summer of 2008 is obvious. In real time, however, there was a deep split in the economics profession about whether aggressive policy responses—including both big rate cuts from the Fed and financial sector bailouts in both Europe and the United States—were warranted and about the relative risks to growth and inflation of expansive monetary policy. Thus, oil prices and upward pressure on inflation expectations ended up being a sideshow in 2008 and for policy decisions for the foreseeable future. Nonetheless, it is useful to try to ascertain the lessons for inflation and monetary policy from this episode.

17 See Taylor (2007), who presents a counterfactual simulation that suggests that such policies would have smoothed the up and down of the housing market.

18 Harris (2008) argues that the Fed's "open mouth operations" during this period also erred on the side of being too easy. Specifically, Chairman Greenspan and other Fed officials may have encouraged asset bubbles by arguing that the rise in prices was justified by economic fundamentals or by denying that a bubble could be identified. Harris concludes, "My advice to the Fed is simple. When asset markets are hot, do not add fuel to the fire by denying that a bubble exists or arguing that economic fundamentals are pushing up prices." Putting a new twist on an old expression, when it comes to a potential asset bubble, "If you don't have anything bad to say, do not say anything at all."

6.3. PICK YOUR POISON: OIL PRICES, RECESSION RISKS AND INFLATION EXPECTATIONS

How serious was the recession risk from the vantage point of the summer? The consensus forecast in the spring and summer of 2008 was for weak, non-recessionary growth in the year ahead. For example, the consensus forecast in the July Wall Street Journal poll was for moderate growth and a gradual tightening of Fed policy. The market was even more confident that the Fed would be hiking rates (again see Figure 6.1). Outside the US forecasters were even more confident. In its July survey Consensus Economics was not expecting negative GDP growth in any of the countries covered. Central bank forecasts, where available, also assumed a relatively benign baseline.

Despite the optimistic baseline forecast, most economists saw major downside risks in the year ahead. The average forecaster saw a 63% chance that the economy would be in recession during the next 12 months (Figure 6.2). Despite a cut in the funds rate to just 2% and extraordinary efforts to open up the capital markets, there seemed to be a negative feedback loop between the economy, asset prices and credit. Credit spreads had stabilized following the resolution of Bear Stearns, but remained at recessionary levels; the Senior Loan Officer survey showed the fastest tightening in lending standards in the history of the survey; home prices were continuing to drop; financial institutions continued to report large loses and aggressive attempts to reduce leverage.

In the summer of 2008 there was a growing split in the central bank community about whether inflation expectations were becoming unglued or not. The audience at the Fed's Jackson Hole Conference in August 2008 seemed evenly split between those who were more worried about the credit crunch—most business economists and US central bankers—and those worried more about rising inflation risks—most academics and European central bankers.

Within the Fed the easing back of the credit crisis, combined with signs of rising inflation expectations, unleashed a major debate between FOMC "hawks" and "doves." On the one hand, there were one or two hawkish dissents at each FOMC meeting through August 2008 and for the year as a whole there were the most dissents since 1992 (Figure 6.3); in speeches, hawks like Philadelphia President Plosser, argued that the "very accommodative stance" of policy would need to be reversed "sooner rather than later" (Plosser (2008)). Thus at the June FOMC meeting, "A significant majority of participants viewed the risks to their forecasts for output growth as weighted to the downside, and a similar number saw the risks to the inflation outlook as skewed to the upside." (Monetary Policy Report)

Despite the very vocal concerns of the hawks, the majority of the FOMC was not convinced that expectations were unglued (or at least not convinced that they were unglued "enough" to warrant hiking rates). In response to this hawkish rhetoric and growing expectations of rate hikes (Figure 6.1 above) both Vice Chairman Don Kohn and Chairman Bernanke gave speeches confirming that concerns about inflation expectations had risen, but not enough to trigger a rate hike. For example, in a speech on 10 June, Bernanke (2008) warned "The Federal Open Market Committee will strongly resist an erosion of longer-term inflation expectations, as an unanchoring of those expectations *would be* destabilizing for growth as well as for inflation" (emphasis added). Reading the sentence carefully, he was talking about a hypothetical situation when he said that unanchored expectations "would be destabilizing." Testifying to Congress on July 15-16, Bernanke was noncommittal: "balancing the risks to the outlook for growth and inflation is a significant challenge."

Was this just wishful thinking? Should the Fed have moved from "open mouth operations" to actual policy tightening? While inflation expectations were clearly rising in the summer of 2008, this does not necessarily mean that they were becoming "unglued." If inflation expectations were reacting to current inflation in a "linear" fashion and if inflation was likely to fall in the coming year, then the rise in expectations should not have been a concern. This is the case if either there was a bubble in energy prices or if prospective weak economic growth was likely to bring down inflation.

The ECB, viewing the world rather differently from the Fed, did tighten in the summer of 2008. In our view, this was a bit of overkill since growth was already weakening rapidly. On the other hand, the ECB correctly worried about its credibility in 2005 and 2006—after all, it is a relatively new central bank and its official target was headline inflation.

While it is a tough judgment call, and it is hard to avoid creeping 20-20 hindsight, we think the Fed's decision to remain on hold in the summer of 2008 was correct. The risk of a nonlinear break in the economy diminished in the earlier part of the summer, but remained a major risk. Moreover, if the Fed never draws on its reservoir of anti-inflation credibility, then it is of no value. A point in time when there was serious risk of a sharp economic downturn is the right time to use that capital.

Before we conclude this discussion of policy, it is worth drawing a few lessons from the emerging market economies' policy response to rising energy and headline inflation, in both the early and late parts of the period of rising oil prices.

In section 3 we argued that emerging market economies accounted for most of the demand surge that drove oil prices higher. We also noted that EM economies—particularly in Asia—benefited the most from the recycling of petro dollars. It is perhaps then not surprising, as we argued above, that there were signs of overheating in the emerging markets as early as 2007 and by 2008 a serious inflation problem was brewing. In a large measure this reflected an unwillingness to take politically tough decisions. A number of economies tried to control inflation with price controls on the offending items. As Figure 6.4 shows, real central bank interest rates remained unusually low as resource utilization surged and inflation rose. It is hard to escape the idea the emerging markets were "saved" from inflation by the capital markets crisis.

This also colors the way we see the developed economies. The surge in oil prices globally was due to a tepid supply response in the face of very strong demand from emerging markets. Thus if easy monetary policy contributed to the oil price boom, most of the excess ease came from emerging markets, not the United States and certainly not Europe, where core inflation was never a real concern. This raises a sticky question for policy makers: what should central bankers do if other central bankers are making a policy mistake? If we put aside possible cooperative or non-cooperative aspects to policy, such as "jawboning" monetary policy makers in other countries, we have given our policy prescription above: central banks should tighten if this is needed to keep inflation expectations under control.

7. CONCLUSION

The seven-fold increase in oil prices from the beginning of 2002 to the peak in July 2008 rivals the increases experienced in the 1970s in magnitude, though not in speed. The increases in oil prices in the 1970s came in two, sharp episodes. The increases this decade were the results of a sustained series of increases over a six and a half year period.

The movements in oil prices are driven by many factors affecting supply and demand. The intertemporal linkages of oil through the exhaustible resource constraint mean that oil behaves like an asset. Perceptions of changes in the supply and demand balance over a long horizon can lead to substantial swings in the current price of oil. Yet, oil is an industrial commodity subject to increasing marginal cost of extraction, delivery, storage, and so on that can place a wedge between the long-run valuation of oil in the ground and the price of delivered oil. These considerations imply that flow supply and demand considerations can move oil prices substantially.

This theoretical point is critical for understanding elements of the run-up in oil prices, but especially for explaining its collapse since the middle of 2008. Absent factors that detach the spot market from the long run supply/demand equilibrium, even a business cycle event such as currently unfolding should not have much effect on the equilibrium price of a storable asset. That prices moved down so sharply in the second half of 2008 in response to the slowdown in industrial demand for oil implies that the equilibrium had been in the region of very steeply sloped costs of extraction and distribution.

Our analysis supports an emerging consensus among macroeconomists expert in oil—Hamilton (2009a, 2009b), Kilian (2008, 2009)—that a proper accounting for the sources of fluctuations in the oil market is critical for understanding the behavior of prices in the 2000s. In particular, strong world-wide aggregate demand is the main ingredient to understanding the sustained increase in the price of oil from 2002 to mid-2008. Our analysis emphasizes that global supply and demand conditions determine the price of oil, and points to very strong demand from emerging markets as a principal factor in the rise in oil prices. This demand emanated from real factors associated with emergence of China and India as economic powerhouses and with the recovery of emerging economies from the crises of the late 1990s. We also highlight that this emerging market growth was strongly accommodated by expansionary monetary policy. Emerging market policy rates were low throughout this period.

Supply factors did not cause spikes in prices owing to geopolitical shocks (although uncertainty about security in the Middle East certainly contributed to fluctuations in price during the decade). Of course, oil prices are determined in equilibrium. The trend in non-OPEC supply flattened during this period and incremental fields in Saudi Arabia and elsewhere looked like they would be more expensive to exploit in the longer run. So with strong emerging market demand, it was reasonable to be forecasting a higher equilibrium price for the long run.

The increases in oil prices this decade occurred during a period where inflation was low, inflation expectations were relatively well anchored, and where the credibility of the Fed and other developed-economy central banks was high. This macroeconomic environment shaped the Fed's response to the oil price increases during the 2000s. In particular, the Fed was targeting core inflation. Moreover, because core inflation was contained, it maintained low interest rates for a longer period coming out of the 2001 recession than it might otherwise have, and stopped raising interest rates earlier (or stopped at a lower level) than it might have had it put more weight on headline inflation.

To be sure, the policy of targeting core inflation and therefore letting oil price increase pass through to the level of headline prices is the optimal response to an exogenous change in oil prices in the benchmark new Keynesian model. In that model, prices and wages are sticky, so that it is efficient to not force prices down when a flexible price or a price determined in world markets jumps up. This policy recommendation is confirmed by our analysis of a new Keynesian model modified to allow for an external oil sector. It is also essentially the same policy recommendation made by Solow (1980) using an aggregate supply, aggregate demand framework.

Notwithstanding the recommendation implied by the benchmark model, we believe that the Fed should have put more weight on the increases in headline inflation this decade when formulating its policy. That is, the Fed should have paid some attention to the signals coming from oil prices and raised interest rates faster and higher than it did in 2004 to 2006. Why do we make this policy recommendation despite the implications of the model? The model assumes that inflation expectations are completely anchored. This paper presents two lines of analysis that suggest that relying too strongly on this feature of the model is risky for policy makers.

First, inflation expectations increase when oil prices increase. One-year ahead price change expectations by consumers respond quite strongly to changes in oil prices. Longer-term consumer expectations and longer-term expectations from inflation-linked also respond somewhat to oil. Perhaps these responses are excessive. Perhaps they are too much conditioned on an historical correlation that is not warranted given the current policy regime. Nonetheless, the Fed should not lightly ignore these findings given that the assumption of anchored expectations is critical for the optimality of allowing oil price increase to pass through to headline prices.

Second, even within the model that presumes anchored inflation expectations, core inflation will increase substantially if there is a sequence of shocks to oil prices such as we saw in 2002 to 2008. Our simulations show that core inflation can rise in response to the sequence of oil price shocks the US economy experienced. Thus, the model lends some credence to the nervousness of the public about how oil feeds inflation. That is, it is very hard for the public to sort out a sustained increase in headline inflation that comes from a sequence of positive oil price shocks from a shift in the target inflation rate.

Oil prices, of course, were only one of the signals in the 2002-2006 period that got discounted with the Fed's focus on core inflation and its containment. The emphasis on core instead of headline inflation pushed policy in the same direction, i.e., a level of comfort with sustained low interest rates, as did the Fed's willingness to discount asset and housing market price boom as long as core inflation was contained.

Finally, notwithstanding our recommendation that the Fed put somewhat more weight on movements in oil prices, especially when they lead to a sustained excess of headline over core inflation, we endorse the Fed's decision to cut the Funds rate once the magnitude of the shock to housing was apparent. Oil prices were still increasing, and headline inflation was not decelerating. We believe, however, that the balance of risks had shifted sharply toward recession by fall 2007, and therefore overrode the concern that inflation pressure was building. Had that shock not occurred, however, we believe that the US was at substantial risk of seeing a sustained increase in inflation going forward.

Appendix A Small Scale New Keynesian Model

In this section, we develop a small scale model to aid in interpretation of questions related to oil and monetary policy. This model adds imported energy to baseline models such as the ones developed in textbooks such as Woodford (2003) and Galí (2008). Our analysis proceeds in traditional calibrated fashion, and should be considered a complement to the empirical and narrative work presented in other sections of our paper. Section A.1 presents the model, section A.2 the parameter values that we choose in our calibration. Because the basic setup is familiar, we skip over many details.

A key question in our analysis is the contrast between headline and core inflation targeting. Sections A.3 and A.4 focus on this contrast. In section A.3 we present some impulse responses for a relatively simple parameterization of the model, comparing the responses under headline and core inflation targeting rules. In section A.4 we use the model to compute how standard deviations of certain variables vary with the targeting rule. We find that headline inflation targeting leads to an increase in volatility of all the variables that figure into welfare calculations in analyses such as Woodford (2003). Hence we conclude, as did Bodenstein et al. (2008), Dhawan and Jeske (2007) and Duval and Vogel (2008), that core inflation targeting is preferable.

In section A.5 we put aside headline inflation targeting, on the belief that core inflation targeting better characterizes U.S. monetary policy. We feed in a series of energy price shocks matched to ones realized in 2002-2008, and ask how core inflation will respond. We find that core inflation accelerates, and substantially. We interpret this as raising doubts about the reasonableness of the model's assumption that expectations are model consistent.

A.1 Model

We add imported energy to an otherwise familiar model. We assume a representative agent economy in which firms combines labor (N) and energy (E) to produce a single good (Q) that is either consumed or exported to pay for imported energy. All energy is imported. Trade is balanced each period. The real price of energy is exogenous, and is the only shock whose effects will be analyzed.

Notation: In general, upper case values denote levels, lower case values denote logs. Throughout, inessential constants are omitted. Table A.1 lists parameters, along with parameter values whose rationale will be presented in section A.2 below. Define:

(A.1a) N_t: labor supplied by households, used in production;

(A.1b) C_{qt}: household consumption of the produced good Q;

(A.1c) C_{et}: household consumption of energy;

(A.1d) E_t: energy used by firms in production;

(A.1e) P_{qt}, P_{et}: nominal price of the produced good and of energy;

(A.1f) ψ_t = log real price of energy = $\ln(P_{et}/P_{qt})$;

(A.1g) ω_t = log real wage = $\ln(W_t/P_{qt})$, where W_t = nominal wage;

(A.1g) $\pi_{qt} = \ln(P_{qt}/P_{qt-1})$ = core inflation;

(A.1h) $\pi_{wt} = \ln(W_t/W_{t-1})$ = wage inflation;

(A.1i) Q_t = real gross output.

The model is standard, apart from the use of energy as a factor of production. We assume the usual continuum on [0,1] of monopolistically competitive firms that produce differentiated products. Household consumption C_{qt} is the usual Dixit-Stiglitz aggregate of these differentiated products. Prices and wages are sticky, and are reset in Calvo fashion with probabilities $1-\xi_p$ and $1-\xi_w$ respectively. Prices and wages that are not reset may be indexed to the general rate of price or wage inflation. Firms take as given wages and the price of energy. The latter is assumed to evolve exogenously. A complete derivation would begin by indexing firms and households by i and j ($0 \leq i \leq 1$, $0 \leq j \leq 1$), and derive a set of first order conditions. The next step would be to make suitable assumptions about markets in state contingent claims, and then aggregate to obtain variables that are functionally the same as individual firm and household variables, but without the firm and household subscripts. Because this derivation is familiar (see references above), we simply present the aggregate relations that result.

The household's per period utility function is separable in consumption and leisure, with consumption C_t a Cobb-Douglas aggregate of C_{qt} and C_{et}:

(A.2) per period utility = $\ln(C_t) - f_n(1+\gamma)^{-1} N_t^{1+\gamma}$, $C_t = C_{qt}^{1-\theta} C_{et}^{\theta}$.

The parameters satisfy $0 \leq \theta < 1$ and $\gamma > 0$, $f_n > 0$. The household's discount factor is β. Households take as given all prices.

The gross output production function is isoelastic in labor and energy:

(A.3) $Q_t = A_t N_t^{n} E_t^{e}$, $0 < \alpha_n, \alpha_e < 1$, $0 < \alpha_n + \alpha_e \leq 1$.

In (A.3), A_t is productivity, assumed to evolve exogenously, and held constant in the analyses that we complete.

First order conditions for the firm include ones that state that the real marginal revenue product of each factor equals its real cost. Given the production function (A.3), these conditions may be written:

(A.4) $\alpha_e(Q_t/E_t) = M_t(P_{et}/P_{qt})$,

(A.5) $\alpha_n(Q_t/N_t) = M_t(W_t/P_{qt})$,

where $M_t \equiv$ markup.

We temporarily put aside presenting other first order conditions to log linearize an identity that will be used to solve our log linear model. The identity for nominal gross output is

(A.6) $P_{qt} Q_t = P_{qt} C_{qt} + P_{et} C_{et} + P_{et} E_t$.

In light of the utility function (A.2), the first two terms on the right hand side of (A.6) may be written

(A.7) $P_{qt}C_{qt} + P_{et}C_{et} = (P_{qt}{}^{1\text{-}\theta}P_{et}{}^{\theta})C_t.$

Substitute (A.7) into (A.6), use (A.4) to eliminate E_t from (A.6), and divide through by P_{qt}. Take logs, recall that $\psi_t \equiv \ln(P_{et}/P_{qt})$, that lower case values denote logs, and, as always, omit constant terms. The result is

(A.8) $q_t = c_t + \theta\psi_t - \ln[(M_t - \alpha_e)/M_t].$

Let

(A.9) $\bar{M}$ = steady state value of M_t, $\mu_t = \ln(M_t)$, $\zeta = \alpha_e/(\bar{M} - \alpha_e)$.

Then a log linearization of the last term on the right hand side of (A.8) leads to

(A.10) $q_t = c_t + \theta\psi_t - \zeta\mu_t.$

Recall that the log of the markup is the negative of the log of real marginal cost, call it mc_t.
Hence (A.10) can be written

(A.11) $q_t = (1\text{-}\theta)c_{qt} + \theta c_{et} + \theta\psi_t + \zeta mc_t,$

where (A.2) has been used to write $c_t = (1\text{-}\theta)c_{qt} + \theta c_{et}$.

Equation (A.11) is one of 10 equations that determine the 10 endogenous variables q_t, c_{qt}, c_{et}, n_t, ω_t, e_t, mc_t, π_{qt}, π_{wt} and i_t, where it is the nominal interest rate. Three first order conditions from the household include

(A.12) $c_{et} = c_{qt} - \psi_t,$

(A.13) $\pi_{wt} - d_w\pi_{wt-1} = \beta \mathsf{E}_t(\pi_{wt+1} - d_w\pi_{wt}) + \lambda_w(c_{qt} + \gamma n_t - \omega_t)$, $\lambda_w = (1\text{-}\xi_w)(1\text{-}\beta\xi_w)/[\xi_w(1+\eta_w\gamma)],$

(A.14) $c_{qt} = \mathsf{E}_t c_{qt+1} - \mathsf{E}_t(i_t - \pi_{qt+1}).$

In (A.13), (A.14) and in the remainder of this section E_t is mathematical expectations, and is not to be confused with the level of energy E_t used in production. For energy used in production, we shall henceforth need to reference only the log e_t but not the level. We trust that using E_t in this way will cause no confusion.

Equation (A.12) states that the marginal rate of substitution between the two consumption goods (Q and energy) equals the relative price ψ_t. Equation (A.13) describes wage setting under the assumption of Calvo pricing and wage indexation. The parameter d_w ($0 \leq d_w \leq 1$) is the degree to which wages are indexed to the previous period's rate of wage inflation. The formula for λ_w reflects: the household's rate of time preference β and labor supply elasticity γ (see A.2); the probability that a given wage will not change in a given period (apart from automatic indexing) ξ_w; the elasticity of substitution across labor varieties η_w. The scale variable $c_{qt} + \gamma n_t - \omega_t$ is the gap between (a)the marginal rate of substitution between consumption of our produced good and leisure, and (b)the real wage. (See Galí (2008, ch. 6) and Woodford (2003, ch. 3) for the derivation of equation (A.13)). Finally, equation (A.14) states that the household does not expect to be better off by consuming one fewer unit of Q today, lending at rate i_t and consuming the proceeds tomorrow. (The intertemporal condition (A.14) of course also holds for c_{et} and c_t; for the purpose of our solution, it is most convenient to express it in terms of c_{qt}).

Four conditions from the production side of the model are

(A.15) $q_t = a_t + \alpha_n n_t + \alpha_e e_t$,

(A.16) $\omega_t + n_t = \psi_t + e_t$,

(A.17) $\pi_{qt} - d_p \pi_{qt-1} = \beta \mathrm{E}_t(\pi_{qt+1} - d_p \pi_{qt}) + \lambda_p mc_t$, $\lambda_p = [(1-\xi_p)(1-\beta\xi_p)/\xi_p]$,

(A.18) $mc_t = -q_t + [\alpha_n/(\alpha_n + \alpha_e)](\omega_t + n_t) + [\alpha_e/(\alpha_n + \alpha_e)](\psi_t + e_t)$.

Equation (A.15) is the logarithmic version of the production function (A.3), while (A.16) follows from (A.4) and (A.5). Equation (A.17) results from the assumption of Calvo pricing. In this equation, d_p, $0 \leq d_p \leq 1$, is the degree to which prices are indexed to the previous period's aggregate inflation rate and ξ_p the probability that a firm will not be able to change its price (apart from automatic indexing).[19] Finally, (A.18) is one way of writing the standard expression of marginal cost for our production function.

An identity ties price and wage inflation to the increase in the real wage

(A.19) $\omega_t = \omega_{t-1} + \pi_{wt} - \pi_{qt}$.

In addition to (A.11)-(A.19), our tenth and final equation is a monetary policy rule. We assume a very simple rule in which the monetary authority responds to core or headline inflation:

(A.20a) $i_t = f_{iq} \pi_{qt}$, or

(A.20b) $i_t = f_{ih} \pi_{ht}$.

In (A.20b), π_{ht} is headline inflation. Because the share of energy in consumption is θ, headline and core inflation are related via

(A.21) $\pi_{ht} \equiv \pi_{qt} + \theta\Delta\psi_t \equiv (1-\theta)\pi_{qt} + \theta\Delta p_{et}$.

We consider policies in which f_{ih} (when core inflation is the target) or f_{iq} (when headline inflation is the target) is sufficiently large to deliver a stationary solution. The monetary policy rules (A.20a,b) omit the output gap, interest rate smoothing and a shock for simplicity. Because, as well, we focus on the effects of energy price shocks, we hold constant the productivity shock a_t in (A.15).

19 Our formula for λ_p omits Galí's (2008) and Blanchard and Galí's (2007) adjustment term that accounts for decreasing returns to scale. One can think of a fixed capital stock with share $1-\alpha_n-\alpha_e$ operating in the background, as in Erceg et. al (2000) or Bodenstein et al. (2008), in which case the dynamics of the model are unchanged. Alternatively, were we to insert the adjustment, numerical results would be unchanged were we to simultaneously decrease the calibrated value of ξ_p modestly.

We assume that the real energy price ψ_t follows a stationary AR(1) processes,

(A.22) $\psi_t = \varrho_\psi \psi_{t-1} + \varepsilon_{\psi t}$, $\varepsilon_{\psi t} \sim$ i.i.d. with finite variance, $|\varrho_\psi|<1$.

A.2 PARAMETER VALUES

We experiment with 10 sets of parameters, constructed as: 5 sets of non-energy parameters, with each set paired with two sets of energy parameters. In these 10 sets, we experiment with both headline and core inflation targeting. We assume that the period in the model corresponds to a quarter.

Table A.1 lists parameter values. We divide them into three categories. The first category, listed in panel A in the table, are parameters that are held constant across all parameter sets. With one exception, these are parameters that relate neither to wage or price stickiness nor to energy. The quarterly discount factor β is set to 0.99, the Frisch labor elasticity γ to 1.0, labor's share in the production function α_n to 0.7, the elasticity of substitution across labor and across varieties to 6.0, and the steady state markup $\bar{M}$ to 1.2. The only wage or price parameter held fixed across parameter sets is the probability of not being allowed to reoptimize one's price ξ_p, which is set to 0.67. This implies a mean price duration of 3 quarters.

The monetary policy parameter is set to 1.5 on the measure of inflation being targeted. That is, the core and headline targeting rules are

(A.23a) $i_t = 1.5\pi_{qt}$,

(A.23b) $i_t = 1.5\pi_{ht}$.

Our second category of parameters relates to wage and price stickiness. We experiment with five different assumptions about such stickiness, because related research using similar models has found that the model's behavior is sensitive to such assumptions (Blanchard and Galí (2007), Duval and Vogel (2008)), though in the end we found little such sensitivity to the answers to the questions that we consider. The five assumptions are associated with five parameter sets labeled A through E, and described in panels B and C of Table A.1. Parameter set A assumes flexible wages and no indexation of wages and prices, and hence matches the model exposited in textbooks. Parameter set B introduces sticky wages. The assumed degree of stickiness matches that of prices, with the probability of not being able to reoptimize ξ_w set to 0.67. Parameter sets C through E maintain the same assumptions about ability to reoptimize prices or wages, i.e., $\xi_p = \xi_w = 0.67$. Parameter set C assumes full price indexation but no wage indexation, D assumes full wage indexation but no price indexation, E assumes full price and wage indexation. Recent empirical work has found that similar models fit U.S. data best if they have full wage and price indexation (Giannoni and Woodford (2004), Christiano et al. (2005)). Hence parameter set E is perhaps the one that generates the most realistic results.

The third and final category of parameters relates to energy. We experiment with two different assumptions about energy. The two assumptions are associated with parameter sets labeled 1 and 2, and are described in panel D of Table A.1. Parameter set 1 makes low end assumptions about the importance of energy, while parameter set 2 makes high end assumptions. The share of energy in consumption θ is set to match approximately one of the following averages: the share of gas and oil consumption in total consumption in 1990s (parameter set 1, θ=0.02); the share of total energy in consumption, in the 1980s and mid 2000s (parameter set 2, θ=0.06). Energy's share in the production function α_e is similarly set to either the low

(α_e=0.01, parameter set 1) or high (α_e=0.02, parameter set 2) of observed shares of energy in gross output in the 1997-2007 period. The values in parameter set 1 are similar to those chosen in Blanchard and Galí (2007, p48), those in parameter set 2 (column (5)) similar to ones Bodenstein et al. (2008, p17) (with some slippage in both cases because our model is not identical to either of these). The AR coefficient for the evolution of the real oil price ϱ_ψ is set to 0.97, which is the estimated AR(1) coefficient using quarterly (last month of quarter) of the log real oil price (West Texas intermediate relative to CPI ex food and energy), 1983:Q2-2008Q2.

We reference a complete parameter set by combining an assumption about wage and price stickiness with an assumption about the importance of energy. For example, parameter set A1, whose impulse responses are shown in the next section, assumes price stickiness but no wage stickiness and no price or wage indexation, along with the low end assumptions about the importance of energy.

A.3 IMPULSE RESPONSE TO AN ENERGY PRICE SHOCK, PARAMETER SET A1

We use the model to examine the impact of a 10% increase in the real oil price ψ_t, in parameter set A1. The pictures of responses for parameter set A2 (not displayed) have the same shape, but, unsurprisingly, are larger in magnitude. We comment briefly below on impulse responses when parameter sets B through E are used.

The path of the energy price shock is presented in Figure A.1F. By assumption, this exogenous shock declines monotonically at a rate of .97 per quarter. This is the *only* one of the impulse responses that is not annualized.

In terms of endogenous variables, we present responses of the headline inflation (Figure A.1A), core inflation (Figure A.1B), the interest rate (Figure A.1C), consumption relative to flexible price consumption c_t^*(Figure A.1D) and consumption c_t (Figure A.1E). We multiply the model's responses by 4 to present results at annual rates. We use consumption as our measure of real activity (recall that nominal final sales equals nominal consumption), c_t relative to c_t^* as an indicator of both the welfare effects of policy and the state of excess demand. Each figure has the response under core and under headline inflation targeting. We first work through the response under a headline inflation target, and then turn to the response under a core inflation target.

By assumption, the share of energy in consumption is 2% (θ=0.02). Thus, absent any response from the economy, the presumed 10% increase in energy price would result in a 0.2% increase in headline inflation, or a 0.8% at an annual rate. We see in Figure A.1A that when headline inflation is targeted, the actual increase is about 0.55%. Why is the increase less than 0.8%? In short, this is because an induced rise in the interest rate puts the economy into recession, thus dampening the incipient increase in inflation. Specifically: in accordance with equation (A.23b), we see in figure A.1C that the interest rate that corresponds to a .55% rise in headline inflation is one of about $1.5 \times .55 \approx 0.85\%$. We see in figure A.1D that .85% interest rate hike caused c_t-c_t^* to fall by .7%. The Phillips curve (A.17) incorporated in the model yielded slackening of inflation. As we have seen, the incipient rise in headline inflation of .8% instead turned into an actual increase of .55%; we see in Figure A.1B that core inflation actually fell by about .25%.

In subsequent periods, the energy price slowly reverts to its original level. There was slight continued inflation as measured by either core or headline, again via the Phillips curve. Clearly the dynamic response in periods 1, 2, … is, well, not very dynamic: simply adding energy to the baseline New Keynesian model does not change the fact that this baseline does not have interesting dynamics in response to AR(1) shocks. But this does not mean that there are no lingering effects from the oil price shock. Note in particular (Figure A.1E) that consumption is still about 1.2% (annualized) below steady state in period 1. Consumption returns only slowly to its pre-shock value.[20] Note as well that although a fall in consumption is desirable following a positive energy price shock, headline targeting causes consumption to fall well below c_t^* (Figure A.1D).

Turn now to core inflation targeting. The enormous 10% jump in energy prices causes little direct movement in core inflation, since energy prices are such a small part of core (Figure A.1B). Hence when core is targeted, interest rates move hardly at all (Figure A.1C). The slight movement in core inflation does, via the Phillips curve, cause a slight uptick in consumption relative to c_t^*, though the magnitude is so small that in Figure A.1D it looks as if $c_t - c_t^*$ stays at zero. Nevertheless, $c_t - c_t^*$ is positive, and slowly decays back to zero. As well, core and headline inflation and interest rates stay above steady state, and slowly decay back to zero (Figures A.1A, A.1B, A.1C).

The story is similar in other parameter sets, though indexing of prices or wages leads to smaller initial responses and distinctly more persistence. For example, when prices and wages are both indexed (parameter set E), there is a hump shaped response of core inflation π_{qt} under both targeting rules. But all the pictures suggest, as do Figures A.1B, A.1C, A.1D and A.1E, that headline inflation targeting increases volatility, with the possible exception of volatility in headline inflation itself.

We acknowledge that had we included interest rate smoothing in the monetary policy rule, the responses we saw in the Figures for parameter set A1 would likely be muted, making the core and headline targeting rules behave more similarly on impact. But of course the differences between the two rules would also be more persistent.

A.4 RELATIVE VOLATILITY OF HEADLINE AND CORE INFLATION TARGETING

For each of our 10 parameter sets (A1, A2, B1, …, E1, E2) we computed the relative standard deviation of each variable, under the assumption that the only source of volatility is energy price shocks. Since this is a relative calculation, we do not have to take a stand on the size of the standard deviation of $\varepsilon_{\psi t}$ (the shock to the energy price, see equation A.22): the ratio is the same regardless of this value.

Of course, other exogenous shocks—to technology or monetary policy, in our model—cause volatility as well. But absent shocks to energy prices, headline and core inflation targeting rules are identical. This means that impulse responses to other shocks, and hence volatility due to other shocks, will be the same under the two targeting rules (under the assumption that energy shocks are independent of other shocks.) Hence if energy price shocks cause the standard deviation of a variable, say core inflation π_{qt}, to be higher under headline than under core inflation targeting, then the standard deviation would also be larger if we were recognize that other shocks also affect volatility.

20 Apart from the effects of price stickiness (which are small, from period 1 forward), the model implies that consumption will fall by $[\alpha_e/(1-\alpha_e)]+\theta$ times the shock in oil prices. Since $[\alpha_e/(1-\alpha_e)]+\theta \approx .03$, consumption falls by about .3% on a quarterly basis, or 1.2% when annualized.

Table A.2 present some results on volatility. In the Table, y means that the volatility of the indicated variable was higher under headline inflation targeting, n when it was lower. As can be seen, with occasional exceptions for headline inflation π_{ht} itself, core inflation targeting resulted in lower volatility. This is of course clear in the impulse responses presented above.

The variables listed in the Table were chosen largely in light of the welfare analyses in Erceg et al. (2000), Woodford (2003) and Giannoni and Woodford (2004). If we were to remove energy from the model, these authors suggest that welfare measures would be weighted sums of the variances of the following variables: parameter set A: price inflation and c_t-c_t^*; B: price inflation, c_t-c_t^* and wage inflation; C: the change in price inflation, c_t-c_t^* and wage inflation; D: price inflation, c_t-c_t^* and the change in wage inflation; E: the change in price inflation, c_t-c_t^* and the change in wage inflation. (In equilibrium, in the model without energy, c_t-c_t^* is equal to the output gap.) The preponderance of y's in Table A.2 suggests that targeting core inflation is preferable from a welfare standpoint.

Whether the welfare gain is large or not of course depends on how important energy shocks are for overall volatility.

A.5. RESPONSE TO A LONG SERIES OF POSITIVE ENERGY PRICE SHOCKS

We close by using the model to consider what happens to core inflation if there is a long series of positive energy price shocks. We assume core but not headline inflation targeting, on the presumption that core inflation has been the target for U.S. monetary policy. One of the implicit maintained assumptions of the model is that expectations are model consistent and policy is credible; the public correctly understands the monetary rule and the inflation target (implicitly subtracted from the inflation rate, since all variables, including inflation, are expressed as deviations from mean). In our view, that maintained assumption is called into question if inflation is above target for an extended period of time.

We constructed such a series of energy price shocks as follows. We used the sample also used to calibrate the AR(1) parameter for the energy shock in the model, i.e., an AR(1) in the real oil price, quarterly (last month of quarter), 1983:2-2008:2. We used the 26 quarterly residuals, 2002:1-2008:2, as shocks. As one might imagine, the residuals in this deliberately chosen period tend to be positive, with an average value of 7.4% (or about 30%, at an annual rate); 18 of the 26 residuals were positive, while only 8 were negative. We assume that we begin in the steady state of the model. We fed in this series of 26 shocks and ask how core inflation responds, for each of our parameter sets.

For a given set of assumptions about wage and price stickiness (i.e., choice of parameter set A, B, C, D or E), the response was of course smaller for parameter set 1 than parameter set 2. For a given choice of parameter set 1 or 2, responses in parameter set A (no wage stickiness) were distinctly smaller than in other four parameter sets, which were broadly similar. But in every parameter set (including parameter set A), the response of core inflation was positive in every quarter. That is, the core price level rose monotonically through the 26 quarters, relative to the trend implied by the target inflation rate. (Recall that all variables, including inflation, are measured relative to their mean; the mean value of inflation is the target value of the monetary authority.) Thus this implies inflation in excess of target in a string of 26 consecutive quarters. None of the 8 negative shocks to energy prices sufficed to move core inflation back to or below its target (steady state) value for even a single quarter.

End of period values for cumulative inflation (relative to the trend implied by target inflation) and average annual inflation (again relative to target) are given in Table A.3 Parameter sets B through E implied end of period cumulative increase in core prices of about 15-20% when parameter set 1 was used, 30%-40% when parameter set 2 was used. For example, in parameter set E2, core prices rose (cumulatively) by 21.1% by 2006:4, 26.1% by 2007:4 and 32.2% by 2008:2. If we divide by the number of years corresponding to the length of the sample (e.g., by 6, if the ending point is 2007:4), we find that core inflation averaged 4.3% per year. The figure for parameter set E1 is 2.2% per year.

Of course, the U.S. did not see core inflation at this level in the actual data. Obvious reasons include that that we are starting off the exercise with all variables (including core inflation) at steady state, that we are shutting down other shocks—no collapse in credit markets at the end of the sample in our exercise!—and that the model itself makes simplifying assumptions. But we take as the lesson of this calculation that even when expectations are well anchored, core inflation can and will accelerate if there is a long series of positive energy shocks. And such an event can plausibly be precisely the trigger for inflation expectations becoming unanchored.

TABLE A.1. MODEL PARAMETERS

A. PARAMETERS HELD FIXED IN ALL SPECIFICATIONS			
(1) Parameter	(2) Description	(3) Eq'n No.	(4) Value
β	subjective discount factor	n.a.	0.99
γ	labor supply elasticity	A.2	1.0
α_n	labor share in production function	A.3	0.7
η_w	elasticity of substitution across varieties of labor	A.13	6.0
$\bar{M}$	steady state markup	A.9	1.2
ξ_p	prob. of not changing price	A.17	0.67
f_{iq}	weight on core inflation, when that is the target	A.20a	1.5
f_{ih}	weight on headline inflation, when that is the target	A.20b	1.5

B. DESCRIPTION OF PARAMETER SETS	
A	sticky prices, flexible wages, no indexation of wages or prices
B	sticky prices and wages, no indexation of wages or prices
C	sticky prices and wages, indexation of prices but not wages
D	sticky prices and wages, indexation of wages but not prices
E	sticky prices and wages, indexation of both wages and prices

C. OTHER NON-ENERGY PARAMETERS

(1) Parameter	(2) Description	(3) Equation No.	(4) Value in Parameter Set				
			A	B	C	D	E
ξ_w	prob. of not changing wage	A.13	10^{-8}	0.67	0.67	0.67	0.67
d_p	degree of indexation of prices	A.17	0	0	1.0	0	1.0
d_w	degree of indexation of wages	A.13	0	0	0	1.0	1.0

D. ENERGY PARAMETERS

(1) Parameter	(2) Description	(3) Eq'n No.	(4) Set 1	(5) Set 2
θ	energy share in consumption	A.2	0.02	0.06
α_e	energy share in production	A.3	0.01	0.02
ϱ_ψ	AR coefficient for oil price shock	A.22	0.97	0.97

NOTES:

1. Parameter sets are defined by combining the parameters listed in panel A (which are common to all parameter sets) with one of the sets in panel C and one of the sets in panel D. For example, parameter set A1 fixes parameters as indicated in panel A, column 4A in panel C, and column (4) in panel D.

2. Each parameter set is then combined with each of two monetary policy parameters, one corresponding to core inflation targeting, one to headline inflation targeting. See equations (A.20a) and (A.20b).

TABLE A.2. IS THE STANDARD DEVIATION HIGHER UNDER HEADLINE INFLATION TARGETING?

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Parameter Set	Variable					
	π_{qt}	$c_t - c_t^*$	$\Delta\pi_{qt}$	π_{wt}	$\Delta\pi_{wt}$	π_{ht}
A1	y	y	y	y	y	n
A2	y	y	y	y	y	n
B1	y	y	y	y	y	n
B2	y	y	y	y	y	n
C1	y	y	y	y	y	y
C2	y	y	y	y	y	y
D1	y	y	y	y	y	y
D2	y	y	y	y	y	y
E1	y	y	y	y	y	y
E2	y	y	y	y	y	y

NOTES:

1. See Table A.1 for definitions of parameter sets and variable definitions.

2. A *y* indicates higher and an *n* indicates lower volatility under headline than core inflation targeting. See section A.4 for further discussion.

TABLE A.3. CUMULATIVE / MEAN CORE INFLATION RATES RESULTING FROM A SERIES OF ENERGY PRICE SHOCKS

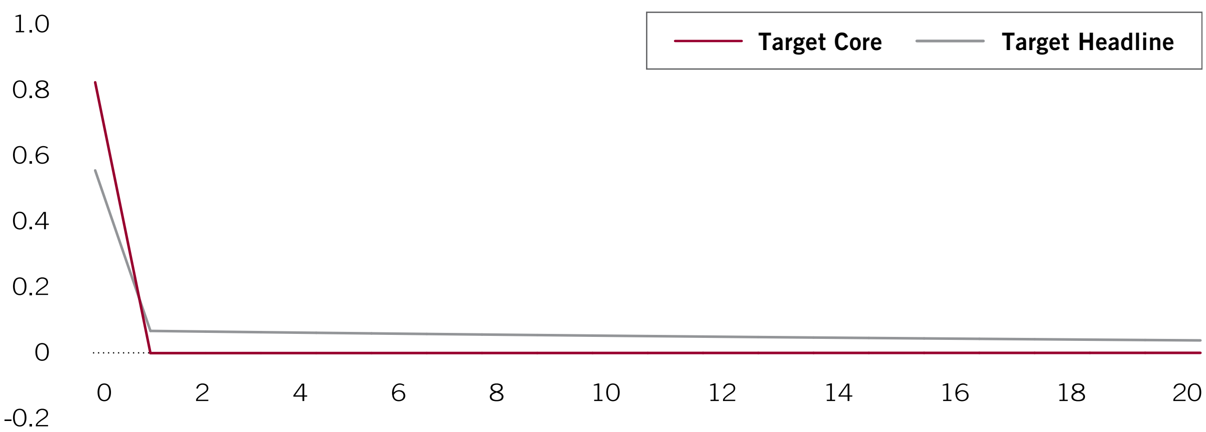
End Date	Parameter Set									
	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2
2006:4	6.2/1.2	12.4/2.5	12.7/2.5	25.7/5.1	13.8/2.8	28.1/5.6	9.8/2.0	19.7/3.9	10.5/2.1	21.1/4.2
2007:4	8.2/1.4	16.5/2.8	16.1/2.7	32.6/5.4	16.7/2.8	34.0/5.7	12.7/2.1	25.7/4.3	13.0/2.2	26.1/4.3
2008:2	9.7/1.5	19.6/3.0	19.5/3.0	39.5/6.1	20.0/3.1	40.7/6.3	15.7/2.4	31.7/4.9	16.0/2.5	32.2/5.0

NOTES:

1. See note 1 to Table A.1 for definitions of parameter sets.

2. A series of energy price shocks was computed for the 2002:1-2008:2 period. These were fed into the model, assuming all variables were initially in steady state. For each parameter set, the figure to the left of the slash is the resulting cumulative rise in core prices; the figure to the right of the slash is the mean annual inflation rate. The cumulative rise is relative to the trend associated with target inflation, and mean annual inflation rate is relative to target inflation. For example, the figure "6.2/1.2" in A1, 2006:4 indicates that by 2006:4, the sequence of energy price shocks fed in from 2002:1 to 2006:4 led to core prices rising 6.2 percent relative to trend, implying an annual rise in inflation 2002:1-2006:4 of 1.2 percent above target. The "9.7/1.5" figures in 2008:2 for parameter set A1 are the corresponding values if we continue the experiment through 2008:2.

FIGURE A.1A. RESPONSE OF HEADLINE INFATION



NOTES TO FIGURES A.1A THROUGH A.1F:

1. Figures A.1A through A.1F plot responses to a 10 percent positive shock to the energy price. The energy price response (Figure A.1F) is not annualized. All other responses are annualized.

2. The horizontal axis is quarters. The vertical axis is percentage change. The "target core" and "target headline" lines depict the responses when the monetary policy rule targets core inflation (equation A.23a) versus headline inflation (equation A.23b).

3. The figures are based on parameter set A1. See section A.3 of the Appendix for further discussion.

FIGURE A.1B. RESPONSE OF CORE INFLATION

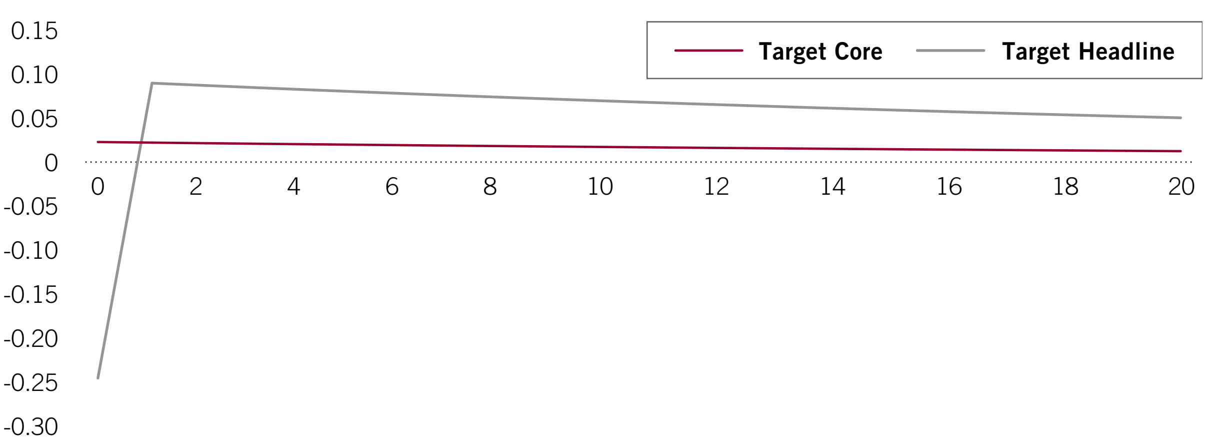


FIGURE A.1C. RESPONSE OF INTEREST RATE

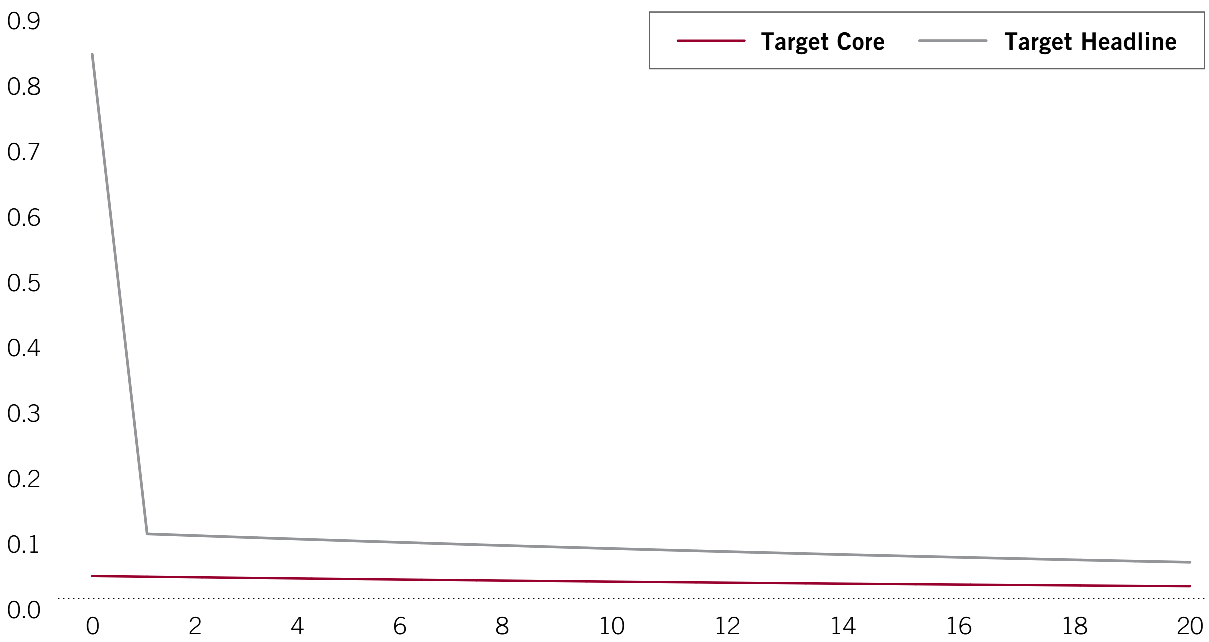


FIGURE A.1D. RESPONSE OF C-C*

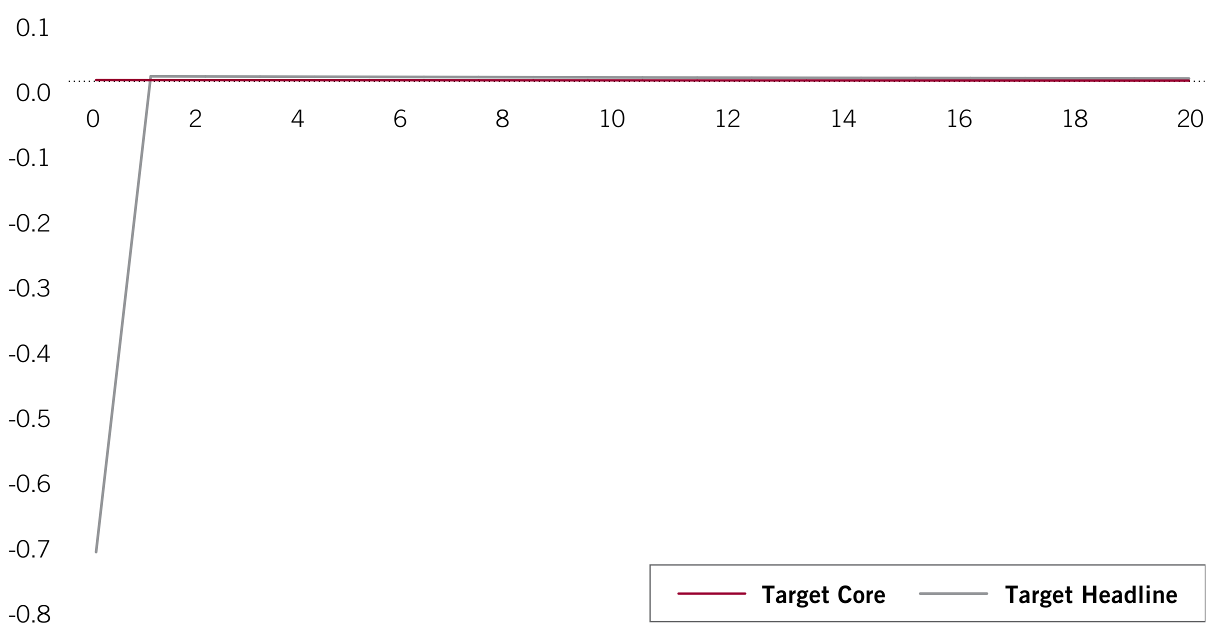


FIGURE A.1E. RESPONSE OF CONSUMPTION

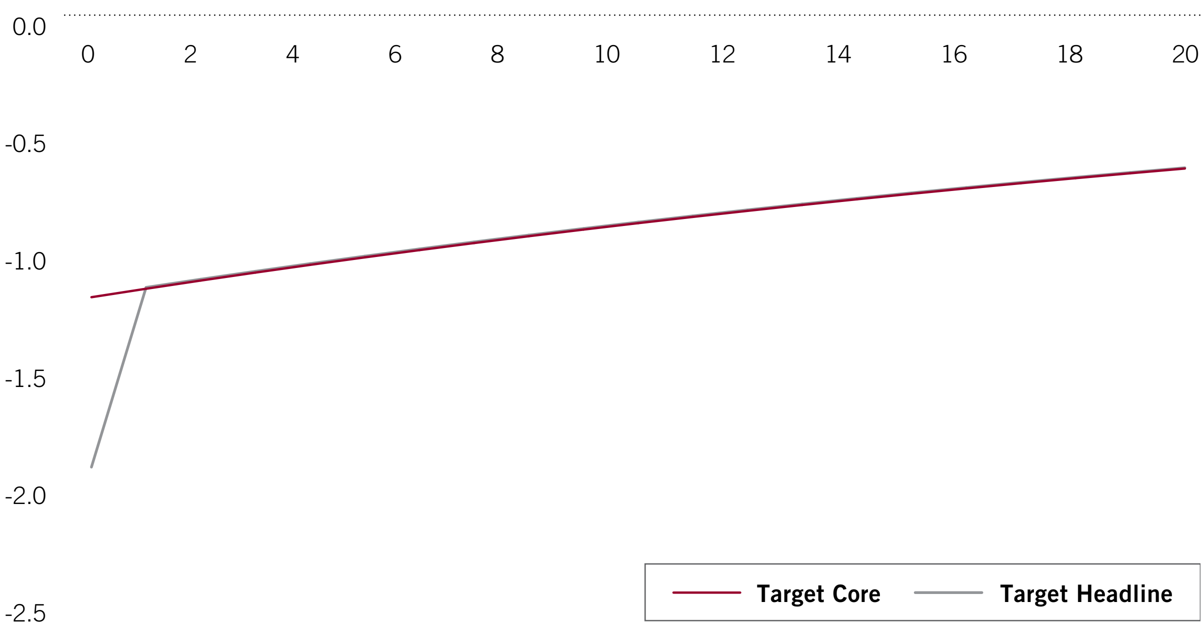


FIGURE A.1F. RESPONSE OF ENERGY PRICE SHOCK

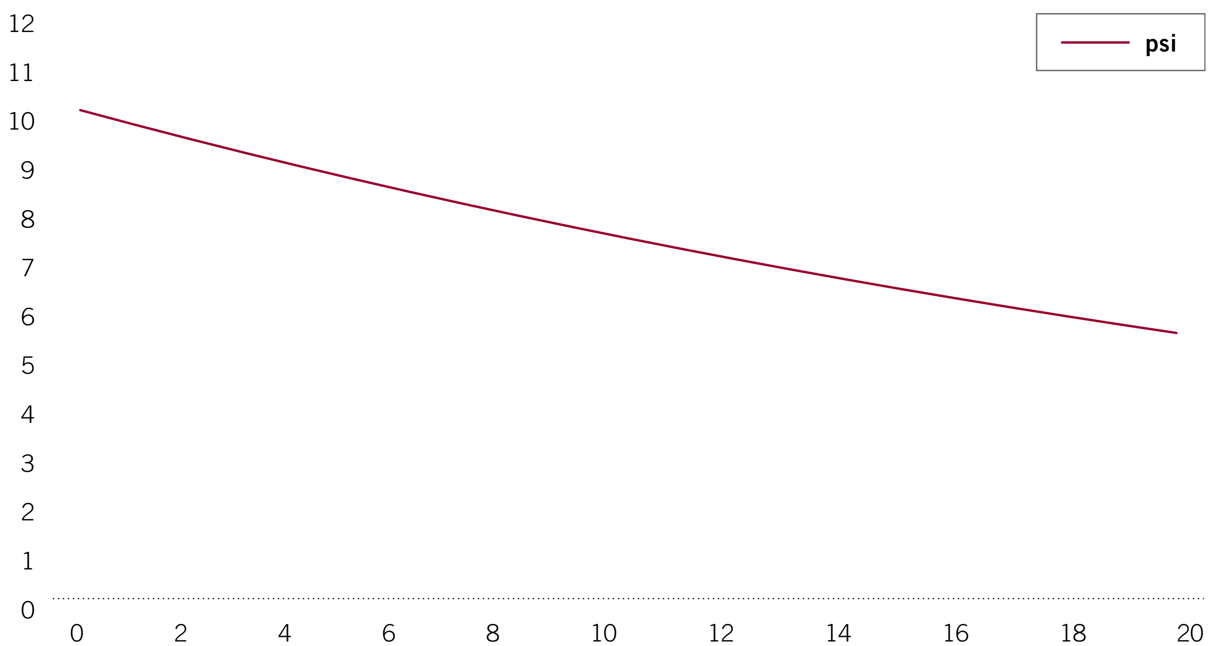


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TABLE 3.1. OIL AND THE MACROECONOMY: 2002 – 2008

	Cumulative real oil price increase	Global real GDP growth	Global CPI inflation	Change in global unemployment rate
1Q2002 - 3Q2006	231.5	16.1	13.5	-0.6
4Q2006 - 2Q2008	71.7	5.3	7.0	-0.3

Note: See footnote 3 for source of global data.

TABLE 3.2. CRUDE OIL CONSUMPTION, 2007

	Cost ($bn)		Cost (%GDP)		Net marg. cost ($10)		Net cost since 2001eop ($bn)	
	Gross	Net	Gross	Net	$bn	%GDP	Gross	Net
Global	**5,878**	**93**	**11.6**	**0.2**	**13**	**0.0**	**8,145**	**265**
Developed	**2,956**	**692**	**8.0**	**1.9**	**100**	**0.3**	**4,231**	**2,659**
US	1,428	348	10.3	2.5	50	0.4	2,020	1,328
Euro area	773	271	6.3	2.2	39	0.3	1,123	1,077
Japan	348	127	8.0	2.9	18	0.4	515	516
Emerging	**2,921**	**-599**	**21.4**	**-4.4**	**-87**	**-0.6**	**3,913**	**-2,395**
EM Asia	**1,332**	**301**	**18.6**	**4.2**	**44**	**0.6**	**1,769**	**1,054**
China	542	103	16.7	3.2	15	0.5	690	336
India	190	49	16.1	4.2	7	0.6	254	176
Korea	164	60	16.9	6.2	9	0.9	228	228
Taiwan	77	28	20.1	7.4	4	1.1	107	107
ASEAN	817	40	63.8	3.2	6	0.5	418	801
Latin America	**518**	**-65**	**15.8**	**-2.0**	**-9**	**-0.3**	**701**	**-318**
Brazil	151	9	11.3	0.7	1	0.1	204	36
Chile	24	9	14.4	5.2	1	0.8	27	27
Columbia	16	-8	7.6	-4.1	-1	-0.6	22	-33
Mexico	140	-37	13.6	-3.6	-5	-0.5	192	-168
CEEMEA	**1,071**	**-835**	**33.4**	**-26.0**	**-121**	**-3.8**	**1,443**	**-3,130**
OPEC	389	-744	22.3	-42.7	-108	-6.2	512	-2,859
Poland	37	13	8.6	3.2	2	0.5	48	48
Russia	186	-183	14.4	-14.2	-27	-2.1	261	-663
Turkey	46	17	7.0	2.6	2	0.4	65	65

Note: Net values are net of domestic production. Consumption and production data are from 2008 BP Statistical Review. All dollar costs are based on the the annual average OPEC crude basket. Net cost since 2001 is the cumulative net cost using net consumption and OPEC crude price from 2002 through 2007. All figures are based on annual averages. Global consumption does not net to zero in 2007 owing to a net fall in global inventories as well as a few minor technical details that drive a wedge between consumption and production. CEEMEA includes all countries of Central and Eastern Europe, Middle East and Africa.

TABLE 3.3. OPEC'S MARGINAL PROPENSITY TO IMPORT OUT OF EXPORT REVENUE (MPI)

	Memo: 2007 exports (US$ bn)	1985-2006 average		2007
		Short-run	Long-run	Long-run
OPEC	**897**	**0.34**	**0.51**	**0.71**
GCC	447	0.36	0.50	0.72
Saudi Arabia	194	0.37	0.31	0.45
UAE	120	0.43	0.98	1.37
Kuwait	46	0.09	0.38	0.40
Qatar	38	0.22	0.29	0.64
Oman	26	0.11	0.72	0.62
Bahrain	23	0.58	0.32	0.41
Iran	79	0.21	1.14	0.59
Other OPEC	371	0.38	0.46	0.72

Source: IMF Direction of Trade. GCC (Cooperative Council for the Arab States of the Gulf) includes UAE, Bahrain, Saudi Arabia, Oman, Qatar, and Kuwait.

TABLE 3.4. MERCHANDISE TRADE WITH OPEC (BILLIONS OF US DOLLARS)

	OPEC exports		OPEC imports		Trade offset ratio
	ch 02-07	07 level	ch 02-07	07 level	ch 02-07
Global	**446**	**675**	**325**	**465**	**0.73**
Developed	**265**	**411**	**139**	**232**	**0.52**
United States	106	153	36	54	0.34
Canada	8	11	3	5	0.45
Euro area	93	144	81	127	0.87
United Kingdom	7	11	9	17	1.27
Japan	71	121	21	37	0.30
Australia	4	7	5	10	1.33
EM	**181**	**264**	**186**	**233**	**1.03**
Latin America	**11**	**18**	**21**	**28**	**1.97**
Argentina	0	0	3	4	18.50
Brazil	7	12	11	14	1.55
Chile	0	1	1	2	3.99
Colombia	1	2	3	4	3.33
Mexico	2	3	2	3	1.25
Peru	0	1	1	1	1.57
CEEMEA	**22**	**29**	**22**	**28**	**1.03**
Czech Republic	0	0	1	1	4.23
Hungary	0	0	1	2	11.07
Poland	0	0	1	1	4.68
Romania	1	1	1	1	1.09
Russia	1	1	4	6	4.64
Slovak Republic	0	0	0	0	3.10
South Africa	9	12	2	3	0.24
Turkey	10	13	12	13	1.16
EM Asia	**149**	**218**	**143**	**178**	**0.96**
China	45	56	53	64	1.19
India	9	15	20	26	2.20
Indonesia	3	6	2	3	0.51
Korea	44	66	15	22	0.34
Malaysia	7	10	9	11	1.36
Philippines	4	6	1	1	0.21
Singapore	22	36	33	39	1.51
Thailand	13	19	9	12	0.70

Source: IMF Direction of Trade.

TABLE 3.5. ESTIMATED RESPONSE OF US CONSUMPTION GROWTH TO OIL PRICE SAMPLE PERIOD: 1961Q1 TO 2008Q3

Dependent variable is real PCE growth		
	Coeficient	t-Statistic
Constant	4.07	11.56 *
Error correction term	-82.42	-6.23 *
Lagged real PCE growth, ar	-0.17	-3.00 *
Real DPI growth, ar	0.23	4.81 *
Lagged real DPI growth, ar	0.07	1.38
Real fed funds rate	-0.39	-6.82 *
Price of WTI	-0.02	-1.38
Lagged price of WTI	-0.02	-2.22 *
Change in unemployment rate	-3.62	-6.01 *
Percent change in wealth	0.03	2.31 *
Adjusted R-squared	0.52	
Standard error	1.95	

* significant at the 95% confidence level
Variables expressed at annual rate (ar).

TABLE 4.1. CUMULATIVE INFLATION IN EXCESS OF TARGETS, 2001—2007

Country	Headline vs. Core	Headline vs. Target	Core vs. Target
US	3.9	5.4	1.5
Euro Area	3.8	2.6	-1.2
UK	3.4	-0.5	-3.8
Japan	2.6	-6.3	-9.0

*Assume the following targets: US (1.75), Euro (1.9), UK (2.0), Japan (1.0)

Source: Authors' estimates and Haver Analytics.

TABLE 5.1. DO OIL PRICES AND CORE INFLATION MOVE EXPECTED INFLATION?

Dependent variable: Measure of Expected inflation	*p*-value for current and lagged values: Oil price growth	*p*-value for current and lagged values: Core inflation	Sample period	
Michigan Survey, 12 months ahead	0.00	0.00	1983:01	2008:12
Michigan Survey, 5 to 10 years ahead	0.08	0.00	1990:08	2008:12
TIPS, 5 year, 5 years ahead	0.42	0.92	2001:12	2008:12
TIPS, 10 year	0.04	0.91	1998:05	2008:12

Note: Table reports p-value for test that current and lagged value of the log change in oil prices and the level of core inflation (CPI excluding food and energy) are significant in a regression of measures of expected inflation. The regression equation includes three lags of the expected inflation measure and current and three lags of the oil price and core inflation variables. The TIPS expected inflation are measured as of the end of the month.

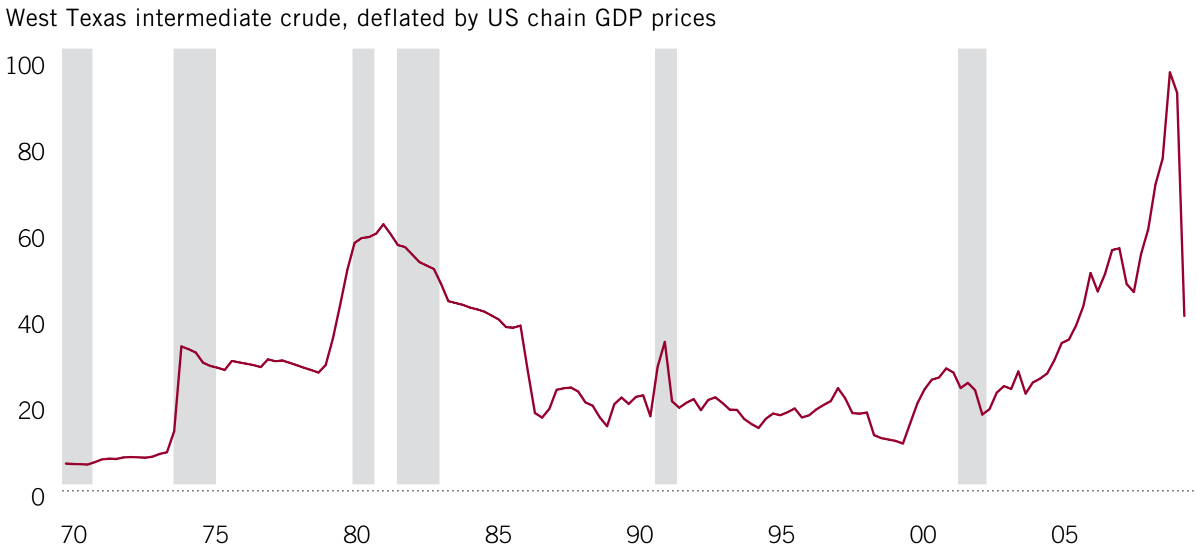
TABLE 6.1. FOMC CENTRAL TENDENCY FORECASTS

	June 2008			October 2007		
Indicator	2008	2009	2010	2008	2009	2010
GDP (Q4/Q4)	1.0 - 1.6	2.0 -2.8	2.5 - 3.0	1.8 - 2.5	2.3 - 2.7	2.5 - 2.6
Unemployment (Q4)	5.5 -5.7	5.3 -5.8	5.0 - 5.6	4.8 - 4.9	4.8 - 4.9	4.7 - 4.9
PCE (Q4/Q4)	3.8 - 4.2	2.0 - 2.3	1.8 - 2.0	1.8 -2.1	1.7 - 2.0	1.6 - 1.9
Core PCE (Q4/Q4)	2.2 - 2.4	2.0 - 2.2	1.8 - 2.0	1.7 - 1.9	1.7 - 1.9	1.6 - 1.9

Source: Federal Reserve Board

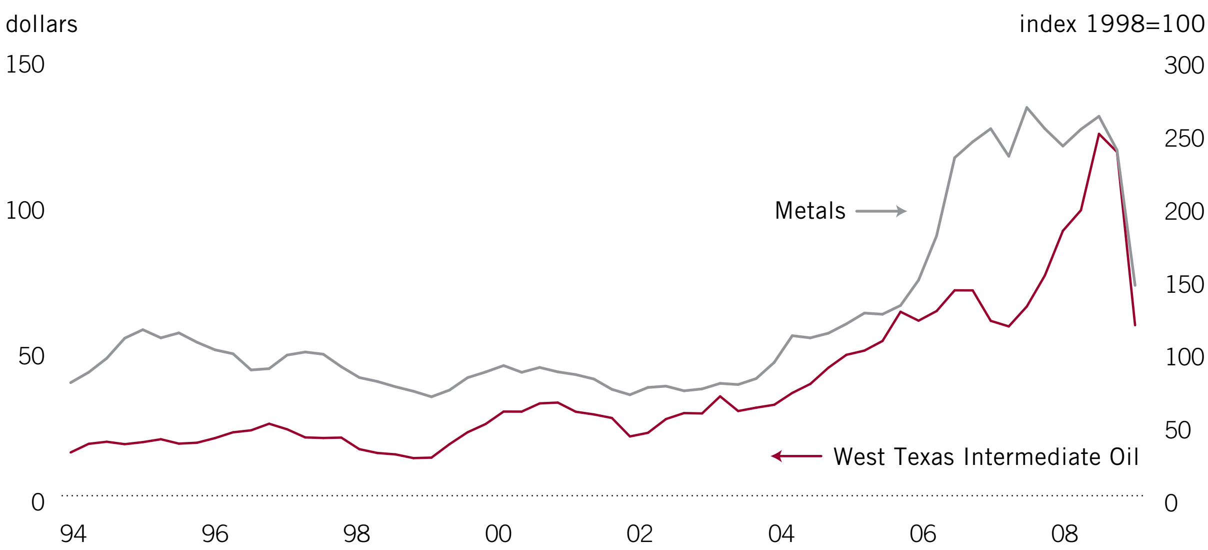
Note: Forecasts assume "appropriate monetary policy" and exclude highest and lowest three forecasts. GDP refers to the growth rate in real GDP. PCE refers to personal consumption expenditure inflation.

FIGURE 3.1. REAL OIL PRICE



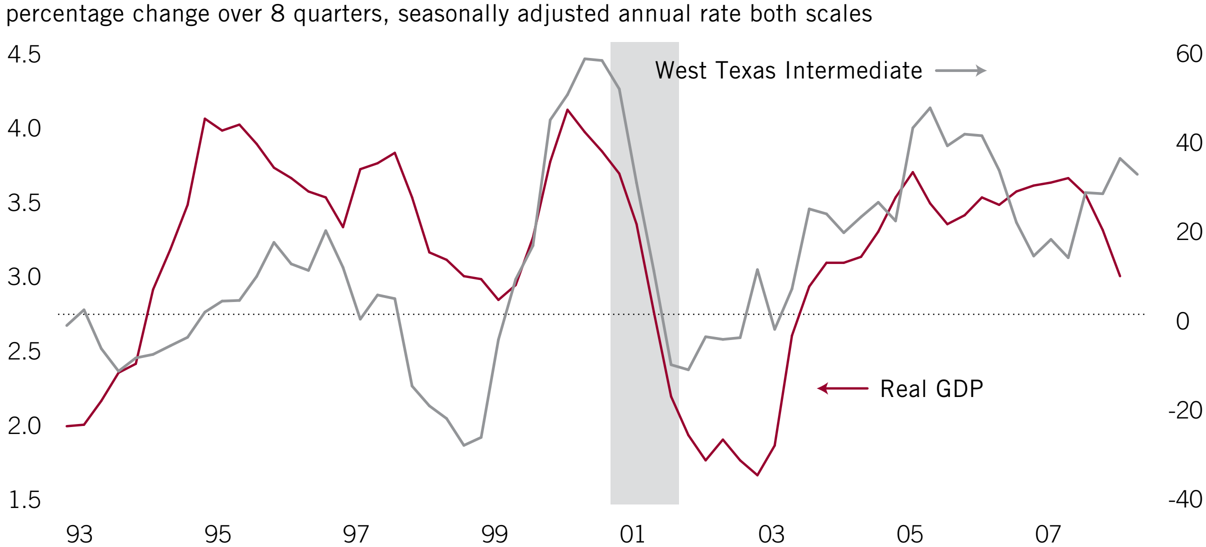
Note: Shaded areas denote U.S. recessions.

FIGURE 3.2. OIL PRICE AND JPMORGAN METALS PRICE INDEX



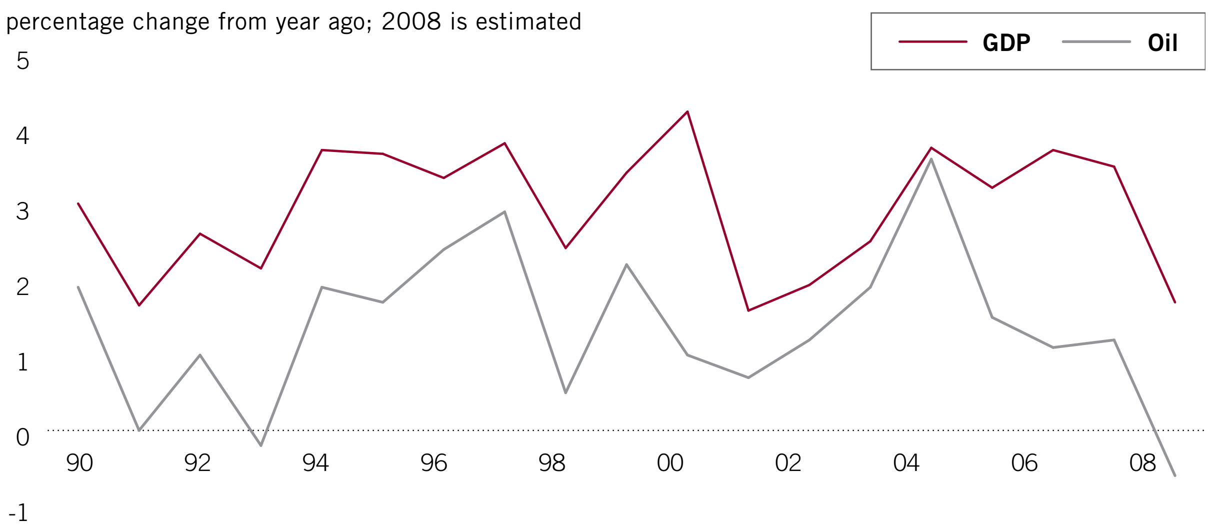
Source: JPMorgan.

FIGURE 3.3. GLOBAL GDP AND OIL PRICES: 1993—2008



Note: Shaded area denotes a U.S. recession. See footnotes 3 for source of global data.

FIGURE 3.4. REAL GLOBAL GDP AND OIL CONSUMPTION



Note: See footnote 3 for source of global data.

FIGURE 3.5. OIL CONSUMPTION, BARRELS

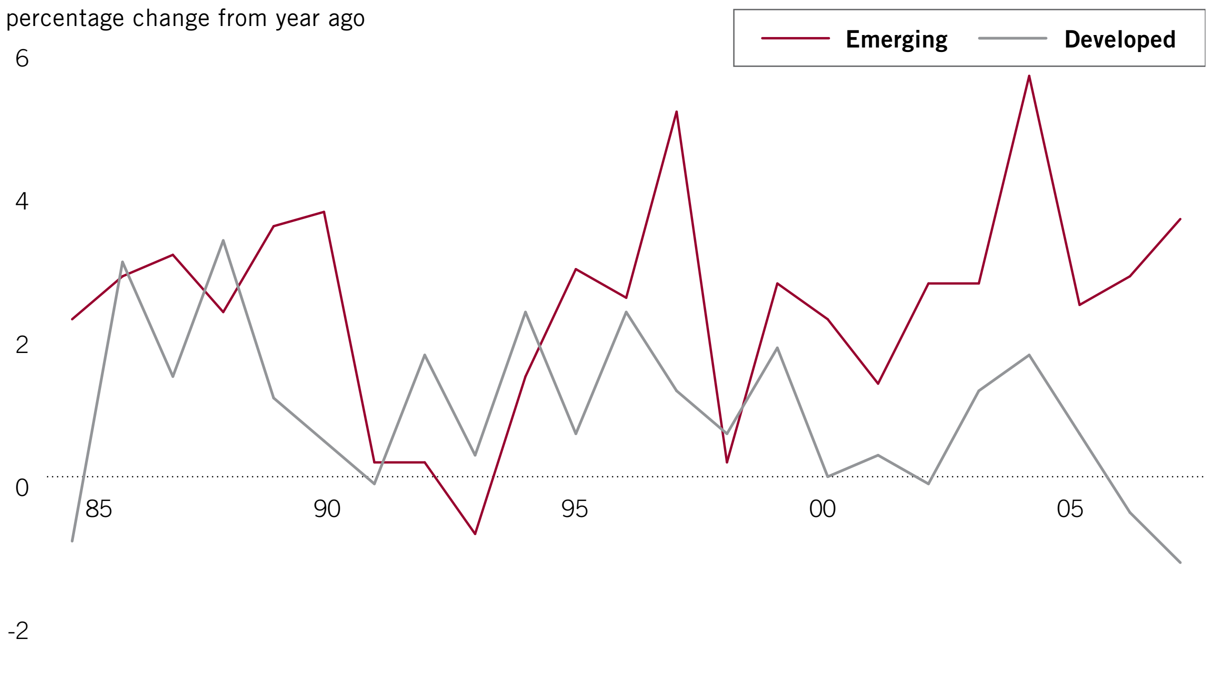
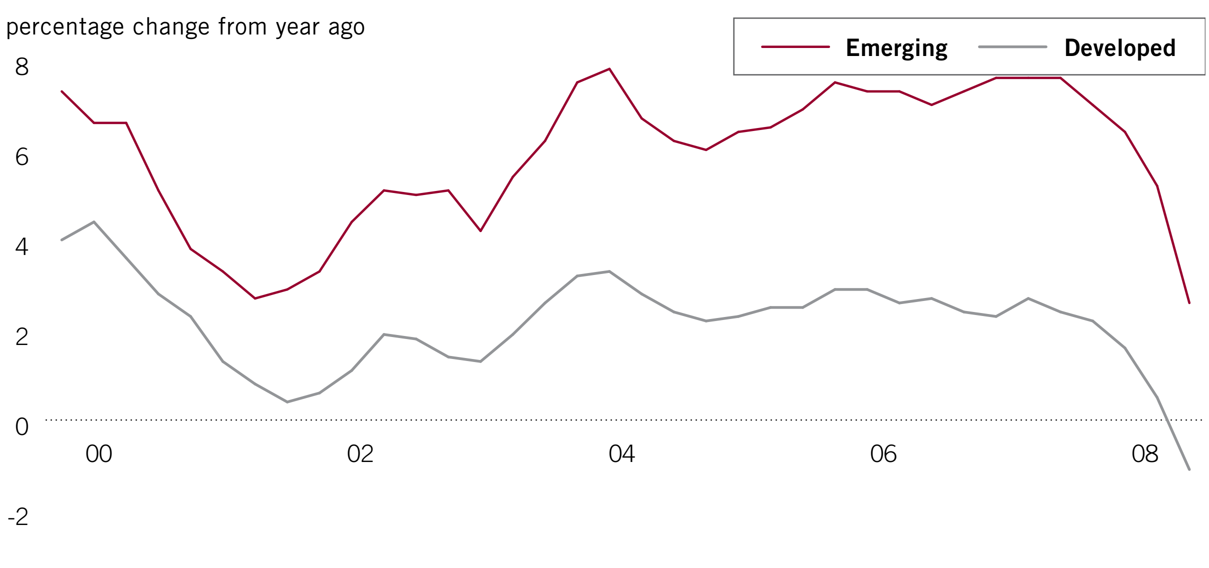
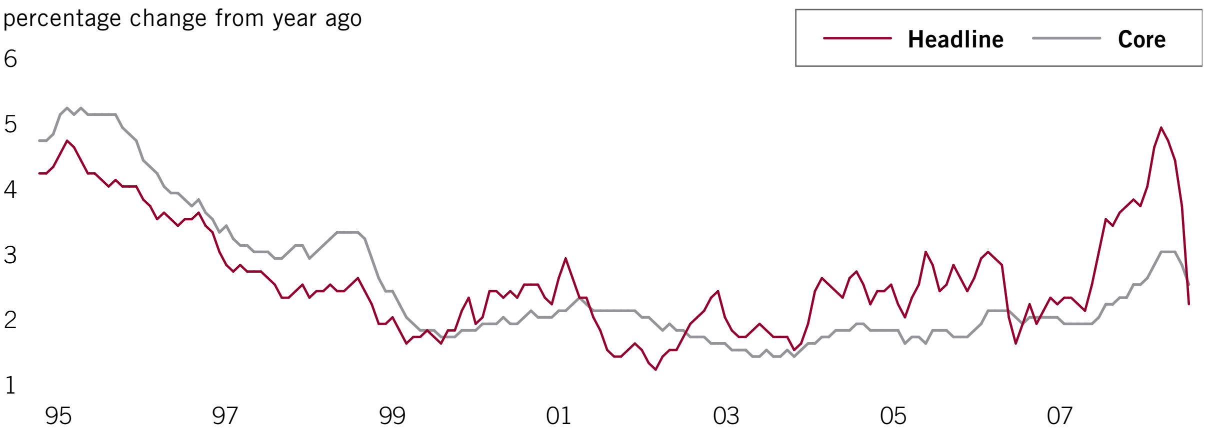


FIGURE 3.6. GLOBAL GDP



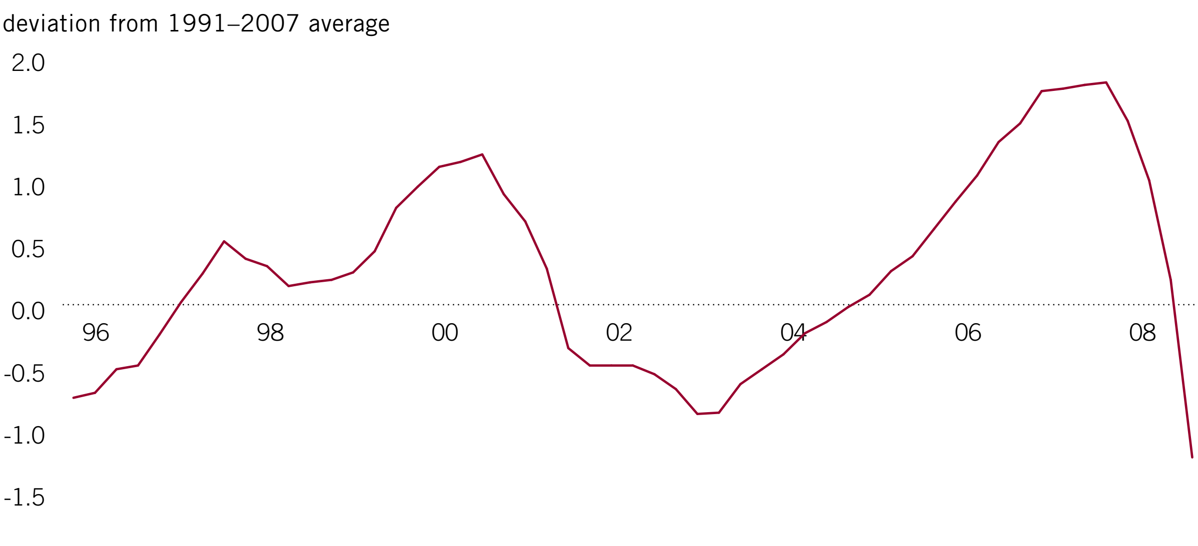
Note: See footnote 3 for source of global data.

FIGURE 3.7. GLOBAL CPI



Note: See footnote 3 for source of global data.

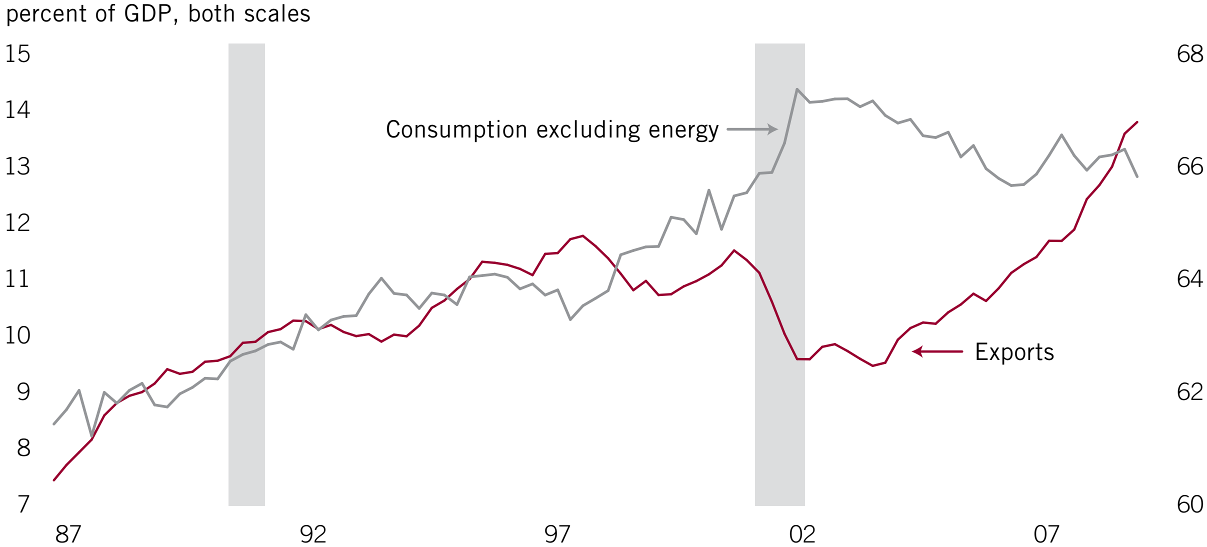
FIGURE 3.8. GLOBAL RESOURCE UTILIZATION RATE



Note: Resource utilization rates are a GDP weighted average across countries. The individual country utilization rates are a weighted sum of the deviation in the unemployment rate and capacity utilization rate from its mean, measured in standard deviation units.

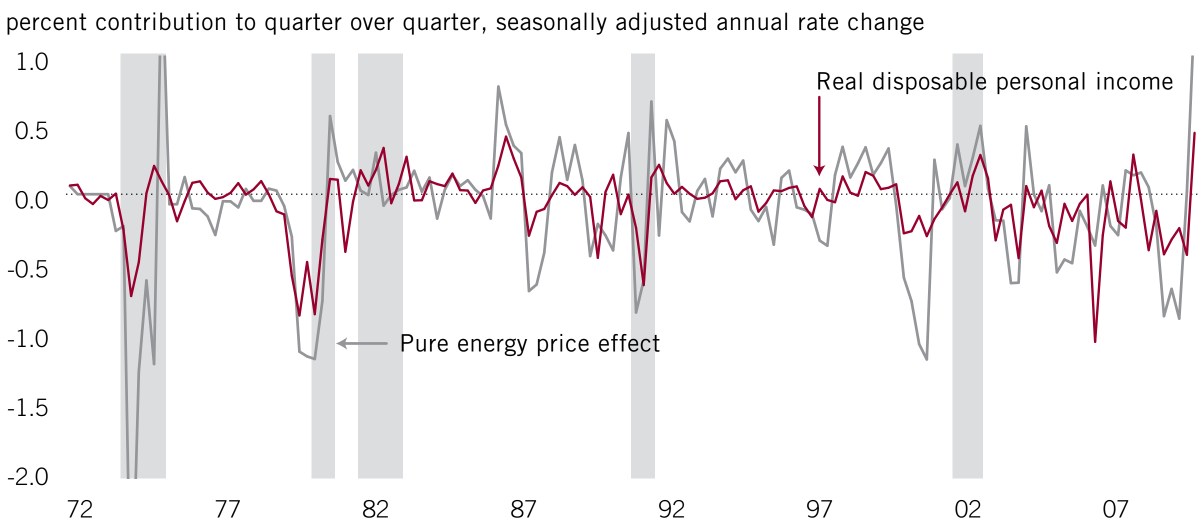
Source: JPMorgan

FIGURE 3.9. US CONSUMPTION EXCLUDING ENERGY AND EXPORTS, SHARE OF GDP



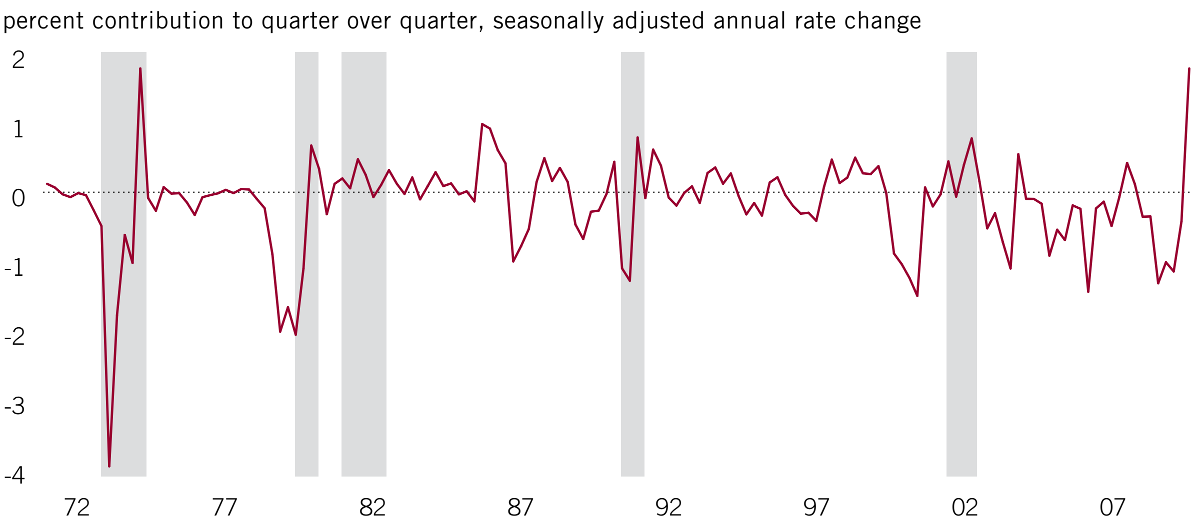
Note: Shaded areas denote U.S. recessions.

FIGURE 3.10. ESTIMATED EFFECTS OF ENERGY PRICES ON US CONSUMPTION GROWTH: INCOME AND PRICE EFFECTS



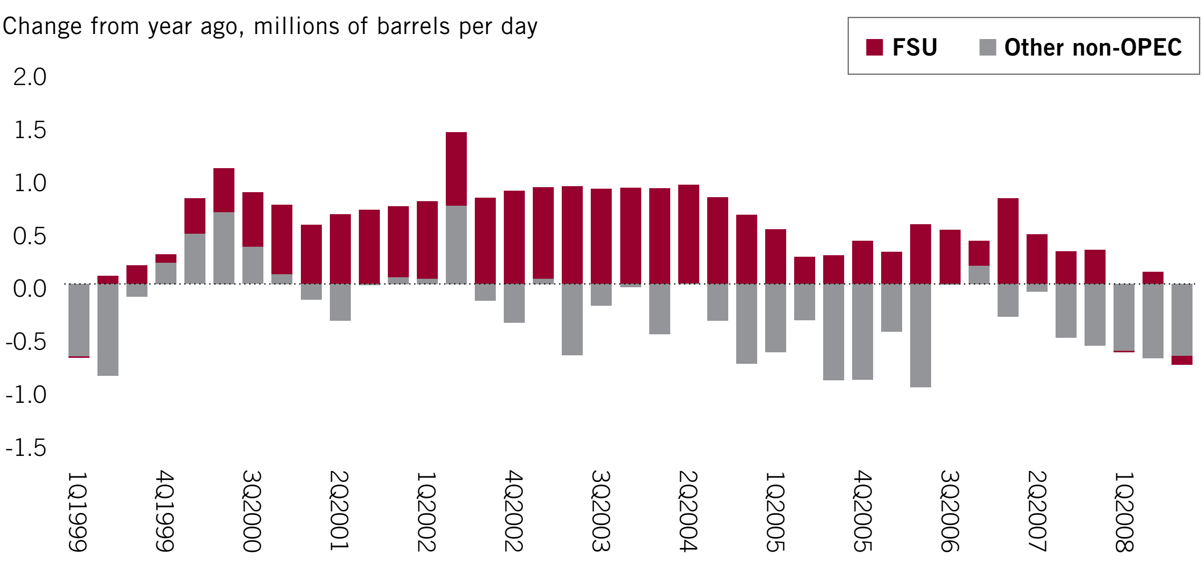
Note: Shaded areas denote U.S. recessions. Based on estimates reported in Table 3.5.

FIGURE 3.11. ESTIMATED EFFECTS OF ENERGY PRICES ON US CONSUMPTION GROWTH: SUM OF INCOME AND PRICE EFFECTS



Note: Shaded areas denote U.S. recessions. Based on estimates reported in Table 3.5.

FIGURE 3.12. CHANGE IN NON-OPEC OIL SUPPLY



Note: "FSU is "Former Soviet Union."

FIGURE 3.13. STOCK PRICE OF EXXON AND BP, 2008

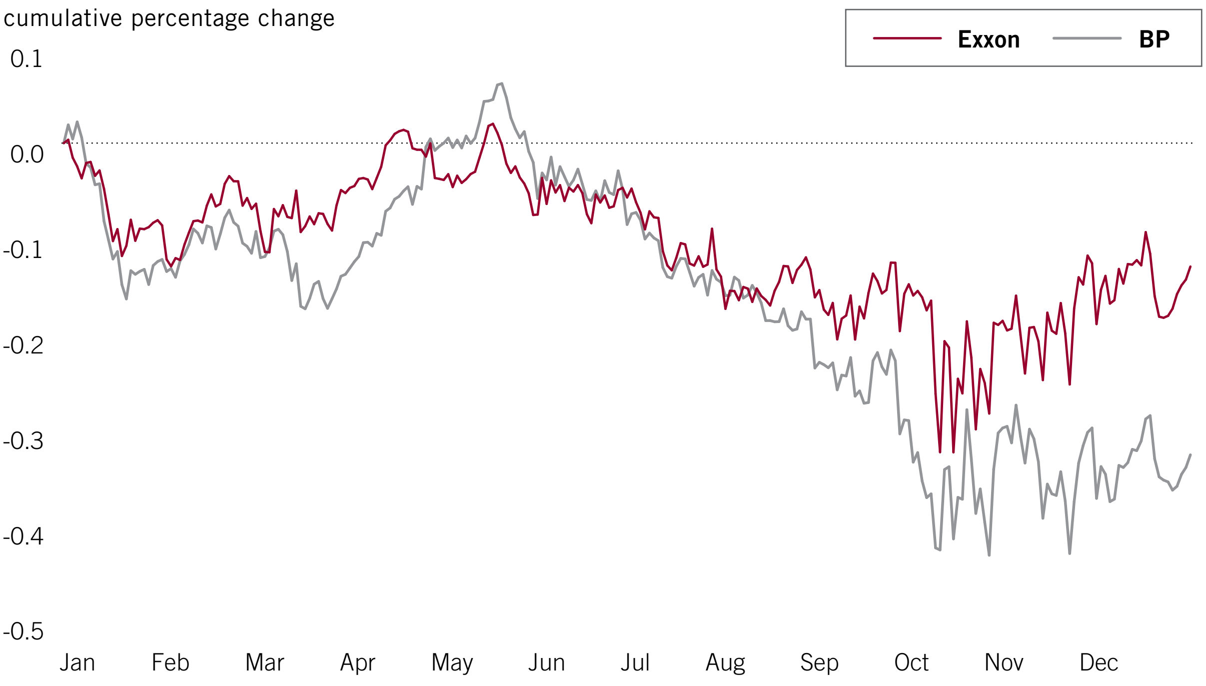
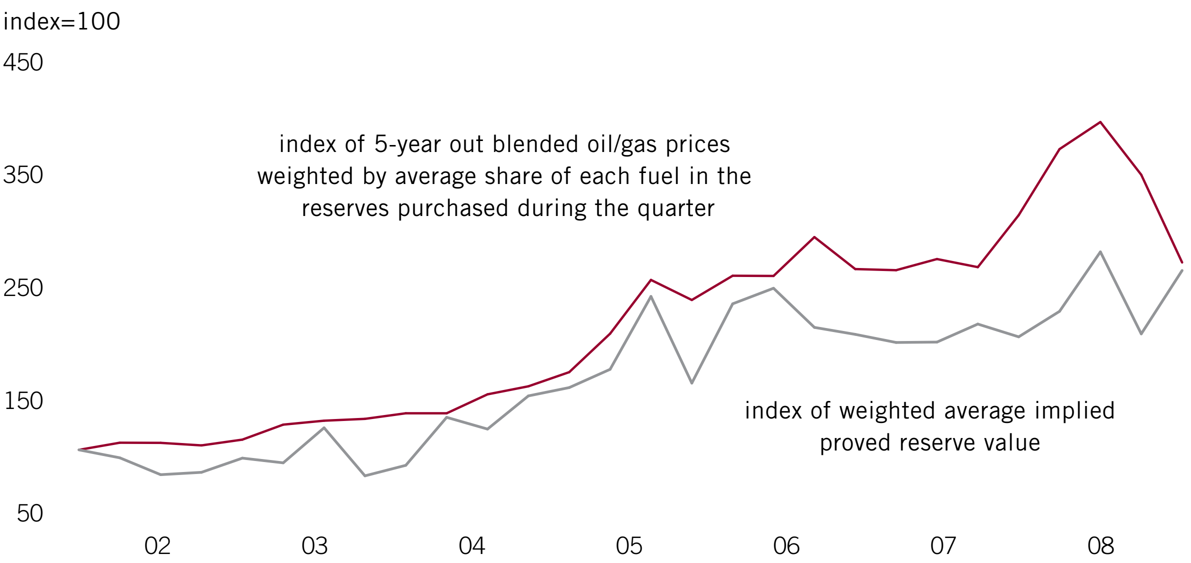


FIGURE 3.14. IMPLIED VALUE OF PROVEN RESERVES VERSUS FORWARD DELIVERY PRICE



Source: See discussion in Section 3.7.2 of the text.

FIGURE 3.15. WTI FORWARD PRICES, 2008

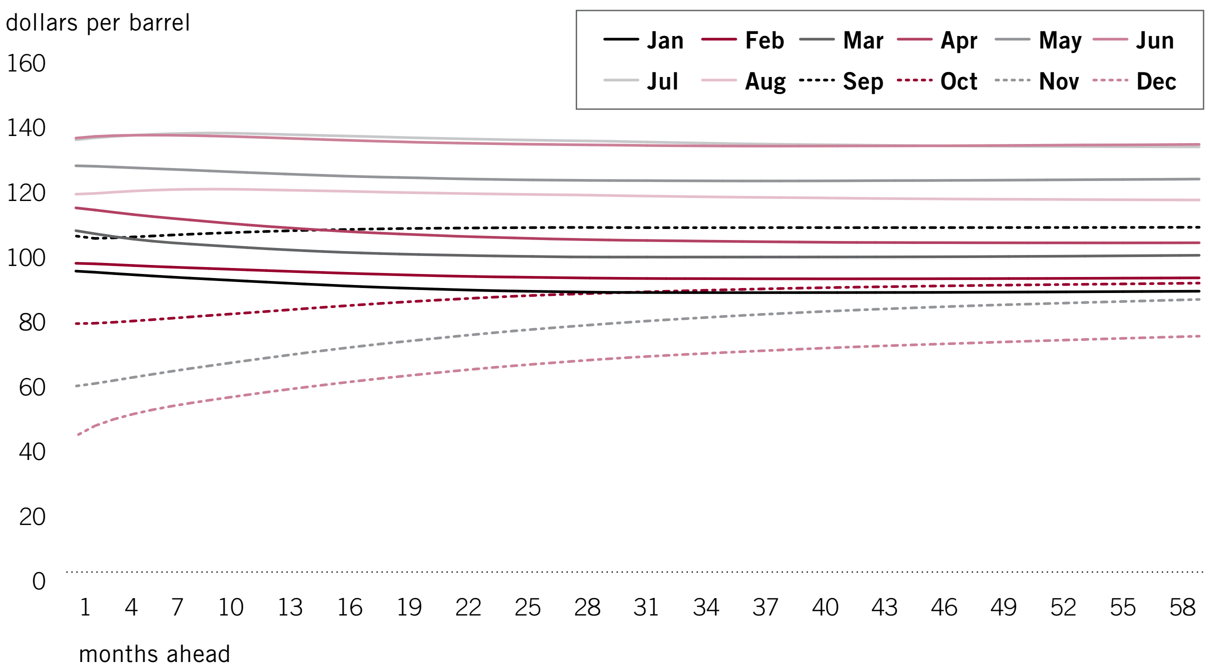


FIGURE 3.16. WTI: SPOT VS. FORWARD PREMIUM

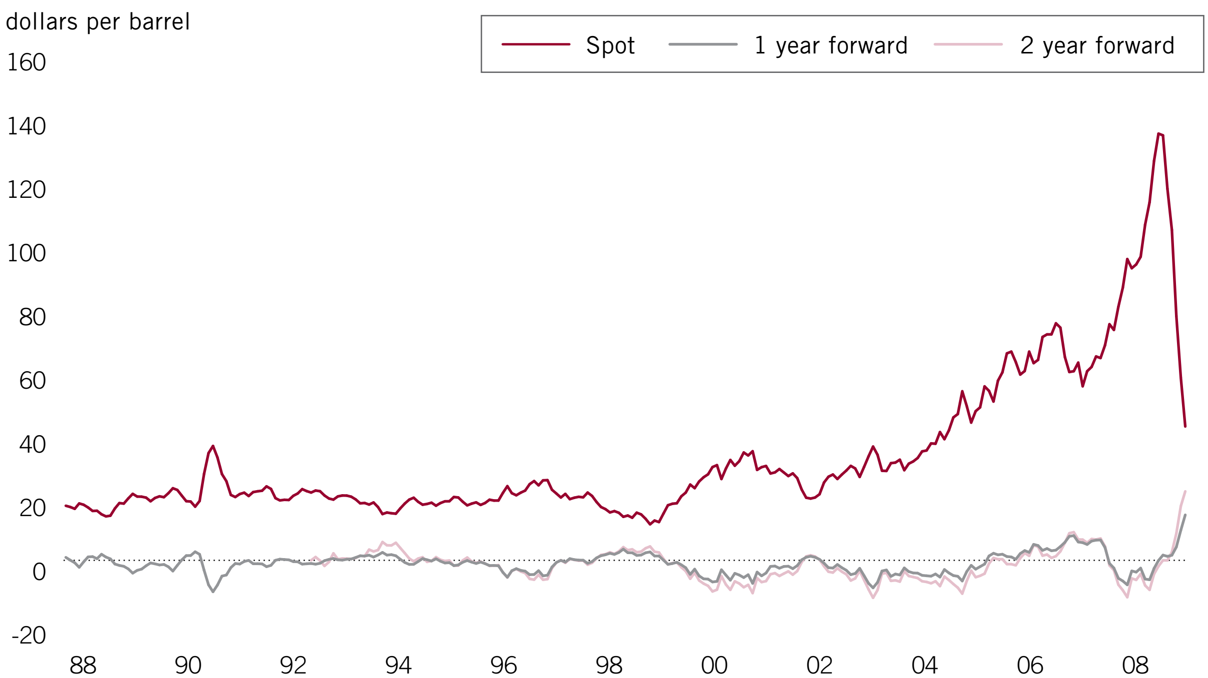


FIGURE 4.1. US CPI INFLATION: HEADLINE VS. CORE

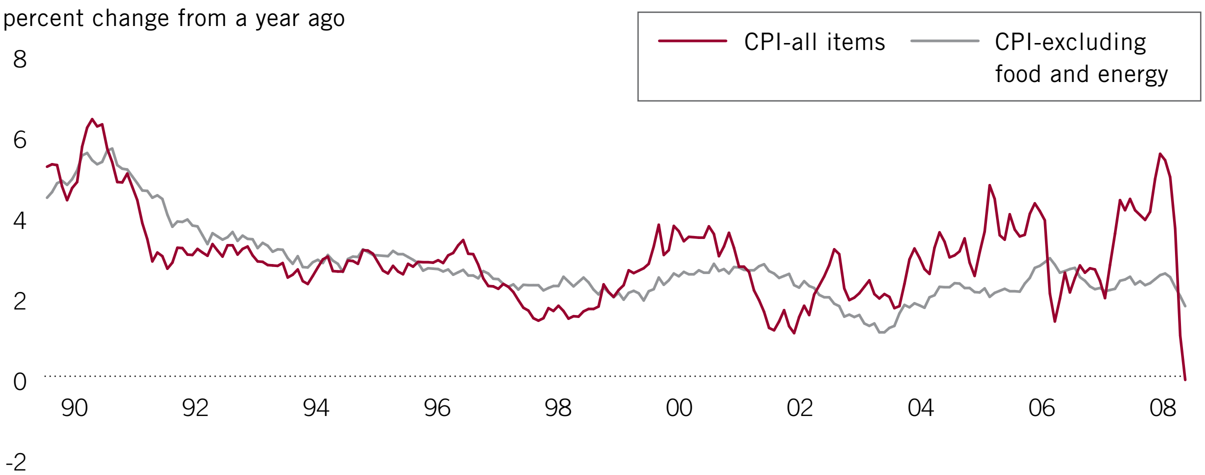
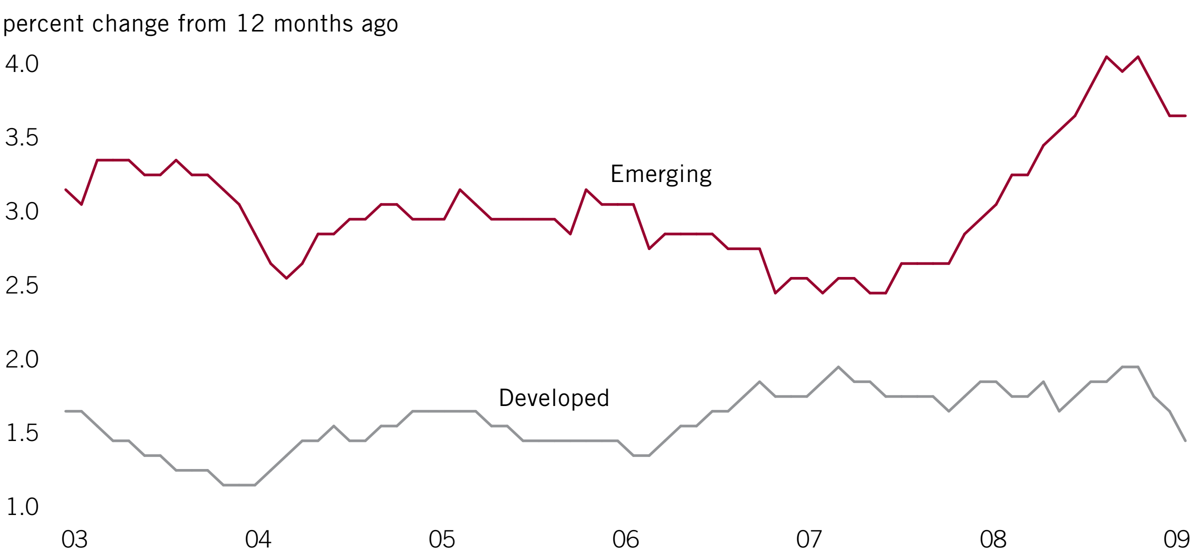


FIGURE 4.2. CONSUMER PRICES EXCLUDING FOOD AND ENERGY



Source. Data are either directly from or derived from national statistics agencies.

Developed: United States, Japan, Canada, Euro area, Norway, Sweden, Switzerland, United Kingdom. Emerging: Brazil, Chile, Colombia, Mexico, Peru, China, Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, Czech Republic, Hungary, Poland, Russia, Slovak Republic, South Africa.

FIGURE 4.3. EMERGING MARKETS WAGES AND UNIT LABOR COSTS

Source: Mostly derived from national statistics offices supplemented with private trade groups. EM sample: Argentina, Brazil, Chile, Colombia, Mexico, Venezuela, China, Korea, Malaysia, Singapore, Taiwan, Thailand, Czech Republic, Hungary, Poland, Russia, Slovak Republic, South Africa, and Turkey.

FIGURE 5.1. US INFLATION EXPECTATIONS SURVEYS

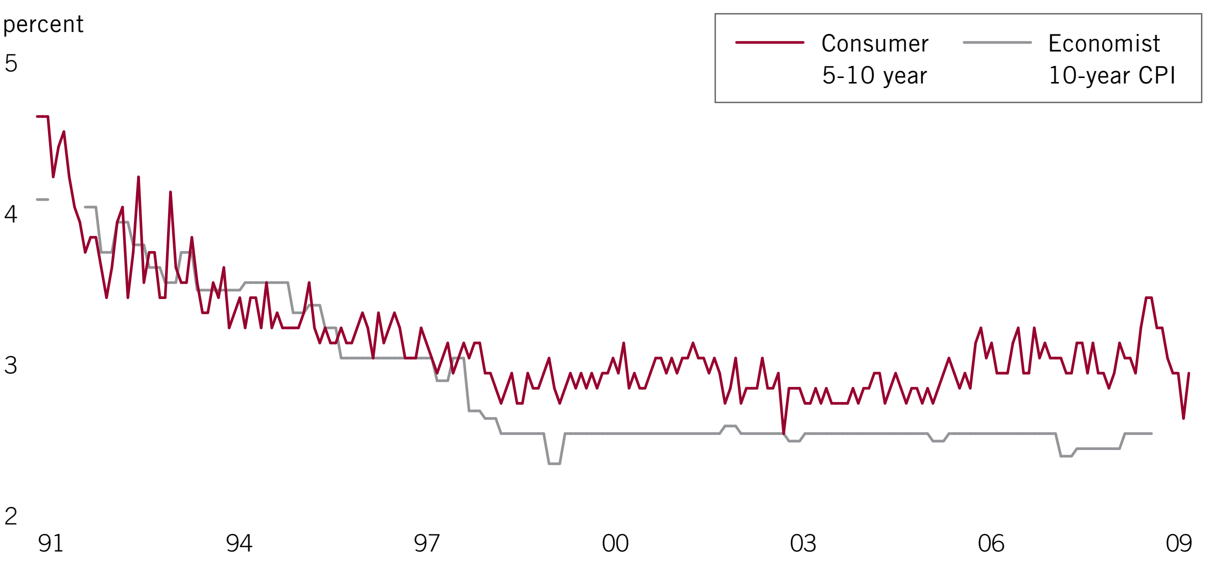


FIGURE 5.2. FIVE YEAR, FIVE YEAR AHEAD BREAK EVEN INFLATION (BEI)

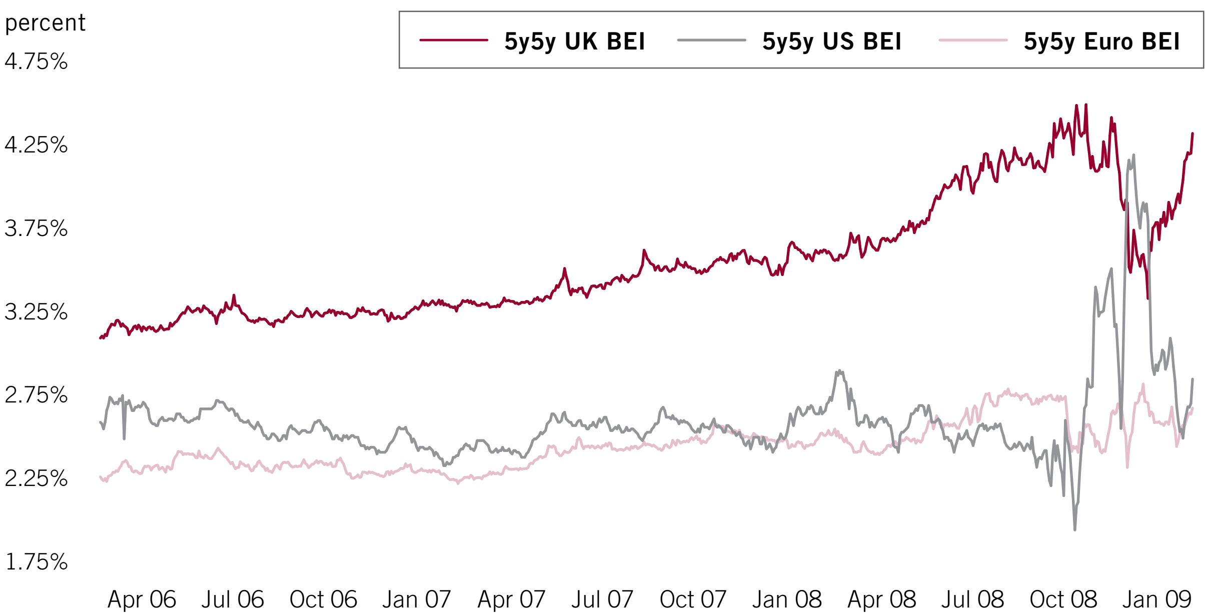
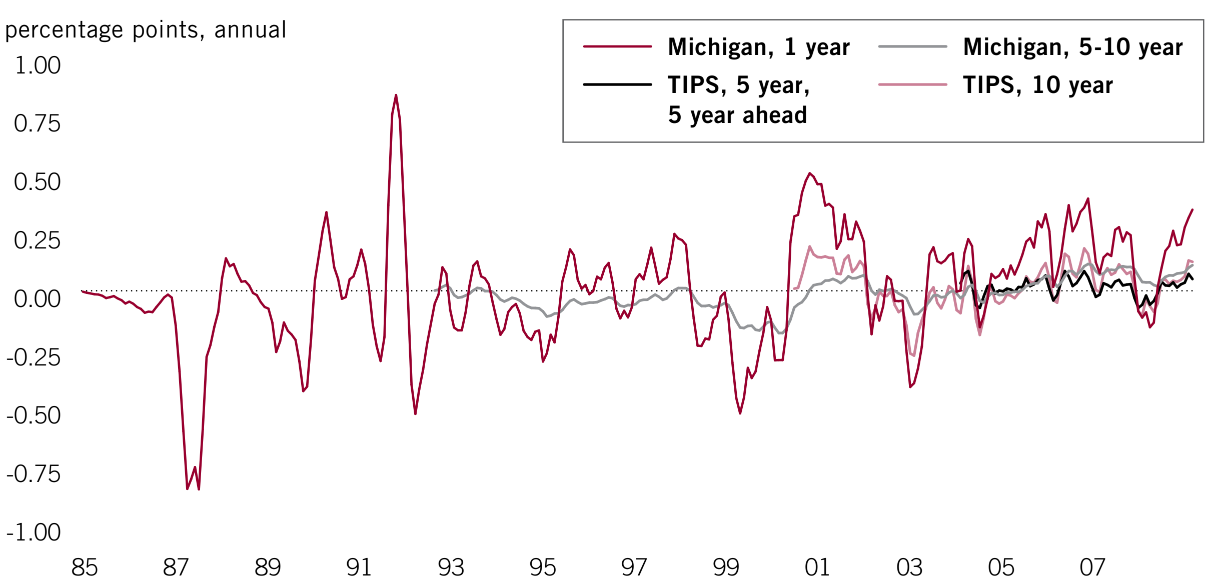


FIGURE 5.3. CONTRIBUTION OF OIL PRICE CHANGES TO EXPECTED INFLATION: HISTORICAL DECOMPOSITION



Note: Author's calculations based on estimates described in the text and summarized in Table 5.1.

FIGURE 6.1. FEDERAL FUNDS RATE, ACTUAL AND EXPECTED, JUNE 30, 2008

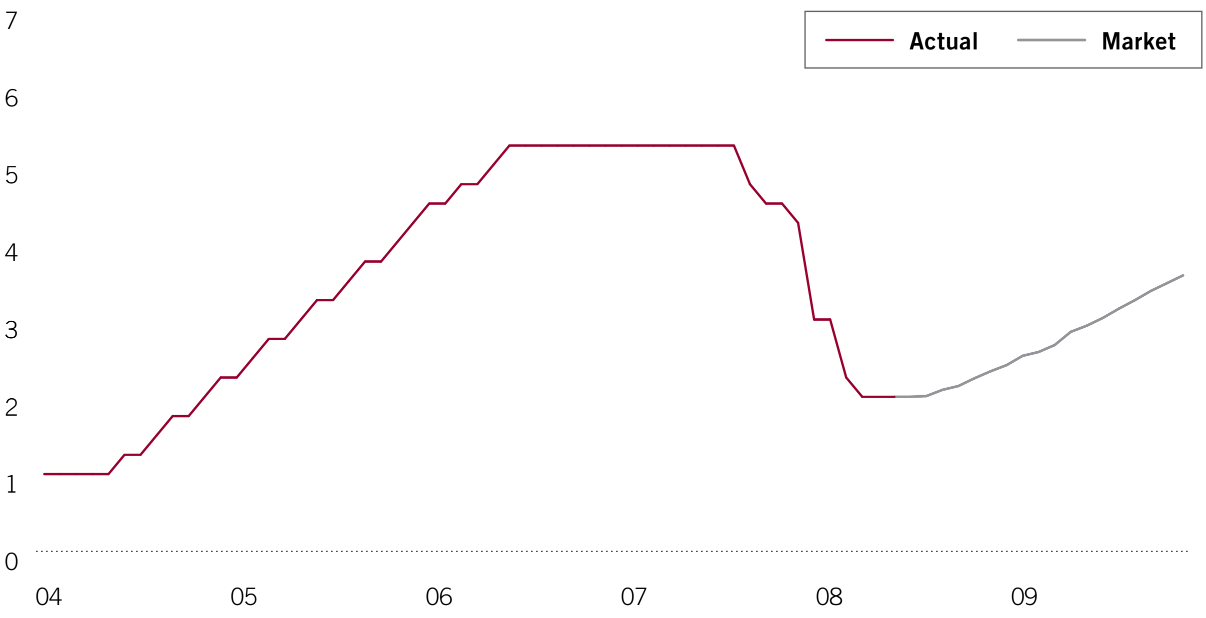
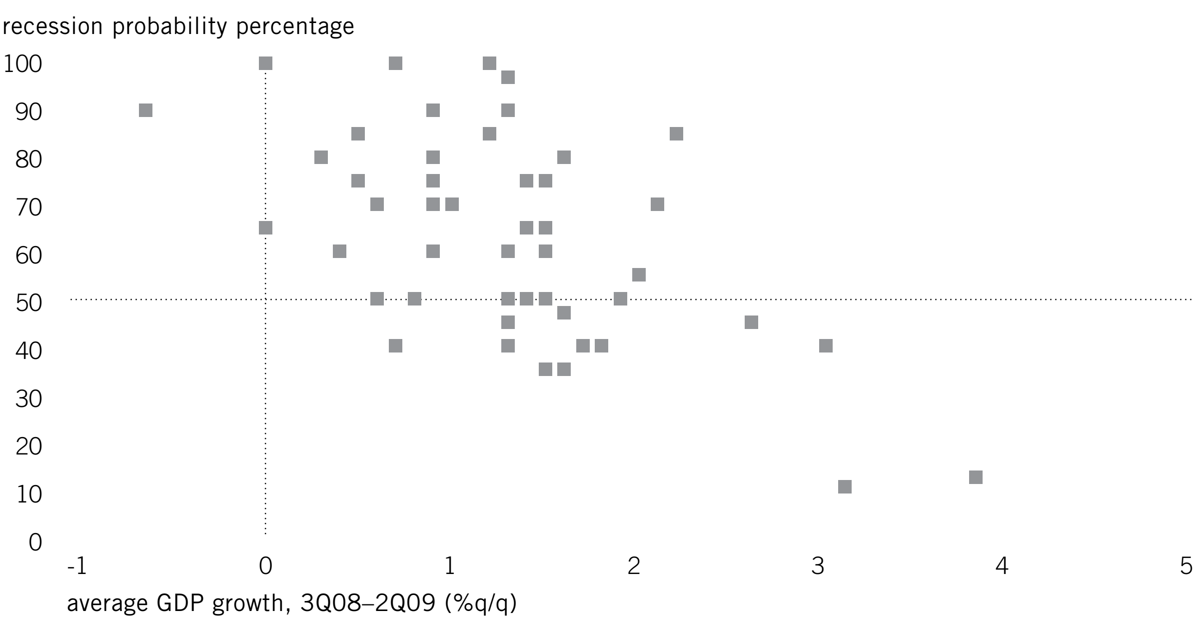
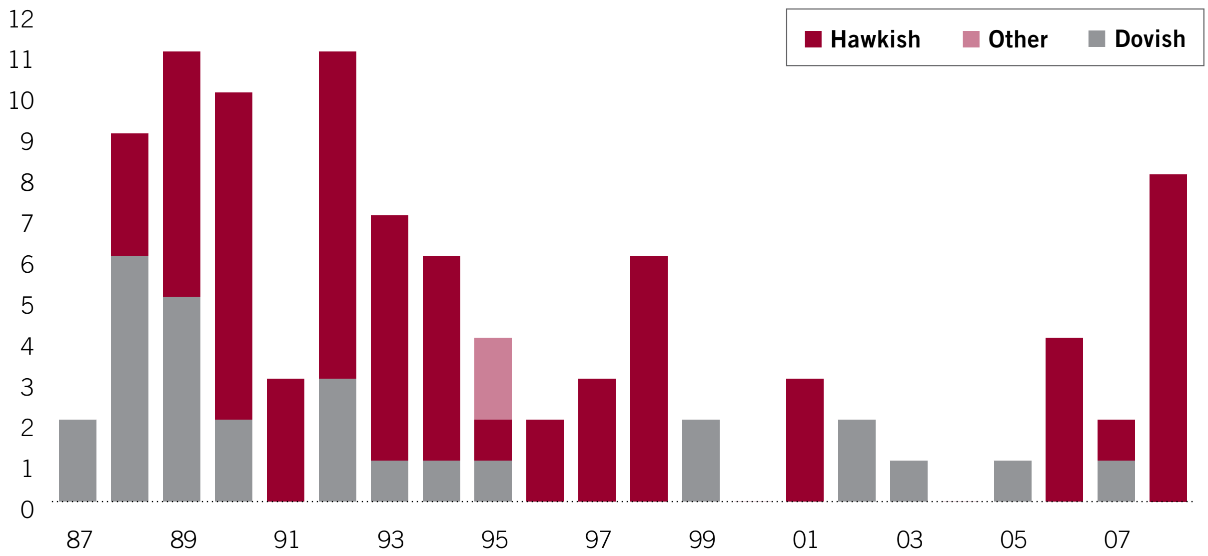


FIGURE 6.2. BASELINE FORECASTS AND RECESSION PROBABILITIES



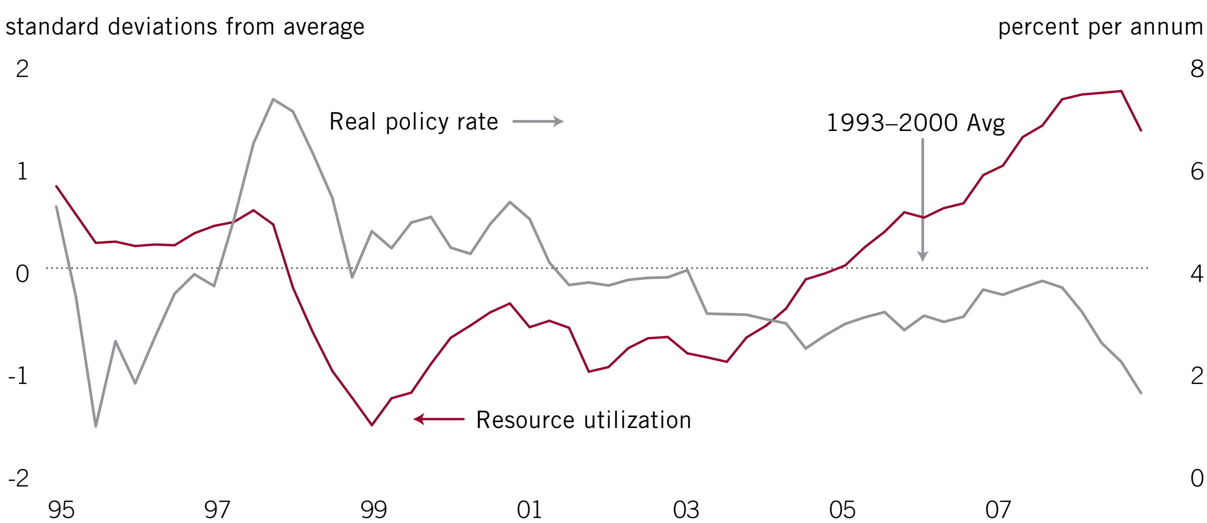
Source: July 2008 survey, Wall Street Journal

FIGURE 6.3. FOMC DISSENTS



Note: Dissents are from the FOMC meeting. Dissents are coded as "Dovish" for those favoring easing and "Hawkish" for those favoring tightening. "Other" dissents in 1995 related to the use of the Exchange Stabilization Fund to aid Mexico.

FIGURE 6.4. EMERGING MARKETS RESOURCE UTILIZATION AND AVERAGE POLICY RATE



Discussion of "Oil and the Macroeconomy: Lessons for Monetary Policy"

PRESENTATION TO THE 2009 U.S. MONETARY POLICY FORUM
CONDUCTED BY THE UNIVERSITY OF CHICAGO BOOTH SCHOOL OF BUSINESS
AND BRANDEIS INTERNATIONAL BUSINESS SCHOOL

New York, New York
By James Bullard, President and CEO, Federal Reserve Bank of Saint Louis

President Bullard, speaking extemporaneously, praised many aspects of the paper and made five main comments that he supported with both empirical evidence and reference to the scholarly literature.

- First, he explained that the 2008 peak in oil prices is difficult to explain as a pure demand phenomena.
- Second, he noted that the weak theoretical foundations for concentrating on "core inflation" as the relevant measure of inflation for the monetary authority. He also questioned the reliability of focusing on price indices that are often constructed using the assumptions implicit in New Keynesian macroeconomic models.
- Third, he argued that the finite supply of oil could lead to a long-term trend in the price of oil.
- Fourth, he pointed out the overall effect of oil price changes depends in part on how policymakers in other countries respond to price movements.
- Finally, he cautioned of the difficulties in gauging inflation expectations which are critical determinants of actual inflation. President Bullard concluded by saying that he expected oil prices to remain an important factor for monetary policymakers to consider for the foreseeable future.

Discussion of "Oil and the Macroeconomy: Lessons for Monetary Policy"[1]

PRESENTATION TO THE 2009 U.S. MONETARY POLICY FORUM
CONDUCTED BY THE UNIVERSITY OF CHICAGO BOOTH SCHOOL OF BUSINESS
AND BRANDEIS INTERNATIONAL BUSINESS SCHOOL

New York, New York
By Janet L. Yellen, President and CEO, Federal Reserve Bank of San Francisco

It's a pleasure to discuss this thoughtful and comprehensive report on the macroeconomic implications of oil price movements.[2] Even though we are no longer faced with sky-high oil prices, the issues discussed here remain important and policy relevant. It is hard to believe that oil prices will not go up again sometime in the future, so it is vital that we learn from the last episode, both about how the economy is likely to be affected and how monetary policy should respond.

Perhaps not surprisingly, most of my discussion relates to the latter topic, namely the Fed's policy response to the swings in oil prices over the last seven years. But I would like to start by commenting on the paper's discussion of the relationship between the market price of oil and the value of oil in the ground. Thinking of this relationship in terms of Tobin's q is an elegant and insightful contribution. As the authors point out, oil in the ground is like any other irreproducible asset, which should be described by Hotelling's theory that the price of such an asset minus marginal cost increases at a rate equal to the prevailing interest rate. But oil above the ground has distinct characteristics. And a number of factors can cause its price to depart—for some time—from the value implied by Hotelling's model. Thus, q—the ratio of the market price of oil to its value in the ground—can and does deviate from unity. The authors provide an important and informative example of such a departure, which uses data on mergers and acquisitions to calculate the value of the oil in the ground and compare it to the market price of oil over the last few years. This exercise, together with one based on the stock prices of large oil companies, suggests that the market price of oil was temporarily high in 2007, and that the jump in the first part of 2008 represented a further departure from the long-term value. I will return to this topic later.

Let me now turn to the paper's discussion of oil prices and monetary policy, a topic that has sparked much debate among academic economists and policymakers during my two stints as a Fed policymaker. The authors have accurately summarized the main issues involved in the debate that took place during 2002–2008, both inside and outside the Fed. As is well known, an oil price shock typically poses a dilemma for policymakers: Higher oil prices depress output and raise inflation. While the reduction in output provides a reason for policy to ease, the uptick in inflation pushes policy in the opposite direction. It is rarely obvious which element deserves greater weight in policy decisions, and that leads to debate about the appropriate response. The oil shocks of the past several years were no exception.

1 I would like to thank Bharat Trehan, John Fernald, John Judd, John Williams, and Sam Zuckerman for assistance in preparing these remarks.

2 Harris, Kasman, Shapiro, and West (2009)

I agree with the authors' assessment that the Fed focused primarily on core rather than headline inflation to gauge the extent of underlying inflationary pressures during this period. This strategy, as the authors note, can be justified on theoretical grounds. Since core inflation rose only slightly, the Fed's main inflation gauge did not signal a need to tighten policy dramatically. But as energy costs soared, the economy did experience an uncomfortable increase in headline inflation. The authors argue that the Fed should have paid more attention to the acceleration in headline inflation and raised interest rates by more than it did from 2004 to 2006.

Their argument is buttressed by two exercises, one of which examines some data on expected inflation while the other is based on model simulations. I will comment on each of these, in turn. Using a small vector autoregression model—where the price of oil is assumed to be exogenous—the authors show that changes in the price of oil help predict (or, more specifically, Granger cause) the Michigan survey's measure of expected inflation and also one of two expectations measures based on Treasury yields. This result suggests to the authors that the Fed may have lost, or been on the verge of losing, at least some of its inflation-fighting credibility. Such a loss of credibility would obviously be problematic. For one thing, it would increase the amount by which the Fed would have to increase rates to offset any given inflationary shock.[3]

It's not clear to me, however, that the Fed's credibility was actually under such serious threat. Even taking the results at face value, the increase in expected inflation was small. Figure 5.3 in the paper reveals, in particular, that for three of their four measures, expected inflation in 2008 was only about one-tenth of a percentage point higher than what it would have been in the absence of any increase in the price of oil over this period.

But I think there are good reasons *not* to take these results at face value. Consider, first, the authors' choice of survey measures. They argue that an increase in readings from the Michigan survey—following years of stability—reflects increasing inflation expectations. But they discount the stability of inflation expectations in the Survey of Professional Forecasters (SPF), arguing that it indicates "…forecast inertia rather than a super-credible central bank." I find the authors' preference for consumer surveys over those of professional forecasters surprising since it is usually argued that households pay less attention to the latest data than do the professionals who are paid to make these forecasts. Moreover, households probably update their forecasts of inflation less frequently than professionals. It's also worth pointing out that the lack of responsiveness of professional forecasts to *relative* price shocks appears to be a recent phenomenon, likely due, in my view, to increased Fed credibility and not some newly acquired inertia on the part of the forecasters. Research by my staff shows that while the SPF forecasts were sensitive to headline inflation data in the past, these forecasts have responded in recent years to core rather than headline inflation data.[4] This finding suggests that professional forecasters no longer expect relative price changes to have a persistent effect on inflation.

I would also take issue with the authors' assumption that oil prices are exogenous. For one thing, this assumption is at odds with the paper's extended discussion about how the price of oil is determined by economic developments in the U.S. and other countries. Moreover, the assumption is probably not

3 See, for example, Orphanides and Williams (2004, 2007).

4 Trehan (2009).

innocuous: previous research has shown that treating oil as endogenous in such models can greatly reduce the estimated effects of oil shocks.[5]

Last, and certainly not least, I would question the authors' conclusion that inflation expectations have become unanchored based on their finding that oil prices help predict the Michigan survey measures of expected inflation. This finding does imply that a jump in the price of oil causes expected inflation to increase for a time. But it does not prove that the increase is permanent rather than transitory. A permanent response of expected inflation to a change in oil prices requires either that the expectations process be nonstationary or that oil prices be expected to continue rising forever. In other words, the authors' finding of a link between oil prices and survey measures of expected inflation is perfectly consistent with a *temporary* impact of oil price shocks on both inflation and inflation expectations. Importantly, these are precisely the responses that are consistent with well-anchored expectations—except, of course, if consumers believe that the Fed would absorb the hit of an oil shock entirely in the form of reduced output.

Let me turn now to the second exercise in the paper, which involves simulating a new Keynesian model to examine the effects of oil shocks. As the authors point out, their specification reproduces a standard feature of such models, which is that it is better for monetary policy to target core inflation than headline inflation. But the authors then proceed to conduct an unusual simulation. To mimic the pattern of oil price increases from 2002 to 2008, they subject the model to a sequence of 26 quarterly shocks in which the average increase in the price of oil is about 7½ percent. While they present results for several different parameter combinations, the typical outcome entails a core inflation rate that is about 2 to 4 percentage points higher than the assumed inflation target of around 1¾ percent. The authors argue that such a sequence of oil price and inflation increases could cause inflation expectations to become unanchored. The implication is that the Fed should have tightened policy more than it did to keep expectations from being cast adrift.

A key element of their simulation is the assumption of a long period of increasing oil prices. Was it reasonable to expect such an outcome on a priori grounds? We can use the authors' elegant framework to answer this question. The first factor that is relevant in forecasting oil prices in that framework is the price of oil in the ground, as determined by the Hotelling model. However, the authors do not argue that this price changed substantially over the last five years or so. The second relevant factor is the behavior of q. In the authors' framework, q should be expected to converge toward unity in the medium to long term. Thus, the theory of the oil market presented in the paper suggests that forecasters during the 2002–2008 period should have expected oil prices to gradually revert to more "normal" levels over time, once q exceeded one. Of course, the model does not pin down precisely what might happen to the market price of oil for the next four, six or even eight quarters. Oil prices are notoriously hard to predict at these (and indeed at all) horizons, and there is plenty of room to argue about the role played by fundamentals, special factors, speculation, etc. But throughout most of this period, futures prices were predicting, even as oil prices rose, that oil prices would not rise further—and certainly not for six years running. And these were the most important real-time indicators of market expectations available to the Fed. Of course, futures-market forecasts proved wrong, ex post. But it seems to me now, as it did at the time, that there were neither strong empirical nor theoretical reasons to forecast that oil prices would continue rising for six years.

5 See Trehan (1986) and Barsky and Kilian (2004) for discussions of this issue.

Since the improbable did in fact come to pass and the Fed tightened less than the authors consider optimal, it seems entirely appropriate to consider the costs of the Fed's policy judgment. The authors note that the onset of the recession makes it all but impossible to get an unambiguous answer, and I agree. But I still think we can form some judgments based on the behavior of inflation during the more-than-five-year period, ending in mid-2008, during which oil prices kept moving higher. In 2001—the year before oil prices began to rise—core PCE price inflation was 1.9 percent. It averaged 2.2 percent over 2005–2007 and registered 2.2 percent during the first half of 2008. So, core inflation did rise somewhat. We can debate just how much of that increase should be attributed to oil shocks, rising capacity utilization levels, and the wearing-off of the unusual sequence of productivity shocks of the late 1990s, which had helped to push inflation to an unusually low level for a time. The important point, though, is that the actual increase in core inflation fell far short of the increase predicted by the model simulations presented in the paper.

During the period of rising oil prices and high headline inflation, policymakers paid close attention to the behavior of wages for possible signs that higher inflationary expectations might be spilling over into wage bargains. Reassuringly, there was little evidence of any increase in the rate of wage growth, a linkage that I consider necessary for a sustained increase in the inflation rate. For instance, after increasing at a 4.3 percent pace in 2001—the year before oil prices began their sustained increase—the Employment Cost Index rose by an average of a little over 3.2 percent per year over 2005–2007 and at an annual rate of 2.8 percent in the first half of 2008. Other compensation measures also reveal relatively steady wage growth during this period.[6] So, data on wages, like those on core inflation, reveal little evidence of any impact resulting from the long sequence of large oil price shocks.

The authors attribute the lack of any sizable run-up in core inflation to other shocks that may have hit the economy at the same time. But it is important to emphasize that a significant body of recent research instead suggests that the measured effect of oil price shocks has diminished over the last several decades. Over a decade ago, Hooker (1996) showed that the effect of oil price shocks had diminished since the early 1980s and subsequent research has verified this finding. In fact, this influential research has shifted the academic debate concerning oil shocks, with some authors now questioning whether such shocks were ever actually as important as was believed in the 1970s (Barsky and Kilian, 2004, Bernanke, Gertler, Watson, 1997) and others investigating what structural changes in the economy may have diminished the impact of such shocks (Blanchard and Gali, 2007).

It seems to me that a change in the conduct of monetary policy following the experience of the 1970s has probably caused inflation expectations to become better anchored, explaining why recent oil shocks have inflicted relatively little damage on the economy. This hypothesis could at least partly explain why the huge run-up in energy prices through the middle of last year was not accompanied by rising wage demands. That in turn enabled the Fed to follow an easier monetary policy that gave greater weight to the output effect of rising oil prices than would have otherwise been possible.

Since mid-2008, oil prices have, of course, plummeted. But the extraordinary weakness in the economy means that the usual trade-offs associated with such supply shocks are absent right now. Any boost to

6 Other wage and compensation measures reveal the same general behavior. Total compensation per hour in the nonfarm business sector rose by 4.1 percent in 2001, an average of 4 percent over 2005–2007, and by 2.4 percent at an annual rate in the first half of 2008. Average hourly earnings rose by 3.8 percent in 2001, an average of 3.6 percent per year over 2005–2007, and at a 3.8 percent rate in the first half of 2008.

spending from falling oil prices will be more than welcome in the current circumstances. And with inflation now below desirable levels, a decline in inflationary expectations that could push core inflation down over time would be most unwelcome. I argued earlier that the Fed's inflation credibility helped over a number of years to keep inflationary expectations anchored in the face of rising oil prices and high headline inflation. My hope is that inflationary expectations will remain similarly well-anchored now, serving to stabilize core inflation. The FOMC's recently released longer-run inflation projections should be useful in this regard, helping to reinforce inflation expectations of around 2 percent.

To conclude, let me emphasize that I enjoyed reading the paper and found the discussion of recent developments quite informative. But, the arguments in this paper did not persuade me to change my opinion of recent Fed policy. As I noted, during the period of rising oil prices, there was little evidence that policy was inappropriate: labor compensation growth remained well contained and inflation persistence appeared to be low, most likely because of increased Fed credibility. The Fed must always be vigilant in guarding its inflation credibility. But I did not think then, and I do not think now with the benefit of hindsight, that expectations became or were close to becoming unanchored at any point. Nor do I think that the Fed should have taken out substantial insurance against the possible consequences of a highly unlikely sequence of shocks, especially when a growing body of research suggested that the impact of oil shocks had declined substantially since the 1970s.

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Panel Discussion, U.S. Monetary Policy Forum, February 27, 2009

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*The views expressed here are my own and are not necessarily those of Columbia University or the National Bureau of Economic Research.

The organizers of this panel asked us to focus on a set of four questions:

- Have the events since August 2007 changed your view of the transmission mechanism or the strategy for monetary policy?
- Does the Fed have all the tools (legal, staff, communication strategy, etc) to properly carry out its monetary policy mandate?
- Can monetary policy be meaningfully separated from financial stability responsibilities?
- Given the proximity to the zero bound, is there a preferred way to carry out any further policy easing should that become necessary?

I will focus on answering two questions that are closely related to the four above.

- Have events since August 2007 affected the monetary transmission mechanism?
  In particular, has the subprime financial crisis made monetary policy ineffective?
  I will argue that the answer is no.
- Are there some tools that the Fed should have that would help in current situation?
  I will argue that an explicit numerical inflation goal (often referred to as an inflation target, although this terminology is somewhat problematic) would be particularly useful now.

I. Has the Subprime Financial Crisis Made Monetary Policy Ineffective?

The tightening of credit standards and the failure of the cost of credit to households and businesses to fall despite the sharp easing of monetary policy has led to a common view that monetary policy has not been effective during the recent financial crisis. Not only has this view been expressed by economists such as Paul Krugman (2008), but, as the minutes from the October 28-29, 2008, FOMC meeting indicate, it was also expressed by some participants in that meeting (Board of Governors of the Federal Reserve System 2008). These views hark back to early Keynesian discussions of the ineffectiveness of monetary policy during the Great Depression period. Because of the shocks to credit markets from the financial crisis, the argument is that monetary policy is unable to lower the cost of credit and is thus pushing on a string. Monetary policy is therefore ineffective.

I will argue here that this view is just plain wrong. Not only that, the view that monetary policy is ineffective during a financial crisis is highly dangerous because it leads to the following two conclusions. First, if monetary policy is ineffective, then there is no reason to use it to cope with the crisis. Second, easing monetary policy during a crisis is counterproductive because it can weaken the credibility of the monetary authorities to keep inflation under control and thus be inflationary. I strongly disagree with both these conclusions and I will argue that, to the contrary, financial crises of the type we have been experiencing provide a strong argument for even more aggressive monetary policy easing than normal.

Financial Instability and Macroeconomic Risk

To understand my argument it is first necessary to recognize that the financial system performs the function of efficiently channeling funds to individuals or corporations with worthy investment opportunities by collecting and processing information. Although financial markets and institutions deal with large volumes of information, some of this information is by nature asymmetric; that is, one party to a financial contract (typically the lender) has less accurate information about the likely distribution of outcomes than does the other party (typically the borrower). Historically, banks and other financial intermediaries have played a major role in reducing the asymmetry of information, partly because these firms tend to have long-term relationships with their clients.

The continuity of this information flow is crucial to the process of price discovery—that is, the ability of market participants to assess the fundamental worth of each financial asset. During periods of financial distress, however, information flows are disrupted and price discovery is impaired. The high risk spreads and reluctance to purchase assets that are characteristic of such episodes are natural responses to the increased uncertainty resulting from the disruption of information.

Two types of risks are particularly important for understanding financial instability. The first is *valuation risk*: The market, realizing the complexity of a security or the opaqueness of its underlying creditworthiness, finds it has trouble assessing the value of the security. For example, this sort of risk has been central to the repricing of many structured-credit products during the turmoil of the past year, when investors have struggled to understand how potential losses in subprime mortgages might filter through the layers of complexity that such products entail.

The second type of risk that I consider central to the understanding of financial stability is *macroeconomic risk*—that is, an increase in the probability that a financial disruption will cause significant deterioration in the real economy. In particular, strains in financial markets can spill over to the broader economy and have adverse consequences on output and employment. Furthermore, an economic downturn tends to generate even greater uncertainty about asset values, which could initiate an adverse feedback loop in which the financial disruption restrains economic activity; such a situation could lead to greater uncertainty and increased financial disruption, causing a further deterioration in macroeconomic activity, and so on. This phenomenon is generally referred to as the financial accelerator (Ben Bernanke and Mark Gertler, 1989; Ben Bernanke, Mark Gertler, and Simon Gilchrist, 1996).

We are currently in exactly this kind of adverse feedback loop, and the result has been higher credit spreads despite aggressive cuts in the federal funds rate. Interest rates relevant to household and business spending decisions therefore have risen, along with a sharp tightening of credit standards. The economy has gone into a tailspin and we are now in the midst of a serious recession.

Does this mean that monetary policy is ineffective?

Does the fact that the cost of credit has risen for households and businesses despite aggressive monetary easing mean that monetary policy has been ineffective in the current financial crisis episode? The answer is no. To see this, consider the following counterfactual: What if the Fed had *not* aggressively cut rates during the current crisis?

Valuation risk would certainly have stayed as high because tighter monetary policy would certainly not have made it easier to value securities by either reducing the opaqueness of securities that were hard to value or making it easier to assess credit risk.

On the other hand, tighter monetary policy would surely have led to higher macroeconomic risk. Tighter monetary policy, through its usual channels by restraining consumer spending and business investment, would have made it more likely that the economic downturn would have been even more severe, which would result in even greater uncertainty about asset values. Tighter monetary policy would then have made an adverse feedback loop more likely, in which the greater uncertainty about asset values would raise credit spreads, causing economic activity to contract further: The contraction in economic activity then would create more uncertainty, making the financial crisis worse, causing the economic activity to contract further and so on.

If the Fed had not aggressively cut rates, the result would have been both higher interest rates on default-free bonds like Treasury securities and a substantial increase in macroeconomic risk with much higher credit spreads. Interest rates relevant to household and business spending decisions would then have been *much higher than what we see currently*. Aggregate spending would therefore have been lower and the current recession would be far more severe. Tighter monetary policy would have been very costly indeed.

The logic above indicates that not only has monetary policy been effective during the current financial crisis, but that it has been even more potent than during normal times because it not only lowered interest rates on default-free securities, but also helped lower credit spreads. The argument here does not, however, say that monetary policy can offset the contractionary effect of a massive financial disruption in the credit markets of the type we have been experiencing. The financial crisis has led to such a widening of credit spreads and tightening of credit standards, that aggressive monetary policy easing has not been enough to contain the crisis. This is why central banks have provided liquidity support to particular sectors of the financial system in order to contain liquidity squeezes.

The Federal Reserve, in particular, has implemented large liquidity injections into the credit markets to try to get them lending again. Starting in mid-August 2007, the Fed lowered the discount rate to just 50 basis points above the federal funds rate target from the normal 100 basis points (later to 25 basis points). Over the course of the crisis, the Fed broadened its provision of liquidity to the financial system well outside of its traditional lending to depository institutions, leading Paul Volcker, a former Chairman of the Federal Reserve, to describe the Fed's actions as going to the "very edge of its lawful and implied powers." The number of new Fed lending programs over the course of the crisis spawned a whole new set of acronyms, the TAF, TSLF, PDCF, AMLF, CPFF, and MMIFF and TALF, making the Fed sound like the Pentagon with code-named initiatives and weapons. Like the Pentagon, the Fed has been fighting a war against a potentially destructive enemy, although its weapons were financial rather than guns, tanks, or aircraft.

Even though I believe that the Fed's liquidity injections, which have expanded the Fed balance sheet by a trillion dollars, have been extremely useful in limiting the negative impacts of the financial crisis, they will not be enough. To get the financial system working again, financial institutions will need to be recapitalized sufficiently to bring them back to health, so that they have the proper incentives to go out and make loans to households and businesses with productive investment opportunities. In addition economists (and politicians) have come around to the view that large fiscal stimulus packages may be necessary to keep economies throughout the world from entering into deep recessions or even depressions. Of course it is far from clear whether these fiscal packages, like the close to $800 billion package in the United States, will be effective.

Why Monetary Policy Needs to be Aggressive During Financial Crises

The logic of the argument above which indicates that monetary policy may be even more effective during financial crises also argues for even more aggressive easing of monetary policy during financial crises.

As argued above financial disruptions can have particularly nonlinear effects on the economy because they can lead to an adverse feedback loop. As I outlined in Mishkin (2008a), the resulting nonlinearity argues against the result from a linear-quadratic (LQ) framework that optimal monetary policy should display considerable inertia.[1] An alternative approach is for monetary policy to engage in risk management by using monetary policy to take out insurance against tail risks.

As I mentioned above, periods of financial instability are characterized by valuation risk and macro-economic risk. Monetary policy cannot aim at minimizing valuation risk, but can reduce macroeconomic risk. By easing monetary policy aggressively to offset the negative effects of financial turmoil on aggregate economic activity—this includes cutting interest rates preemptively, as well as using nonconventional monetary policy tools if interest rates fall to close to the zero lower bound—monetary policy can reduce the likelihood that a financial disruption might set off an adverse feedback loop. The resulting reduction in uncertainty can then make it easier for the markets to collect the information that facilitates price discovery, thus hastening the return of normal market functioning.

One danger from aggressive monetary policy easing is that it might unanchor inflation expectations. This unanchoring of inflation expectations could then lead to significant inflation in the future because the behavior of inflation is significantly influenced by the public's expectations about where inflation is likely to head in the long run (Mishkin, 2007). Therefore, aggressive preemptive easing of monetary policy would be counterproductive if these actions caused an increase in inflation expectations and the underlying rate of inflation; in other words, the flexibility to act preemptively against a financial disruption presumes that inflation expectations are well anchored and unlikely to rise during a period of temporary monetary easing.

How can a central bank keep inflation expectations solidly anchored so it can respond preemptively to financial disruptions? The central bank has to have earned credibility with financial markets and the public through a record of previous actions to maintain low and stable inflation. Furthermore, by clearly communicating the rationale for its policy actions, the central bank can make it clear that it will not let inflation spin out of control. In addition, inflation expectations are more likely to remain anchored if

1 The now-classic textbook on this topic is Michael Woodford (2003).

the central bank communicates that it will be flexible in the opposite direction by raising interest rates quickly if there is a rapid recovery in financial markets or if there is an upward shift in projections for future inflation. In this way, the central bank can show that it is prepared to take back some of the insurance it has provided by its earlier monetary policy easing.

Now let me turn to the second question: Are there some tools that the Fed should have that would help in current situation? The answer is yes: the Fed needs to adopt an explicit numerical inflation objective.

II. WHY THE FED NEEDS AN EXPLICIT NUMERICAL INFLATION OBJECTIVE NOW

Many central banks throughout the world have adopted an explicit, numerical objective for inflation, commonly referred to as an inflation target, although this terminology is somewhat misleading because having a numerical objective does not mean that you should try to hit it over short periods of time as the word "target" seems to imply. The Federal Reserve is currently not one of them, but it is discussing this possibility. In the current circumstances with the economy in free fall, is it crazy for the Fed to move in this direction? Is an increased commitment to stabilizing inflation the right thing to do when we are in the throes of a financial crisis and the economy is doing so poorly?

My answer is absolutely yes. Adopting an explicit, numerical inflation objective is exactly what is needed right now to help the U.S. economy to recover.

As many of you know, I have been a strong advocate of the Fed having an explicit numerical inflation objective. The usual argument for establishing a transparent and credible commitment to a specific numerical inflation objective is that it provides a firm anchor for long-run inflation expectations, thereby directly contributing to the objective of low and stable inflation. Adoption of an explicit, numerical inflation objective has been successful in other countries in keeping inflation from going too high. However, particularly important now is that an inflation target can help prevent inflation from falling too low. At this critical juncture, this benefit can have enormous value.

Up until recently, inflation risks were on the upside. But the contractionary shock from the severe disruptions in the financial markets that we have been experiencing lately has shifted the economic landscape completely. Not only has the economy entered a deep recession, but inflation has plummeted. CPI inflation on a year-over-year basis has fallen below 2%, which is below what would be a sensible inflation objective consistent with price stability. On a three-month basis inflation has been falling at a negative 10% rate. Core measures of inflation, which strip out food and energy prices and are thus potentially more accurate guides to underlying inflation, also indicate that the risks to inflation are on the downside. Core CPI inflation on a year-over-year basis is below 2%, but over the last three months has been below 0.5%.

The danger right now is not that inflation expectations will be too high, but rather that they become unanchored in the negative direction. Indeed, inflation expectations, whether measured by consumer surveys, surveys of professional forecasters or the difference between interest rates on non-indexed Treasury securities and Treasury indexed bonds, all point to a sharp decline. Longer run inflation expectations have just recently come down to levels consistent with price stability, but if they fall further they could lead to two dangerous consequences. First, there would be an increased likelihood that inflation would become persistently negative, that is, a deflation. The experiences with deflation in the Great Depression and the "lost decade" in Japan suggest that a deflation causes great hardship in the economy. Second, with the federal funds rate near zero and therefore unable to go lower, persistent deflation would raise the effective cost of borrowing to households and businesses because it would mean that the interest rate adjusted for changes in the prices of real goods and services would rise. Despite an interest rate of zero, monetary policy would then become highly contractionary.

How would adopting an explicit numerical inflation objective help in the current economic environment? First, a commitment by the Federal Reserve to keep the inflation rate near an explicit objective, say 2%, over a longer term horizon would provide more incentives by the Fed, both because it would want to stick to its word and because it would subject it to more public scrutiny, to take future steps to have monetary policy be sufficiently expansionary in the future. Economic research has shown that a lack of such commitment was one reason why nonconventional monetary policy actions such as quantitative easing by the Bank of Japan was ineffective in promoting economic recovery.

Second, when the financial system starts to recover, to keep future inflation under control the Federal Reserve will need to drain the massive amounts of liquidity that it has pushed into the financial system over the past year and a half. A commitment to an explicit numerical inflation objective will encourage the Fed explain to the public how this liquidity will be removed and subject the Fed to public pressure if it was not taking the necessary steps to make this happen. In other words, a commitment to an explicit numerical inflation objective will help the Fed in developing an exit strategy from the enormous expansion in its balance sheet that it has been using to engage in expansionary, nonconventional monetary policy.

How difficult would it be for the Fed to commit to an explicit numerical inflation objective at this juncture? The answer is not very, as I outlined in my last speech as a Federal Reserve governor in July of 2008 (Mishkin, 2008b). I pointed out that doing so would involve three steps.

- First, the horizon for the projections on output growth, unemployment, and inflation should be lengthened. This change might involve simply an announcement of FOMC participants' assessment of where inflation, output growth, and unemployment would converge under appropriate monetary policy in the long run. Alternatively, the horizon for the projections could be extended out further, say to five or more years.

- Second, FOMC participants should work toward reaching a consensus on the specific numerical value of the mandate-consistent inflation rate, and this consensus value should be reflected in their longer-run projections for inflation.[2]

- Third, the FOMC should emphasize its intention that this consensus value of the mandate-consistent inflation rate would only be modified for sound economic reasons, such as substantial improvements in the measurement of inflation or marked changes in the structure of the economy.

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2 FOMC participants would work toward reaching this consensus about mandate-consistent inflation using the overall inflation rate, as measured by PCE inflation, to be consistent with the Federal Reserve's dual mandate. Overall and core (excluding changes in the prices of food and energy) inflation rates are likely to be at similar rates at a horizon of five or more years.

The Fed has just recently adopted the first step after the last FOMC meeting. The second step would also not be very difficult to do since the minutes of the last FOMC meeting indicated that most FOMC participants had a long-run projection of 2% for inflation under appropriate policy, with the lowest value being 1.5%. Thus the difference between FOMC participants on what they think the long-run inflation objective should be is not that large. The last step would be very natural because Federal Reserve officials always emphasize that their decisions on monetary policy are driven by sound economic reasoning. Indicating that the inflation goal should be decided on the same basis is therefore consistent with the way the Federal Reserve has been operating.

The time for hesitation by the Federal Reserve in adopting an explicit, numerical inflation objective is past. The Fed needs to do this now.

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Ensuring Sound Monetary Policy in the Aftermath of Crisis

PRESENTATION TO THE 2009 U.S. MONETARY POLICY FORUM
CONDUCTED BY THE UNIVERSITY OF CHICAGO BOOTH SCHOOL OF BUSINESS
AND BRANDEIS INTERNATIONAL BUSINESS SCHOOL

By Charles I. Plosser, President and CEO, Federal Reserve Bank of Philadelphia

The financial crisis and its ramifications for the broader economy have forced policymakers to be aggressive and creative in their efforts to deal with unfolding events. In my remarks today, rather than review how policymakers got here, I'd like to discuss some of the issues raised by our choices and suggest three ways to strengthen the Federal Reserve's credibility and commitment to sound monetary policymaking going forward.[1]

With December's cut in the fed funds rate target to a range of 0 to 25 basis points, the Federal Reserve's monetary policy entered a new regime. The FOMC's statement indicated that the focus of policy will be to sustain the size of the Fed's balance sheet at a high level.

When the crisis began, the Fed responded by aggressively cutting the fed funds rate and by implementing a number of lending facilities intended to provide liquidity to disrupted credit markets. At first, the Fed was able to offset or sterilize its lending through open market operations, thus there was no significant increase in the size of the Fed's balance sheet or in the amount of total central bank credit provided to the economy. As the turmoil in credit markets continued, we expanded the types of institutions that could access Fed lending and the types of assets we took onto our balance sheet. But the size of that lending soon made sterilization no longer feasible. Since September 2008, the Fed has increased total market liquidity while altering the allocation of credit to particular markets. As a result, the Fed's balance sheet has more than doubled from just over $900 billion last September to almost $2 trillion in January 2009. Moreover, we can expect further increases as we continue to purchase mortgage-backed securities and agency debt and as we implement the TALF, or Term Asset-Backed Securities Loan Facility.

This policy of quantitative easing has come into play because the nominal policy rate has effectively reached zero and further accommodation seems desirable. By expanding the quantity of bank reserves beyond that needed to keep the funds rate at zero, this policy is meant to support the economy. The policy also serves to prevent fears of deflation from turning into expectations of persistent deflation that would cause the real federal funds rate to rise. However, instead of implementing the balance-sheet expansion by purchasing government securities, the asset typically found on the central bank's balance sheet,

1 See Charles Plosser, "Credibility and Commitment," speech given to the New York Association for Business Economics, New York, NY, March 6, 2007.

the Federal Reserve has taken on a wide array of nontraditional assets—dramatically altering the composition of its balance sheet. Chairman Bernanke has called this "credit easing" to distinguish it from other forms of "quantitative easing."[2]

The rationale for credit easing in particular markets, rather than more traditional quantitative easing achieved by the acquisition of more market-neutral Treasuries, is that intermediation in a number of credit markets has been disrupted, and the Fed has decided to take an active role in efforts to improve that intermediation. The jury is still out, however, as to how effective these policies will be.

But there is no doubt that the current framework for monetary policy and its reliance on targeted credit programs have carried the Federal Reserve into uncharted territory and poses some challenges for policy going forward. Today I would like to suggest three steps we can take now to strengthen the Fed's credibility and commitment to fulfill its dual mandate of price stability and sustainable economic growth. I believe these steps can better position us when the time comes to resume more traditional monetary policy.

The first step is to reinforce our commitment to providing a nominal anchor for our economy. It is essential to do so if we are to achieve the most unique of all our objectives—price stability.

With the fed funds rate essentially at zero, and our focus on credit easing, we are allowing our balance sheet to grow, or shrink, based on criteria entirely unrelated to providing that nominal anchor. It is difficult to make credible commitments to price stability when the implementation of policy is disconnected from such an important policy objective.

Fortunately, I believe there is a way out of this dilemma: the Fed should adopt an explicit inflation objective and publicly commit to achieving that objective over some intermediate horizon. To me, the exact number or price index for the objective is somewhat less important than the public commitment to a goal. Such a commitment would help anchor expectations more firmly and diminish concerns of persistent inflation or persistent deflation—not an inconsequential issue in the current environment.

In addition to announcing an inflation objective, we must also clearly communicate our policy strategy to the public so that they understand how the FOMC anticipates achieving that goal. There are different ways to accomplish this. For example, Taylor-like rules that involve adjusting the federal funds rate in response to deviations of inflation from target and shocks to output or economic growth have some advantages. Such simple rules can be useful guides for conducting systematic policy and can help effectively communicate to the public the conditional nature of policy choices.[3]

2 A recent example of "quantitative easing" occurred in Japan between March 2001 and March 2006. Even before that, the Bank of Japan had entered a period of low interest rates, lowering its policy rate to zero in February 1999. Between February 1999 and March 2001, total assets on the Bank of Japan's balance sheet grew by almost 40 percent, from 80 trillion yen to 110 trillion yen. In the five-year quantitative easing period, total assets expanded by another 40 percent, to a peak of 155 trillion yen in December 2005. Thus, it took over five years for the Bank of Japan to double its balance sheet. In contrast, the Fed doubled its balance sheet in about four months. Like the Fed, the Bank of Japan also bought more than just government securities. It purchased both asset-backed securities and equities from commercial banks.

3 See Charles Plosser, "The Benefits of Systematic Monetary Policy," speech given to the National Association for Business Economics, Washington Economic Policy Conference, Washington, D.C., March 3, 2008.

Another advantage of such transparent and simple rules is that if the FOMC chooses to deviate from what reasonable guidelines would suggest, then the Committee would, and should, feel compelled to explain its reasoning, which would further improve the transparency of policy.

Another form of communication that could be useful is for the FOMC to publish quarterly projections of the range and central tendencies of the Committee members' assumed path of policy over the forecast horizon that they believe is consistent with achieving our dual mandate of price stability and sustainable growth. Some see a risk that the public may perceive these projections as a commitment to a particular path for policy. But the experiences of the central banks of Sweden, Norway, and New Zealand, which publish policy path projections, suggest that this risk can be overcome through careful communication.

The second step toward strengthening the credibility of our commitment to sound monetary policy is to clarify the criteria under which we choose to step in as a lender of last resort. We must spell out when we will intervene in markets or extend unusual credit to firms—and then we must be willing to stick to those criteria. Moreover, we also need to complement such clear commitment with a well-articulated exit strategy from such liquidity or credit programs.

Our lending programs were created for extraordinary times and involve significant intervention in the private markets, but they run contrary to a long-standing and sound Fed practice of trying to minimize the effect of its actions on the allocation of credit across market segments. In my view, such programs are not, and should not, be part of the normal operation of a central bank.

The lack of clear ground rules for such intervention can lead market participants to speculate on the next facility the central bank will create or on the next asset class or firm it will rescue. Such speculation increases volatility and places other markets under stress. This is counter-productive to the programs' stated objective of financial stability. Moreover, each intervention creates moral hazard that may lead market participants to take on more risk than they otherwise would—thus sowing the seeds for the next crisis.

The lack of a clearly communicated exit strategy also creates uncertainty in the very markets we are serving with these facilities and also may prove counter-productive to achieving the stability objectives. For example, the central bank's willingness to participate and to lend "cheaply" in selected markets may deter private-sector participants from returning to and restoring normal market functioning. Thus, an exit strategy might involve gradually raising the costs of using the facilities, which may encourage the markets to heal themselves. A clear exit strategy would also enhance the Fed's credibility if the public understood that it does, in fact, have a plan to exit from these unusual interventions.

My third and final suggestion is to draw a clearer distinction between monetary policy and fiscal policy and to ensure that the Federal Reserve retains its independence to conduct sound monetary policy.

This suggestion is motivated by the fact that the current crisis and the Fed's interventions have dramatically altered the composition of the assets on our balance sheet and created confusion in the minds of many as to the respective roles of the central bank and the fiscal authority. These interventions and ensuing confusion have ramifications for our independence and for the conduct of monetary policy.

Eventually economic conditions will improve, demand for excess reserves will fall, and in order to maintain price stability, the Fed will have to begin withdrawing the extraordinarily large supply of liquidity with which it has flooded the market. Under normal operating procedures, this isn't a problem, as the Fed holdings are mainly short-term Treasuries, which can be liquidated to reduce reserves and increase interest rates.

However, under current circumstances, the Fed has substituted less liquid assets for Treasuries. It is true that a number of the Fed's new programs will unwind naturally and fairly quickly as they are terminated because they involve primarily short-term assets. Yet we must anticipate that special interests and political pressures may make it harder to terminate these programs in a timely manner, thus making it difficult to shrink our balance sheet when the time comes. Moreover, some of these programs involve longer-term assets—like the agency MBS. Such assets may prove difficult to sell for an extended period of time if markets are viewed as "fragile" or specific interest groups are strongly opposed, which could prove very damaging to our longer-term objective of price stability. Thus, we must ensure that our current credit policies do not constrain our ability to conduct appropriate monetary policy in the future.

Even more important, credit allocation decisions, in my view, should be under the purview of the fiscal authority, not the monetary authority, since they involve using the public's money to affect the allocation of resources. The mixing of monetary policy and fiscal policy increases the number of entities that might try to influence Fed decision-making in their favor. Both economic theory and practice indicate that central banks should operate independently from such pressures and resist them when they arise so that their policies benefit society at large over the longer term and not any particular constituency in the near term.

So where should we go from here? One suggestion that would promote a clearer distinction between monetary policy and fiscal policy and help to safeguard the Fed's independence would be for the Fed and Treasury to reach an agreement whereby the Treasury takes the non-Treasury assets and non-discount window loans from the Fed's balance sheet in exchange for Treasury securities. Such an accord would offer a number of benefits.[4] First, it would transfer funding for the credit programs to the Treasury—which would issue Treasury securities to fund the programs—thus ensuring that credit policies that place taxpayer funds at risk are under the oversight of the fiscal authority. Second, it would return control of the Fed's balance sheet to the Fed, so that we can continue to conduct independent monetary policy. Going forward, an agreement with Treasury would also state that if the fiscal authority at some point wanted the central bank to engage in lending outside its normal operations and, importantly, should the Fed determine "unusual and exigent circumstances" warranted such action, then any accumulation of nontraditional assets by the Fed would be exchanged for government securities. This would preserve the Fed's independence to control its balance sheet and ensure that the full authority and responsibility for fiscal matters remained with the Treasury and Congress, where it rightfully belongs.

4. For a discussion of such an accord in a different context, see J. Alfred Broaddus, Jr. and Marvin Goodfriend's article, "What Assets Should the Federal Reserve Buy?" and Goodfriend's article, "Why We Need an 'Accord' for Federal Reserve Credit Policy: A Note," Federal Reserve Bank of Richmond Economic Quarterly (Winter 2001). Such an accord would also be consistent with the recommendations made by the Group of Thirty's Working Group on Financial Reform about the role of central banks in providing financial stability. See "Financial Reform: A Framework for Financial Stability," Group of Thirty, Washington, D.C. (2009).

There is a historical precedent for such an accord. In 1951, the Treasury and the Fed struck an accord that freed the Fed from pegging the interest rate on long-term Treasury debt below 2.5 percent, which the Fed had done during and after World War II.[5] By pegging long rates below 2.5 percent, the Fed was committing to add reserves to the banking system when market interest rates began to rise without regard to its inflation goal. This inability to control its own balance sheet was a fundamental problem for the credibility of the Fed in achieving its dual mandate. After considerable negotiations, the Treasury and the Fed reached an accord that freed the Fed to set interest rates consistent with its long-term goals. This allowed the Fed to re-establish its independence and to conduct monetary policy in accordance with its dual mandate.

Today, an accord to substitute Treasuries for non-Treasury debt on our balance sheet would similarly help ensure that the Fed will be able to implement its policy decisions. After all, the time will come when the Fed will want to begin raising interest rates to achieve its goals. With Treasuries back on the balance sheet, the Fed will be able to drain reserves in a timely fashion with minimal concerns about disrupting particular credit allocations or the pressures from special interests.

It is always tempting to make policy based on short-term concerns and argue that we will worry about other things later. Yet, actions we take today have consequences for the choices we face in the future. We must recognize those consequences and take steps that ensure the effectiveness of future policy. Economics has shown that credible and committed policymaking yields better outcomes for the economy at large. By appropriately anticipating the longer-term consequences of our actions today, we can take steps that can ensure the Federal Reserve maintains and enhances its credibility as well as the ability to achieve its longer term objectives.

Since we celebrated Abraham Lincoln's birthday this month, I would like to close with a quote from our 16th president that seems particularly apropos to my discussion today: "You cannot escape the responsibility of tomorrow by evading it today."

The views expressed today are my own and not necessarily those of the Federal Reserve System or the FOMC.

5 For several articles about the 1951 Accord, see the Federal Reserve Bank of Richmond's Economic Quarterly (Winter 2001).

Making Monetary Policy During a Financial Crisis

presentation to the 2009 u.s. monetary policy forum conducted by the university of chicago booth school of business and brandeis international business school

New York, New York
By Eric S. Rosengren, President & Chief Executive Officer

I am pleased to participate in this important forum again this year, and welcome the opportunity to discuss monetary policy during the current financial crisis. Thank you for inviting me to be here with all of you and with Charles Plosser and Rick Mishkin.

As you know, what began as a problem involving securitized subprime mortgages in the United States has become a problem of global reach and historic proportions. The problem grew in scope and severity as investors became skeptical of financial statements, and as the ability to value and trade a wide variety of financial instruments became severely impaired.

Problems in financial markets spilled over into the real economy and contributed to deteriorating economic conditions. The U.S. economy lost 1.8 million jobs over the past three months. With the economy likely to shrink significantly in the first half of this year, the unemployment rate rising higher than 8.5 percent is, unfortunately, very likely.[1]

Unlike in some previous periods of financial disruption, this time around most countries are well aware of the precarious financial circumstances and have taken action to mitigate the problems. While the responses have varied, in most countries the monetary authorities have eased interest rates, the regulatory authorities have taken actions to shore up financial intermediaries, and the fiscal authorities have adopted more expansionary or "stimulative" policies than previously were planned.

In combination, these actions—along with lower energy prices—will, I hope, provide a foundation for positive economic growth in many countries in the latter half of this year. However, I believe that below-potential growth is likely to persist until financial markets and financial institutions can resume more normal functioning. So in addition to the other steps being taken to stimulate the economy, we need to be sure that actions to support the stability of the financial system are taken without delay—and, in the slightly longer term, that regulatory frameworks are thoughtfully reformed.

monetary policy during the crisis

Figure 1 highlights a striking feature of this financial crisis—the rather rapid movement, at least by central banking standards, to a federal funds rate only a little above zero. The Federal Reserve has moved with commendable speed in lowering the interest rate target to address problems in financial markets and the real economy.

1 See the minutes of the January 2009 meetings of the Federal Open Market Committee and the addendum, a *Summary of Economic Projections*, available at http://www.federalreserve.gov/monetarypolicy/files/fomcminutes20090128.pdf

Of course, one year ago many observers were critical of the Federal Reserve's rapid interest rate cuts. Total inflation was above the "comfort zone" of many, as rapid increases in oil and commodity prices were occurring despite unsettled financial markets. In retrospect, it is fortunate that the Federal Reserve moved as quickly as it did. While the rapid reduction in interest rates did not prevent a recession, it has mitigated the depth of the downturn and cushioned the economy against some of the shocks experienced over the past year.

However—with the federal funds rate bounded by zero, the forecast is one of continued weakness, and challenges in the transmission of funds-rate changes into borrowing rates in the marketplace—the Federal Reserve has turned to some alternative approaches to monetary policy. I would like to take a moment to highlight some key steps we have taken in this regard, and some of their implications.

First, the Federal Reserve has taken pains to make clear in communications that it will take all necessary actions to stabilize the economy. At the same time the FOMC has increased transparency by providing longer-range forecasts of growth, inflation, and unemployment—given the current structure of the economy, the presence of appropriate monetary policy, and an absence of unexpected shocks.[2] Chairman Bernanke addressed this topic in his speech at the National Press Club last week.[3]

The added transparency should help the Fed attain its goals of full employment and price stability. Currently, significant excess capacity in the economy risks lowering inflation and inflation expectations. Since short-term interest rates are effectively zero, reductions in inflation expectations imply a higher *real* interest rate—and, effectively, tighter monetary policy. So the additional clarity on the long-run intentions of monetary policy (as reflected in the longer-range forecasts) might keep inflation expectations well anchored[4] and real interest rates low enough to help get the economy moving again.

An important consideration involves what the long-run goal for inflation should be, given recent experience. Twice this decade, short-term interest rates have approached zero, and the probability of possible deflation has risen significantly. In light of this experience, some might conclude that the implicit inflation target has been too low. A fruitful area for future research would be to re-consider the likelihood and the cost of hitting the zero lower bound, and what that cost implies for setting inflation targets.[5]

2 See the minutes of the January 2009 meetings of the Federal Open Market Committee and the addendum, a *Summary of Economic Projections*, available at: http://www.federalreserve.gov/monetarypolicy/files/fomcminutes20090128.pdf

3 See http://www.federalreserve.gov/newsevents/speech/bernanke20090218a.htm

4 As Chairman Bernanke noted in a speech on February 18 (available at http://www.federalreserve.gov/newsevents/speech/bernanke20090218a.htm), "This further extension of the quarterly projections should provide the public a clearer picture of FOMC participants' policy strategy for promoting maximum employment and price stability over time. Also, increased clarity about the FOMC's views regarding longer-term inflation should help to better stabilize the public's inflation expectations, thus contributing to keeping actual inflation from rising too high or falling too low."

5 A number of papers written in the late 1990s provided estimates of the likelihood of hitting and/or being pinned at the zero lower bound (see, for example, Reifschneider and Williams, "Three Lessons for Monetary Policy in a Low-Inflation Era," *Journal of Money, Credit, and Banking*, vol. 32 (November 2000), pp. 936-66). With hindsight, the estimates in these papers appear a bit optimistic.

But now I would like to spend a bit of time discussing a second, alternative approach to monetary policy that the Fed has been pursuing. Since the fall of last year the Federal Reserve has rapidly increased its balance sheet, from $880 billion in July 2007 to $1.9 trillion as of last Wednesday, February 18. While this expansion of the balance sheet is unprecedented, and gives some observers pause, it is worth taking the time to understand the sources of that growth, the goals behind that growth, and how the Federal Reserve balance sheet can be expected to eventually return to a more normal size, due to market developments and Federal Reserve actions.

EXPANSION OF THE FEDERAL RESERVE'S BALANCE SHEET

Figure 2 shows the composition of the Fed's balance sheet. While this period of financial turmoil began in August 2007, much of the initial activity by the Federal Reserve involved traditional monetary policy—reducing the federal funds rate. Then in 2008, the Federal Reserve began what became a series of actions that expanded our usual "discount window" function. While the discount window had traditionally been available to depository institutions, in the spring of 2008 investment banks gained access to the discount window through the Primary Dealer Credit Facility (PDCF).

The largest expansion of the balance sheet occurred in the wake of the Lehman Brothers failure, as a series of actions were taken in response to the increasingly fragile state of financial markets. The three most significant areas of growth were discount window lending, foreign swap lines, and actions taken to stabilize financial markets.

The discount window lending I am referring to includes traditional discount window loans, primary dealer discount window loans, and lending in the Term Auction Facility (TAF). The largest category of lending in this group is the TAF, which as of February 18 had $448 billion in loans outstanding. This Fed lending has been critical to the reduction in market interest rates that are charged in the interbank lending market.

These TAF loans are arranged through an auction process, and like regular discount window lending, are loans to banks that are in satisfactory condition and are also backed by collateral subject to significant "haircuts," to mitigate risk to the Federal Reserve. In considering how we get to a more normal-sized balance sheet, it is important to note that TAF lending is likely to fall once financial conditions become more normalized, although the Fed could also hasten the reduction by holding smaller auctions or charging a higher minimum stop-out rate.

The second area of substantial balance sheet growth involves central bank liquidity swaps. These are loans made to foreign central banks so they can provide dollar funding to their banks in much the same manner as the U.S. Federal Reserve's TAF. Why we are doing this? Because global dollar markets are interlinked, and dollar markets overseas affect our own domestic financial conditions. Our counterparties are the other central banks, not individual financial institutions, and the swaps are essentially loans.

As the interbank dollar-lending market has stabilized—and given that the rates on the loans by foreign central banks are often set to make them less attractive as markets stabilize—this lending has fallen from a peak of $583 billion on December 17 to $375 billion on February 18. This second area of balance sheet growth also is likely to decline naturally as more normal market functioning resumes.

The third area of substantial balance-sheet growth involves the Federal Reserve liquidity facilities designed to provide market support (see Figure 3). These facilities are designed to improve conditions in short-term credit markets. Some, like the Commercial Paper Funding Facility (CPFF), provide an alternative funding source to the market when interest rate spreads become very elevated. With this facility in place, when interest spreads are high firms have an incentive to issue commercial paper directly to the Federal Reserve. When interest spreads are low, issuers will get a better rate by going to the market, thus unwinding the facility and shrinking the Federal Reserve's balance sheet.

Other facilities like the Asset-backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF) serve as a back-up for holders of existing short-term credit instruments. Both the CPFF and AMLF experienced substantial lending when the programs were first made available, but loan activity has declined as market conditions have improved.

In general, the various programs that have expanded the Federal Reserve's balance sheet should be less attractive to market participants as financial conditions improve. Figure 4 shows that of late, the rate on asset-backed commercial paper has fallen dramatically, and many issuers can receive better terms by issuing commercial paper directly to the market. Figure 5 shows that the prime money market funds have tended of late to have a net inflow of funds, which has helped stabilize short-term credit markets because money market funds are a key investor in these markets.

Two new programs should provide additional help to markets. First, the Term Asset-Backed Securities Loan Facility (TALF) is designed to provide a financing vehicle for credit instruments that have been disrupted by poor functioning in securitization markets. This facility, which will commence operations soon, should make credit more available for student loans, consumer credit, commercial real estate, and small business loans.

A second program involves the large-scale purchases of mortgage-backed and agency securities. For a variety of reasons, mortgage rates had not fallen in response to the decline in the federal funds rate, as is usually the case. As shown in Figure 6, conventional mortgage rates that had been around 6 percent have declined since the announcement of the program. Mortgage rates have been between 5 and 5.25 percent recently. Of course, an additional policy action that could potentially be undertaken by the Federal Reserve would be to expand this program, to help further lower the market rates on home financing.

CONCLUSION

In conclusion, I offer just a few summary thoughts. Over the last year and a half or so, the Federal Reserve has been proactive and innovative in trying to address problems in financial markets and the broader economy. While traditional monetary policy had focused on targeting the federal funds rate, now that this rate has approached the zero-bound the Federal Reserve has focused on other ways to lower the cost of credit in the marketplace, which had not fallen commensurate with the decline in the federal funds rate. Federal Reserve programs have intended to offset disruptions to interbank lending, short-term credit financing, the ability of money market mutual funds to meet investor redemption requests, and housing finance—to benefit all participants in the economy.

It is very important to note that the largest components of the expansion of the Federal Reserve balance sheet are likely to become unappealing to market participants as financial conditions improve and interest rate spreads decline. Thus, much of the Fed's balance-sheet expansion should be reversed as we see the return of more normal trading.

As a student of the Japanese financial crisis, allow me to make one final point. The so-called "quantitative easing" that focused on increasing reserves in Japan during the 1990s, while well-intentioned, in hindsight suggests that merely increasing reserves when financial intermediaries are capital-constrained is unlikely to have much impact.[6]

In contrast, the Federal Reserve programs I have described today are intended to reduce the unusually large spreads created by financial disruptions, so that the cost of credit for a variety of borrowers returns to the level we would expect with more normalized functioning of credit markets. The Federal Reserve's recent monetary policy actions, combined with the fiscal stimulus package that the government recently enacted, should in my view help pull the economy out of the severe recession we have been experiencing.

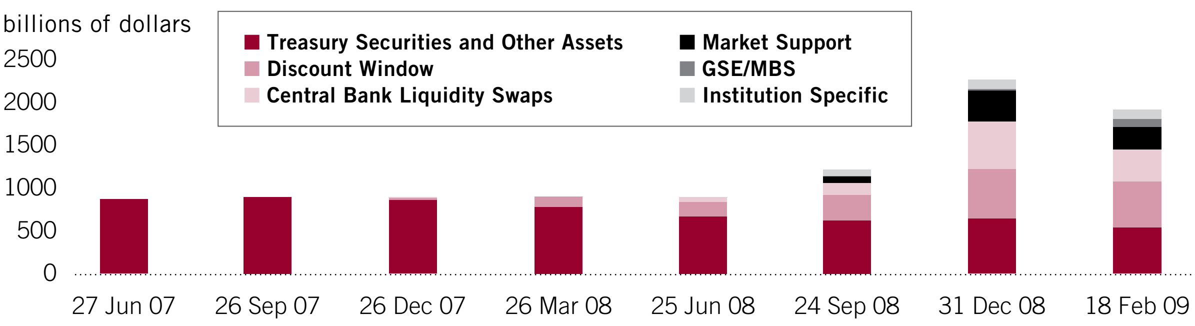
Thank you.

6 Of course, some observers believe quantitative easing was more appropriate in Japan because of its more bank-centric financial system.

FIGURE 1. FEDERAL FUNDS EFFECTIVE RATE [JANUARY 2, 2007 — FEBRUARY 20, 2009]

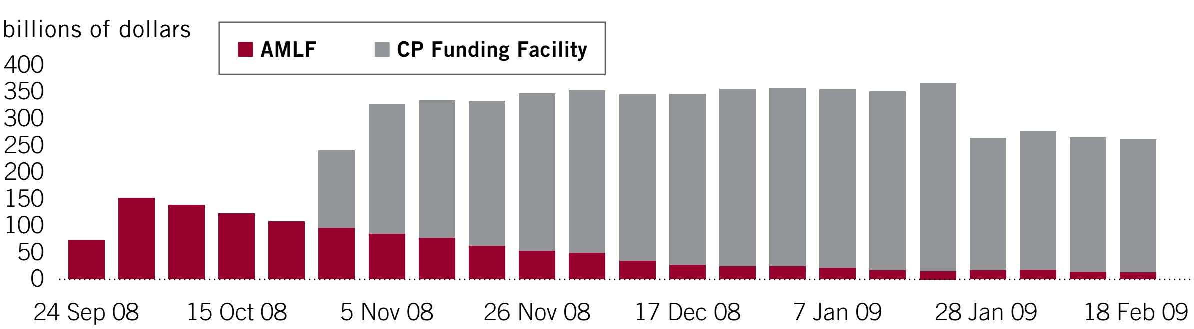
Source: Federal Reserve Board / Haver Analytics

FIGURE 2. COMPOSITION OF FEDERAL RESERVE SYSTEM ASSETS



Source: Federal Reserve Statistical Release H.4.1

FIGURE 3. FEDERAL RESERVE SYSTEM ASSETS HELD BY MARKET SUPPORT FACILITIES

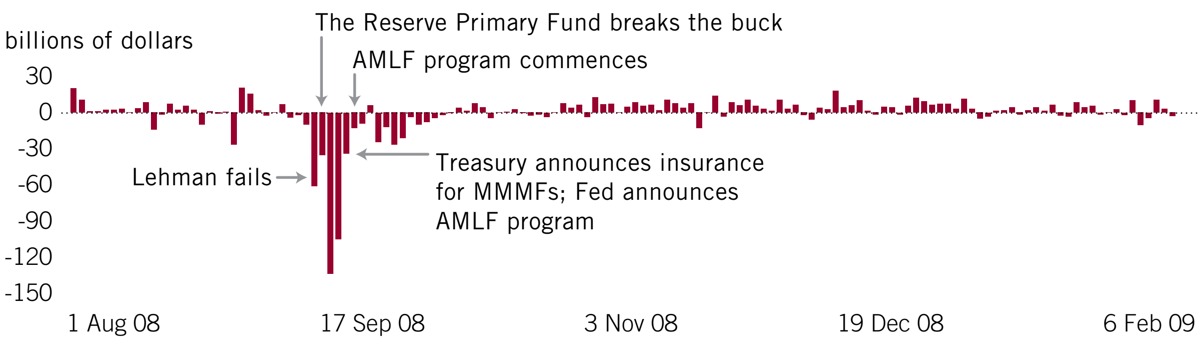


Source: Federal Reserve Statistical Release H.4.1

FIGURE 4. 1-DAY AA ASSET-BACKED COMMERCIAL PAPER RATE

Source: Federal Reserve Board / Haver Analytics

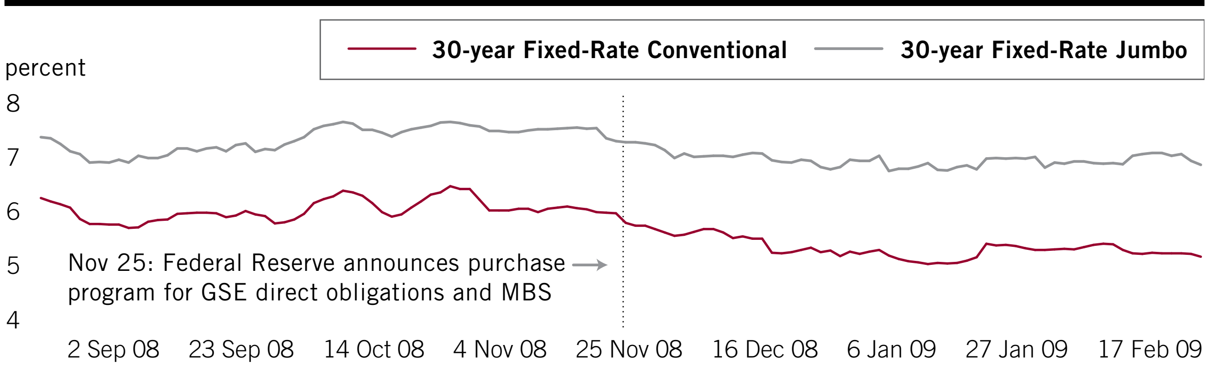
FIGURE 5. DAILY CHANGE IN MONEY MARKET FUND ASSETS IN PRIME FUNDS



Note: Prime funds include both retail and institutional funds. Outflows at prime institutional funds account for 93% of prime outflows since September 17.

Source: iMoneyNet

FIGURE 6. NATIONAL AVERAGE MORTGAGE RATES



Source: Bloomberg

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