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Silke Tober* and Tobias Zimmermann**

Monetary Policy and Commodity Price Shocks

Against the background of the dramatic changes in the prices of oil and other raw materials in the recent past, this paper analyses the effects of commodity price shocks in a New Keynesian model. The focus is on the central bank's choice of inflation target and the degree of real wage rigidity. It turns out that using core inflation rather than headline inflation is the superior strategy. Targeting expected headline inflation, as practised by most central banks, is a viable practical alternative to the core inflation target.

How should central banks react to supply shocks? Given the dramatic changes in the price of oil and other raw materials in the recent past, this is one of the key issues currently faced by central banks. In this paper, we explore what New Keynesian theory has to say about commodity price shocks and monetary policy. We focus on two key issues: real wage rigidity and the inflation indicator used by the central bank. We first discuss what happens in the New Keynesian model given different assumptions about the monetary policy strategy, wage rigidity and the nature of the commodity price shock. Using a DSGE model we offer several simulation results. Next we discuss additional reasons why central banks in the uncertain real world use core inflation and how this may help to anchor expectations. In conclusion the findings are applied to the current situation in the euro area.

Monetary Policy, Rigidities and Commodity Shocks

The “current best practice in monetary policy” is inflation targeting.¹ The term inflation targeting should be understood as inflation-forecast targeting² or in the words of Federal Reserve Bank chairman Ben Bernanke as forecast-based policy.³ Because of the lags with which the economy reacts to monetary-policy actions, central banks have to make use of forecasts. New Keynesian models (NKMs), however, often implement a Taylor rule. We therefore analyse the effects of both types of monetary policy strategies given different assumptions about real wage rigidity.

A Simple New Keynesian Model

We begin with a model with no real wage rigidity. Nominal frictions that characterise New Keynesian Models (NKMs) are assumed to be relevant only in the non-commodity sector of the economy, i.e. in the core

sector.⁴ This assumption is reasonable because food and energy resources are at most transformed into standardised goods, which are traded in near-competitive markets with frequent price adjustments, i.e. the implications of New Keynesian models do not apply to this part of the economy.

Commodity prices change in response to supply or demand shifts. Although the recent drastic rise and subsequent fall in the price of oil are to a large extent caused by demand shifts in consequence of economic booms or downswings, especially in the emerging markets, from the point of view of the oil-importing industrialised countries they represent supply shifts.

NKMs were developed for business cycle analysis. Therefore shocks are usually assumed to be stationary and all model equations are linearised around a steady state with zero inflation. However, in view of the soaring demand from emerging markets, such as China, the relative increase in energy and commodity inflation until mid-2008 was often seen as a more permanent phenomenon. Since it is impossible to forecast the relative prices for commodities with any accuracy, we also analyse the optimal monetary reaction to a permanent shock to commodity price inflation by discussing the results that can be obtained from a non-linearised model.

In the following, it is assumed that the economy consists of two sectors. In one sector, the commodity sector, prices are fully flexible. In the remaining part of the model economy, which is interpreted as the core

¹ Lars E. O. Svensson: What have economists learned about monetary policy over the past 50 years? Speech at the conference: Monetary policy over fifty years, Deutsche Bundesbank, Frankfurt am Main, 21 September 2008.

² Ibid.

³ Ben Bernanke: The logic of monetary policy, Remarks at the National Economists Club, Washington D.C., 2 December 2004.

⁴ Kosuke Aoki: Optimal monetary policy responses to relative-price changes, in: Journal of Monetary Economics, Vol. 48, 2001, pp. 55-80.

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Table 1
Optimal monetary objectives
(ρ_Δ : shock persistency)

	π_s before shock to $\Delta x_{t,t}$	
	> optimal level	\leq optimal level
$\rho_\Delta < 1$	π_s	π_s
$\rho_\Delta = 1$	π	π_s

sector, nominal frictions exist. Prices are sticky because only a fraction of firms can reset their prices in each period.⁵ Our calibration assumes that only 25% of firms are able to change their price in each period, i.e. individual prices stay constant for approximately one year.⁶

In consequence of the two-sector structure of the model economy, inflation and output can be calculated on a sector-specific or an aggregate level. In the absence of supply shocks, inflation in both sectors is equal to zero and output in both sectors corresponds to its natural level. In face of supply shocks, however, inflation and output can differ from their optimal values. Whether this divergence occurs and to what extent depends on the character of the supply shock and the reaction of the central bank. Natural output levels in the respective sectors evolve exogenously, depending on supply shocks in general or the relative price level in the commodity sector in our model. It follows that a central bank in a New Keynesian world should not strive to counteract all output fluctuations but rather to assure that output is equal to its natural level. In other words, with the help of the central bank an economy with nominal friction should evolve as would an economy without nominal friction. The structure of the economy, i.e. nominal friction, serves as a constraint of the central bank in the NKM. The central bank has to identify underlying shocks and use the equations that characterise the dynamics in the economy to restore the optimal levels of inflation and output. In the two-sector case, the evolution of the relative price of commodities must also be taken into account.

Apart from definitions, the equilibrium dynamics of the model economy can be summarised by two well-established equations that determine the output gap and core inflation. A New Keynesian IS equation, which describes the consumption-saving trade-off, can be derived from a standard Euler equation for consump-

tion. Aggregate demand positively depends on the expected output gap and the difference between the expected real interest rate and the natural real interest rate. The natural interest rate is the interest rate that would prevail in a fully flexible economy. The IS curve states that the expected slope of the temporal path of aggregate demand depends, among other things, on the expected real interest rate and therefore monetary policy. On the supply side, a New Keynesian Phillips curve describes the relationship between inflation in the sticky price sector and the aggregate output gap. The greater the price stickiness in the core sector of the economy, the flatter is the Phillips curve. Core inflation depends on expected core inflation since firms take into account their forecasts of future real marginal costs when they are able to modify their prices. Note that both the IS and the Phillips curve can be expressed in terms of core rather than headline inflation. This is reasonable because nominal frictions and distortions occur only in the core sector of the economy. Thus, inflationary pressure on the aggregate level ultimately depends on the output gap in the core sector because the output gap in the commodity sector is an effect rather than a cause.

For analytical and illustrative purposes the New Keynesian Phillips curve can be modified and augmented by relative price changes. The relative price of commodities enters into the Phillips curve and affects inflation in the sticky price sector. The mechanism in the model is the substitution between the flexible price good and the sticky price good. When the relative commodity price increases, households increase their relative demand for the sticky price goods. Facing an increase in demand (relative to supply), sellers in the core sector raise their prices.

To illustrate the effect of different monetary policy strategies two Taylor rules and inflation targeting are considered. The monetary policy rules take on the simplest possible form and assign the same weight to deviations from both policy objectives (inflation and output).

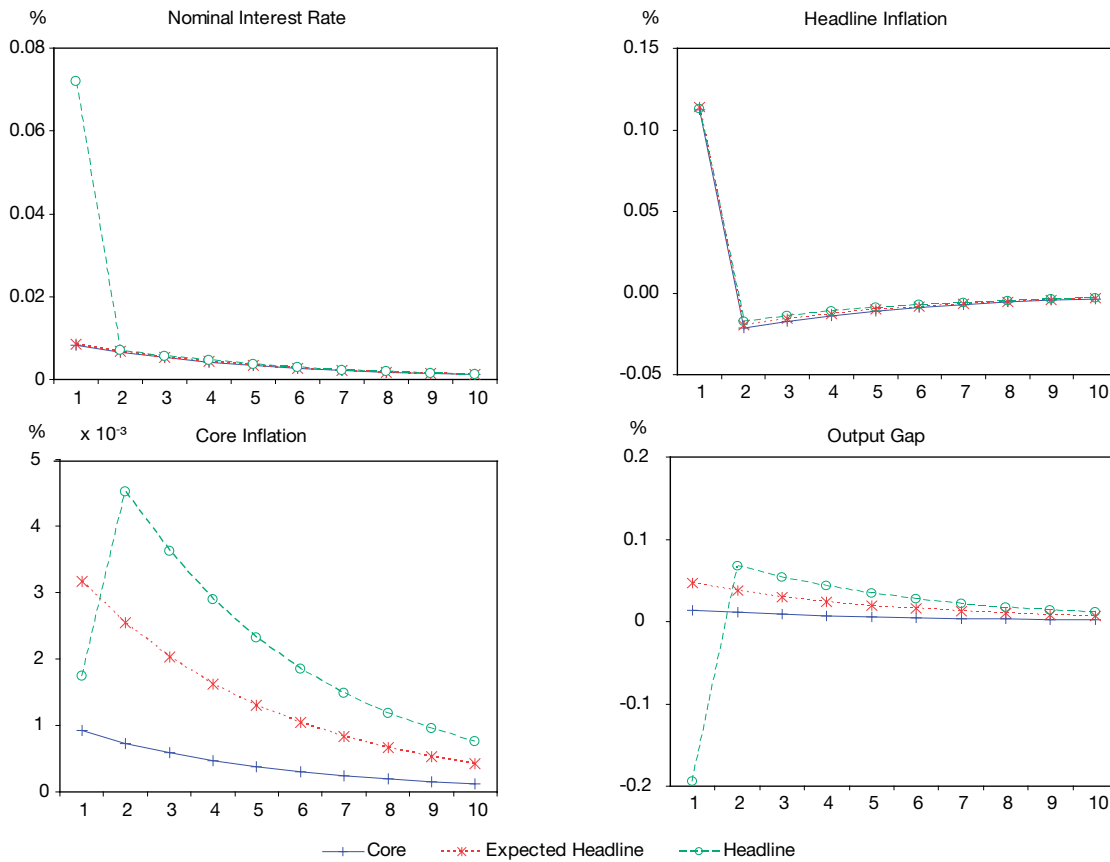
Different Types of Commodity Price Shocks under Different Monetary Policies

Based on the model discussed above, we examine the effect of different shocks to the commodity price level, ranging from a non-permanent increase in the commodity price level to a permanent increase in commodity price inflation. The central bank has a choice between targeting headline inflation and targeting core inflation. As a practical alternative, we also consider the possibility that the central bank targets expected headline inflation (inflation targeting). To illustrate the

⁵ Guillermo A. Calvo: Staggered prices in a utility-maximizing framework, in: Journal of Monetary Economics, Vol. 12, pp. 383-398.

⁶ For a full description of the equations of the model, see an earlier version of this paper which is available at http://www.boeckler.de/show_product_imk.html?productfile=HBS-004252.xml.

Figure 1
Responses of Nominal Variables and the Output Gap to a Persistent Increase in Commodity Prices



different effects of these three monetary policy objectives the simulations are performed three times: first, using headline inflation, second, using core inflation, and third, using one-year-ahead expected headline inflation.

Figure 1 shows how the interest rate, headline and core inflation, and the output gap react to a temporary but persistent commodity price shock given our three monetary policy rules. The simulations show that stabilising core inflation is the superior monetary strategy: both output in the core sector and core inflation stay close to their optimal values. In a two-sector model, the central bank should therefore focus on core inflation, not because it is useful to predict future inflation, but because by doing so the central bank can reduce market distortions in the sticky price sector and achieve an optimal allocation of resources.⁷ Furthermore, if

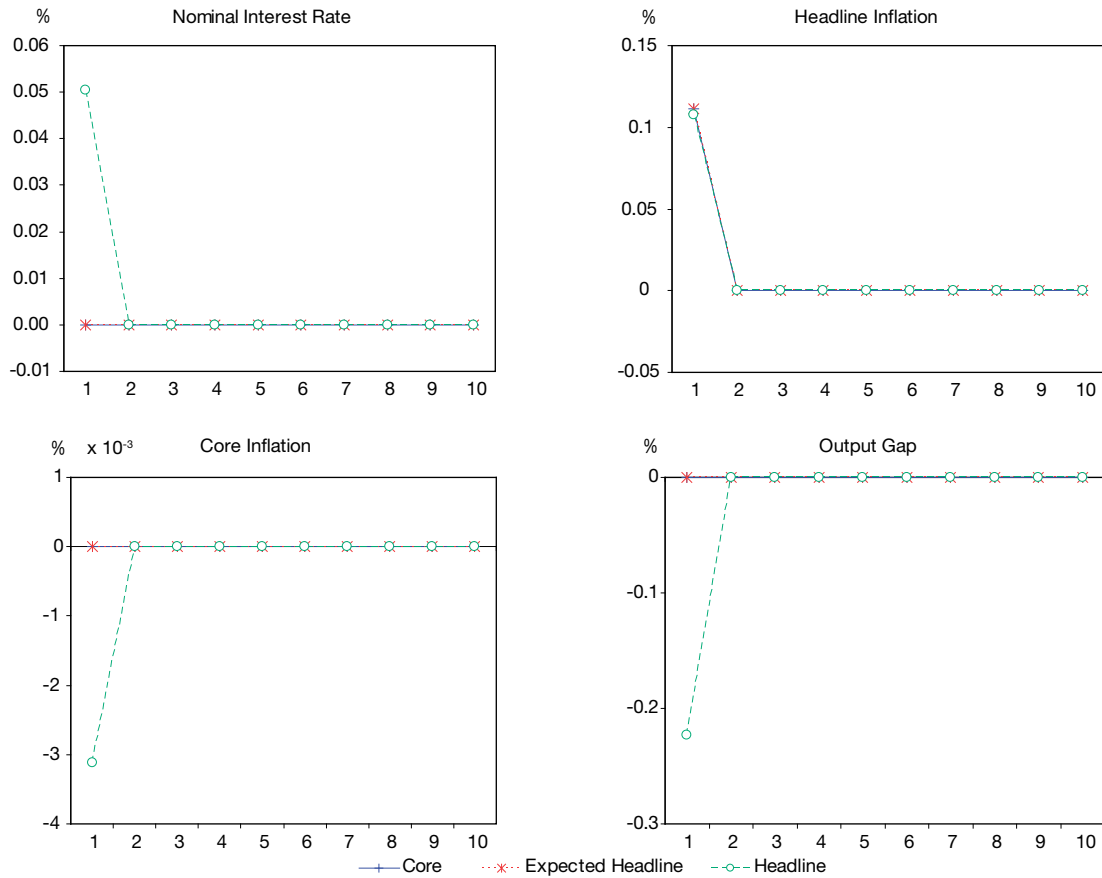
core inflation is stabilised perfectly, changes in relative prices depend solely on changes in the potential output of both sectors. Demand factors do not affect relative prices and relative prices stay at their efficient levels. If the central bank focuses instead on headline inflation, the decline in output and nominal wages will be greater as will the variability of core inflation.

The output losses that occur when the central bank targets headline inflation can be avoided by focusing instead on one-year-ahead expected inflation. However, the positive counter reaction of the output gap does not diminish. As in the case of headline inflation, core inflation is higher when central banks target expected headline inflation given a persistent but non-permanent shock. The reason is that inflation in the commodity sector becomes negative after the initial impulse and rational agents in the core sector, who know the evolution of relative prices, raise their prices more aggressively.⁸ Since both core inflation and out-

⁷ Michael Woodford: *Interest and prices: Foundations of a theory of monetary policy*, Princeton 2003. In our simulations, the central bank cannot stabilise both targets perfectly, because monetary policy is implemented by a simple feedback rule depending on realised variables.

⁸ Romain Duval, Lukas Vogel: *Oil price shocks and the conduct of monetary policy: Some lessons from a new Keynesian perspective*, OECD Economics Department Working Paper No. 603, Paris 2008.

Figure 2
Responses of Nominal Variables and the Output Gap to a Permanent Increase in Commodity Prices



put gap are more volatile, targeting core inflation also prevails over expected headline inflation.

In the simulation with the core-inflation Taylor rule the central bank raises interest rates because core inflation increases. The reason is the increase in the relative price of the commodity that lowers demand in this sector and raises it in the core sector. Given an oil price shock in practice, such a short-term increase in the demand for core goods seems rather unlikely because of the low price elasticity of energy demand and the low elasticity of substitution between goods in the commodity and the core sector. As a result, demand for core goods may actually fall.

The main results also apply to the case of a permanent shock to the relative price level in the commodity sector, because the focus on headline inflation causes core inflation and the output gap to fall before returning to their optimal levels (Figure 2). If the central bank focuses instead on core or expected headline inflation none of these negative reactions occur. Nonetheless,

expected headline inflation as a target will generate a small increase in interest rates, whereas focusing on core inflation leads to a small decrease in interest rates because core inflation is expected to fall in response to the negative output gap (because both reactions are so small, these differences cannot be seen in Figure 2).

It can be shown that, according to the model, core inflation remains the superior monetary target in the case of permanent shocks to commodity price inflation. In this case, the central bank would have to force down core inflation to keep headline inflation stable. In the New Keynesian model, however, a reduction in core inflation causes output losses. These output losses are the result of the permanent trade-off between inflation and output, which can be derived from the New Keynesian Phillips curve. Since the reduction in core inflation must be permanent if central banks focus on headline inflation, stabilising core inflation appears to be the superior strategy in this case as well. It should be noted, however, that the permanent trade-

off between output and core inflation stems from the fact that the model is linearised around zero inflation in both sectors. If the true, non-linear model is considered, the direction of the permanent trade-off crucially depends on the inflation level around which the model is linearised. If inflation in the sticky price sector exceeds a critical level, the effects of permanently depressing core inflation by focusing on headline inflation would be positive rather than negative. Given that an optimal level of core inflation exists in the New Keynesian model, the central bank should target this level irrespective of the permanent level of commodity price inflation.⁹ By solving the non-linearised model for different steady state inflation rates it can be shown that the optimal level of core inflation is very low, approximately 0.5 per cent.¹⁰ However, in practice measuring inflation involves errors and, for several reasons, these measurement errors have a positive bias. Therefore, as a reasonable assumption, the optimal level of inflation might well be in line with the ECB's inflationary objective of "below but close to 2 per cent".

In a nutshell, the analysis of a commodity price shock in the standard New Keynesian model yields the following conclusions. A central bank should strive to stabilise core inflation at its optimal level. If there is no real wage rigidity, the effect on inflation will be temporary whether the initial shock is permanent or not. In the case of a temporary shock, i.e. one that is reversed in the near future, a Taylor rule based on headline inflation will cause output to decline more and core inflation to be more unstable than a Taylor rule based on core inflation, i.e. the consumer price index excluding energy and food. An inflation-targeting central bank, i.e. one that targets expected inflation, would hardly react to the price shock at all. In case of a permanent shock to the relative price level the central bank can also stabilise core inflation and the output gap by focusing on core or expected headline inflation. Permanent shocks to commodity price inflation that are fully anticipated by households and firms do not affect core inflation at all so that no monetary reaction is needed by a central bank targeting core inflation; a central bank focusing on headline inflation or expected headline inflation would have to accept a permanent reduction in core inflation and output.

Do Extensions Change the Implications of the Simple Model?

Next we discuss the two most important extensions of the standard NKM, specifically modelling commo-

⁹ Guido Ascari, Christian Merkl: Real wage rigidities and the cost of disinflations, in: *Journal of Money, Credit, and Banking*, forthcoming.

¹⁰ *Ibid.*

ties as inputs in production¹¹ and the assumption of real wage rigidity.

The results discussed above do not change qualitatively when commodities are also used in production. More expensive commodity imports lower the natural output level in both sectors in a similar manner as adverse technology shocks. When the commodity is not only a consumer good but a factor input as well, there are not only direct effects on the price level but also indirect effects as the higher production costs lead to successive indirect increases in the level of prices. These indirect effects are thought to peter out within one year.¹² If the output objective is interpreted to be the level at fully flexible prices, the central bank can achieve a zero output gap and keep core inflation equal to zero by targeting core inflation.

A different situation arises if there is a high degree in real wage rigidity. In this case, the direct and indirect impact of the commodity price shock on the price level is amplified by second-round effects. No matter what monetary policy strategy is followed, the temporary increase in inflation will be greater, and the monetary restriction and output decline more pronounced. Given real rigidities, the central bank faces a trade-off between output stabilisation and inflation stabilisation.¹³

Given a temporary or permanent price level shock, the Taylor rule based on headline inflation causes output to decline more and core inflation to be less stable than a Taylor rule based on core inflation. However, headline inflation is less stable in the latter case because second-round effects are greater if core inflation is targeted. Therefore, in contrast to the simple model there exists a substantial trade-off between output and inflation stabilisation. A central bank with an inflation target will be less restrictive in the case of a permanent shock to the commodity price level than central banks following one of the Taylor rules because it does not react to the initial jump in inflation. In the case of a temporary shock, targeting expected inflation yields a more stable output gap and less stable inflation than a Taylor rule with headline inflation. Hence, in face of real wage rigidity targeting core inflation yields the smallest decline in output but targeting headline inflation yields the smallest increase in inflation. Inflation (forecast) tar-

¹¹ In Germany, for instance, 70% of all energy imports are used as inputs in production.

¹² Eric O'N. Fisher, Kathryn G. Marshall: The anatomy of an oil price shock, *Economic Commentary*, Federal Reserve Bank of Cleveland, Cleveland 2006.

¹³ Olivier J. Blanchard, Jordi Gali: The macroeconomic effects of oil price shocks. Why are the 2000s so different from the 1970s? Massachusetts Institute of Technology, Department of Economics, Working Paper 07-21, Boston 2008.

getting is a practical alternative since output losses are smaller than if headline inflation is targeted. However, inflation volatility is then even slightly larger than in case of a Taylor rule with core inflation.¹⁴

Given a permanent increase in commodity price inflation, central banks would have to reduce core inflation permanently to keep headline inflation stable. As mentioned above, the permanent positive trade-off between output and core inflation is an artifact of the linearised New Keynesian model. In the true non-linear model the trade-off would only be positive if core inflation was initially below its optimal level. Real wage rigidities also aggravate the effects of permanent changes in core inflation. If core inflation was optimal before the shock, any change in core inflation that might be reinforced by the central bank to keep headline inflation stable would cause a larger decline in output than in case of no real wage rigidities. Keeping headline inflation constant in face of permanent changes in commodity price inflation therefore has even more severe effects than in a model without real wage rigidities.

In general, the effects of real wage rigidity, i.e. the trade-off with which central banks are confronted, are larger the lower nominal price rigidity. The worst-case scenario for practical monetary policy is therefore an economy with highly rigid real wages and highly flexible prices.

All in all, none of the modifications dramatically change the implications for the optimal monetary target. As in the simple model substantial output losses would occur if central banks attempted to stabilise headline inflation when faced with commodity price shocks.

Core Inflation and Expectations

The goal of monetary policy is to stabilise headline inflation over the medium term. Our New Keynesian simulations show that in the event of commodity price shocks monetary policy achieves better results when focusing on core inflation. In these models future headline and core inflation are known to all economic agents. In practice, focusing on core inflation is furthermore an attempt by central banks to discern whether underlying inflation is changing.¹⁵ So as not to react too strongly to transitory changes in inflation, core inflation can serve as a proxy for headline inflation in the short term.¹⁶

A key question is how to calculate core inflation. First round effects include not only the direct impact on the price level but also the indirect effects as higher commodity costs are reflected in other goods and services. The consumption price index excluding energy and food can serve as a proxy, but the excluded categories contain some goods and services that are only minimally affected, whereas some of the included ones are greatly affected by a rise in commodity prices, such as public transportation.¹⁷

Central banks that emphasise core inflation and underlying inflation in communicating with the public may positively affect inflation expectations, thereby aiding the economic adjustments subsequent to an exogenous price shock. Expectations play a crucial role in the transmission of shocks (and of monetary policy) according to the New Keynesian model. Prices are changed at large intervals, so that price setters take expected future inflation into account when setting prices. Anchored expectations, i.e. high central bank credibility, should also make price-wage spirals less likely. Anchored expectations can be understood as the fact that inflation expectations remain unchanged despite high increases in the price of oil: "... market participants believed that central banks would be able to pursue a more relaxed monetary policy in order to offset the adverse demand effects of the oil price increase without having to worry about setting in train a wage-price spiral of the sort seen in the 1970s".¹⁸

How Should the ECB Have Reacted to the Price Shocks of 2007/2008?

A key question the ECB faced in 2008 was whether real wages in the euro area were highly rigid or not. In 2008, there were only very limited signs of a wage-price spiral. In some countries, such as Italy, wage increases were too high given the rate of productivity increase, but there had not been a pick-up in the rate of wage increases there. In the euro area as a whole, compensation per employee in 2007 and 2008 increased at a rate of 2.5% and 3.1% respectively, which is well within the bounds of productivity increase plus inflation target.

¹⁴ Romain Duval, Lukas Vogel, op. cit., p. 6.

¹⁵ It is therefore not "a nefarious scheme to ignore the real hardships people face" (Paul Krugman: Embedded vs. non-embedded inflation, New York Times, 31 May 2008).

¹⁶ Frederic S. Mishkin: Headline versus core inflation in the conduct of monetary policy. Remarks at the Business Cycles, International Transmission and Macroeconomic Policies Conference, HEC Montreal, Montreal, 20 October 2007.

¹⁷ None of the different measures of core inflation can said to be superior *per se* (cf. Frederic Mishkin, op. cit.)

¹⁸ Charles Bean: Monetary policy in an uncertain world, Speech at Oxonia Distinguished Speakers Seminar, The Oxford Institute of Economic Policy, Oxford 2005. Olivier Blanchard raises the question of whether the case for expectations may be overstated in the New Keynesian model: "One may reasonably ask, however, whether a price setter, choosing prices for the next month or the next quarter, will change his decision depending on what his expectation of inflation is, say, in five years. Put another way, while we very much want to believe it, I am not sure we actually understand whether and how anchoring of inflation expectations is so important." (In: Olivier J. Blanchard: The state of macro, Working Paper 08-17, Massachusetts Institute of Technology, Department of Economics, Working Paper Boston 2008, p. 21.)

The year 2008 did see an increase in wage rises, but this was at least in part due to a return to normality in Germany, where nominal wage increases had been well below real productivity increases for several years.

If price shocks are expected to be transitory, the policy advice would be obvious. The ECB should not react to the resulting change in inflation, because the effects of monetary tightening would be felt when headline inflation has declined below the inflation target due to falling oil prices. A policy reaction would in this case increase the variability of both inflation and output. But even if the shock is permanent, headline inflation will be affected only in the short run provided there are no second-round effects.¹⁹ Although it could be argued that monetary restriction is warranted in the case of an oil price shock because a change in the price of oil affects potential output, output itself is lowered by the oil price shock as well, as incomes are lower and negative wealth effects emanate from the less favourable terms of trade.

As it turned out, the oil price shock of 2007/2008 was temporary. Whereas in June of 2008 the price of Brent Crude oil was 86% higher than one year earlier, by December it had fallen to less than a third of its June value. As a result, headline inflation in the euro area declined from its peak of 4% in June and July 2008 to 1.6% in December 2008 and a mere 0.6% in March 2009 with a further slowdown and even negative rates in the months to come more than likely. By contrast, the core rate (HICP excluding energy, food, alcohol and tobacco) has declined to only 1.5%, after hovering around its average annual value of 1.8% throughout 2008. The decline in the price of oil no more warrants a monetary policy reaction than did the previous increase. However, the recession that started in the second quarter of 2008 and the drastic decline in GDP in 2009 – estimated at 4.1% by the OECD and 4.5% by the German joint economic forecast²⁰ – combined with the uncertainties brought forth by the global financial and economic crisis justify a very expansionary monetary policy stance. From the New Keynesian perspective it is important to note that the ongoing recession is primarily the consequence of collapsing global demand and not the outcome of a negative supply shock that would moderate natural output. The resulting large output gap and high

unemployment will cause core inflation to decline as well and calls for a sharp decline in the main refinancing rate.²¹ Decisive monetary policy actions are all the more urgent as there is a risk of (core) deflation, which, once entrenched, is much harder to combat than inflation.²² This problem does not arise in the NKM because the future course of the price level is known to all market participants and deflation is not harder to counteract than inflation. To sum up: Not the decline in headline inflation – largely due to the sharp reduction in oil prices – currently justifies very expansionary monetary policy, but rather the emerging large output gap and the expected future decline in core inflation.

In face of the current global economic and financial crisis the question of whether to target core inflation or headline inflation has become a less pressing issue for the time being. But commodity price shocks will occur in the future as well and the choice of inflation indicator has important ramifications for economic activity. By explaining why some measure of core inflation is an important indicator in the face of commodity price shocks, the ECB could favourably affect inflation expectations as headline inflation temporarily exceeds or falls short of the target of close to but below 2%. The slight increase in medium and long-run inflation expectations in the first half of 2008 suggests that the ECB was not completely successful in communicating these issues to the public. In our view, the lack of communication rather than the commodity price shock is the reason for potential problems in stabilising inflation expectations in the euro area.

Inflation is a sustained rise in the price level.²³ Upward price shocks that do not give rise to second-round effects only increase the rate of inflation temporarily. “They do not cause inflation.”²⁴ The same applies downward price shocks and disflation/deflation.

¹⁹ It should be noted that low real wage rigidity in the face of a supply shock does not necessarily result from flexible wages *per se*, but could be due to nominal rigidity of wages. In this case real wages decline automatically as inflation rises in response to higher oil prices.

²⁰ OECD: Interim Economic Outlook, March, Paris 2009; Joint Economic Forecast (Projektgruppe Gemeinschaftsdiagnose): Im Sog der Weltrezession, Gemeinschaftsdiagnose Frühjahr 2009, IMK Report 37, April 2009.

²¹ The Taylor rule regularly applied by the German Joint Economic forecast, which ignores the lower bound of zero, yields a rate of -4.5% for mid-2010, *ibid.*, p. 88.

²² B. S. Bernanke: Deflation – making sure “it” doesn’t happen here. Speech before the National Economists Club, Washington, DC, 21 November 2002; International Monetary Fund: Gauging Risks for Deflation, IMF Staff Position Note (SPN/09/01), Washington 2009.

²³ “For practical purposes, a representative price index that rises for more than two years would indicate inflation ...” (Willem Buiter: Inflation here, there and everywhere, *Maverecon Blog*, Financial Times, 14 May 2008.)

²⁴ Buiter then goes on to argue, however, that the increase in commodity prices is the result of an overly expansionary global monetary policy. It is hard to argue, however, that the ECB policy has been an important factor in pushing up the price of oil, and even harder to argue that the ECB should tighten the monetary reigns to effect a more restrictive global monetary environment. In a similar vein, the IMF recently argued that the Fed should focus on core inflation when faced with commodity price shocks. (International Monetary Fund: World Economic Outlook, Fall, Washington 2008, p. 114.)