The asymmetric relationship between oil prices and activity in the EMU: Does the ECB monetary policy play a role?

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Abstract

Monetary policy is usually perceived as an important transmission channel in the negative relationship between oil prices and economic performance. It may also constitute a short-term explanation of the non-linearity in this relationship, since Central Bankers may be more sensitive to the potential inflationary threats entailed by high oil price increases than to small increases or decreases. In this paper, we use an extended Taylor rule to investigate the role of oil prices in the ECB monetary policy strategy. A contemporaneous reaction function is estimated using both a GMM framework and an Ordered Probit model, and several oil indicators are constructed and tested. The main results suggest that oil prices play a key role in the ECB interest-rate setting, since it appears as a relevant indicator of future inflation. However, the ECB seems to react asymmetrically: only oil price increases influence its decision setting, not oil prices decreases. Monetary policy may thus transmit and amplify the asymmetry in the relationship between oil prices and activity in the euro area. Further investigations suggest that a preference for price stability provides an important explanation of this asymmetric behaviour of the ECB.

JEL classification: E52, E58, Q43.

Keywords: Oil prices ; Monetary policy ; Taylor rule ; Asymmetry ; ECB.

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1 Introduction

Monetary policy is usually perceived as an important transmission mechanism in the relationship between oil prices and output: when oil prices go up, inflationary pressures may lead the Central Bank to raise its short-term interest rate. This contractionary reaction of monetary policy would then have negative effects on aggregate demand and the economic activity. Another negative side is attributed to monetary policy: it may transmit and strengthen the asymmetry in the oil price-activity relationship. The Central Bank should indeed be differently sensitive to oil prices increases or decreases, and monetary policy would in turn be more restrictive when energy prices go up than convenient when prices fall.

Most papers dealing with the potential role of monetary policy in the transmission of oil shocks to GDP have indeed focused on the United States and the behaviour of the Federal Reserve. Romer & Romer (1989) are among the first to analyse the possibility of a confusion between the effects of monetary policy shocks and oil shocks on real output. They show, using the "narrative approach" of Friedman & Schwartz (1963), that real fluctuations are mainly driven by monetary considerations, if the potential effects of oil shocks on monetary policy are taken into account by eliminating the monetary shocks which followed the big oil shocks of the seventies. Dotsey & Reid (1992) and Hoover & Perez (2004) criticize Romer and Romer's work, underlying the lack of distinction between the effects of oil prices increases and the consequences of monetary policy. Hoover & Perez (2004) explain that there is a "*post hoc ergo propter hoc*" problem. Those two papers show that oil price shocks have as much or more impact on industrial production and unemployment than monetary shocks. However, these studies compare the effects of monetary shocks and oil shocks without assessing the nature and the size of the relationship between them. Bohi (1989) is one of the first to argue that the recessions that followed oil price shocks were caused not by oil shocks themselves but rather by the contractionary reaction of the U.S. Federal Reserve. In the same way, Bernanke, Gertler & Watson (1997) (BGW thereafter) investigate the influence of the systematic reaction of the Fed monetary policy in the U.S. economy (using a VAR modelling) and conclude that the upward movements of the Fed Funds rates explain to a large extent the low economic growth observed after oil shocks. They claim that a counter-inflation monetary policy is systematically harmful, and that a "neutral monetary policy" could avert the contractionary response to oil shocks. Hamilton & Herrera (2004) refute the conclusions of BGW and alleviate the responsibility of monetary policy in the transmission of oil shocks to activity. According to them, the direct impact of rising oil prices on output is underestimated because of a bad specification of the model and a misleading perception of the monetary policy driven by the Federal Reserve. However, Leduc & Sill (2004) demonstrate, in a calibrated general equilibrium model, that monetary policy may contribute to nearly 40 percent to the drop in output following a rise in oil prices. The Central Bank can not fully insulate real output from an oil price shock, and the real effects thus vary depending on the priority assigned by the monetary authority.

Regarding the potential asymmetric effects of monetary policy in the oil prices-activity relationship, the articles from Huntington (1998) with OLS regressions and Balke, Brown & Yücel (2002) in a VAR framework introduce asymmetric measures of oil prices to study their effect on the U.S. economy. Both studies admit the role played by monetary policy in the transmission of the asymmetry, since interest rates react differently to oil price increases and decreases. But they also suggest that this effect of monetary policy should not be over-estimated, and they rather insist on factors such as rigidities in the transmission from crude oil prices to refinery products' prices, or structural adjustments between sectors.

In this paper, we investigate the potential transmission effect of monetary policy in the Economic and Monetary Union (EMU) from an empirical point of view, using estimates of an extended Taylor rule to evaluate the sensitivity of the European Central Bank (ECB) with regard to oil prices fluctuations. The aim of our paper is thus similar to Hess (2000) who estimate an extended Taylor rule with oil prices for the United States during three distinct sub-periods corresponding to Pre-Volcker, Volcker and Greenspan eras. However, the originality of this paper is threefold. Firstly, we focus on the euro area and the behaviour of the ECB, whereas most of the literature about the relationships between oil prices, monetary policy and economic activity deals with the U.S. case. Secondly, we construct several indicators of oil prices to assess whether the effect of oil prices in the ECB interest-rate setting process is asymmetric *and/or* nonlinear. To this end, we pay particular attention to a breaking down into oil price increases and decreases, and we also use another indicator called Net Oil Price Increase (NOPI) initiated by Hamilton (1996). Thirdly, we check the robustness of our conclusions by comparing the results reached using a GMM estimator and an Ordered Probit model. Finally, we assess two potential explanations: the role of oil prices on inflation expectations *versus* the preferences of the European authorities about the inflation rate.

Our results suggest that oil prices play a key role in the ECB interest-rate setting, since it appears as a relevant indicator of future inflation. However, the ECB seems to react asymmetrically: it strongly reacts to inflationary pressures following an oil shock, while its reaction to oil price decreases is very limited. Then it appears that, even if the ECB does not generate the asymmetry in the relationship between oil prices and activity, monetary policy is an important channel of transmission and amplification of the asymmetric link between crude oil prices and the aggregate price level. An inflation bias in the ECB's preferences would lead policymakers to behave in an asymmetric way regarding oil prices.

The paper is structured as follows: Section 2 comes back briefly on the relationship between oil prices and monetary policy, with some theoretical elements and stylised facts. Section 3 deals with the estimation of the contemporaneous Taylor rule using a GMM framework, while Section 4 presents the results reached with an Ordered Probit model. Section 5 evaluates two potential explanations for the observed asymmetry in the ECB's reaction to oil prices. Finally, Section 6 concludes and provides the insights for future works.

2 The relationship between oil prices and monetary policy: Theoretical aspects and some stylised facts

The relationship between oil prices and interest rates is rather intuitive: a Central Bank that is designed to maintain price stability should react to the inflationary pressures entailed by oil price increases by raising its interest rate. Actually, when energy prices are rising, the consumer price level is likely to be affected rather quickly in two ways: directly *via* the prices of refined products (gasoline, kerosene) which are included in the consumer price index, and indirectly through the production costs which pass through to the selling prices of final goods and services. As an example, the IMF estimated in 2005 that a rise to 80 USD per barrel[1] would increase CPI inflation by 1.3% in the US and 0.9% in the Euro Area, Japan, and the United-Kingdom.

The second transmission channel from oil prices to CPI may obviously generate some "second-round effects" which are the ground for a wage-inflation spiral. Indeed, workers may want to adjust their nominal wages to rising oil prices and to the general price level in order to maintain their real wages. That's why the transmission of rising oil price to inflation also depends on the strength and speed of this spiral: the potential effects on inflation are closely related to the nominal rigidities stressed by Mork, Olsen & Mysen (1994). The less rigid the adjustment of real wages is, the larger inflationary pressures would be. For instance, Hooker (2002), using a Phillips Curve framework, finds a less evident pass-through of oil prices to inflation since around 1980. He claims that the first-round effect of oil prices on the overall price level is the only remaining transmission channel, and he argues that there is few room for a wage-price spiral.

Nevertheless, the Board of the ECB seems very doubtful of Hooker's conclusions, according to recurrent speeches from the Board's members (especially its President Jean-Claude Trichet) and statements reported in the Editorial of the ECB Monthly Bulletin[2]. The ECB stresses that oil price developments are an important part of the "economic analysis" component of its monetary policy strategy. It pays particular attention to the likelihood of second-round effects and a wage-price inflation spiral stemming from rising oil prices.

However, we must stress that oil shocks have all the features of a typical supply shock, and thus have opposite effects on inflation and output. If the Central Bank has a twofold objective of fighting

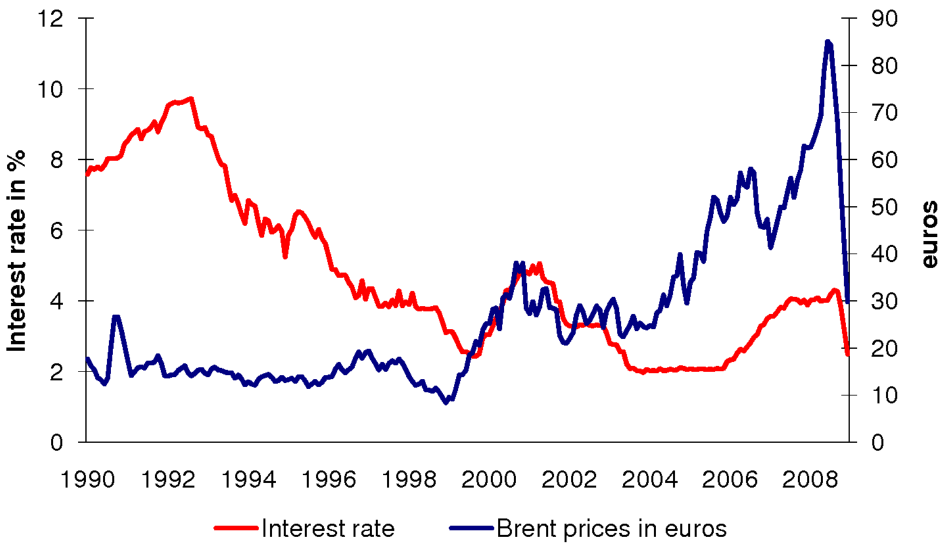
[1] At this time, in January, the price of the barrel was about 45 USD.

[2] An example among many others is provided in an article devoted to oil prices in the ECB Monthly Bulletin from November 2004: *"The oil price increase has already had a significant direct impact on euro area inflation. Against this background, monetary policy has to ensure that this direct effect does not fuel inflationary expectations and has to remain vigilant against the emergence of second-round effects"* (p. 51). A more recent example is extracted from the Editorial of the January 2008 Monthly Bulletin: *"This confirms the strong upward pressure on inflation in the short term, stemming mainly from strong increases in oil and food prices in recent months"* [. . .] *"These risks include the possibility that stronger than currently expected wage growth may emerge, taking into account capacity constraints and the positive developments in labour markets. It is imperative that all parties concerned meet their responsibilities and that second-round effects on wage and price-setting stemming from current inflation rates be avoided"* (p. 5-6).

inflation and stabilizing activity, an oil shock would entail a potential trade-off in interest-rate setting, because a restrictive reaction designed to curb inflation would conflict with the objective of reaching the potential level of economic growth. The reaction of the Central Bank would therefore depend critically on the relative weights given to price stability and economic activity. Since the ECB has a primary objective of price stability, we would expect the ECB to react strongly and rather quickly to oil price developments by adjusting its key interest rate. On the other hand, the U.S. Federal Reserve might be less reactive to such oil shocks given its twofold objective of price stability and output stabilization, even though several articles such as Carlstrom & Fuerst (2006) conclude that the conduct of monetary policy has successfully contained inflationary pressures generated by rising oil prices in the United States since the beginning of the eighties.

To provide a first assessment of the link between oil prices and interest rates, we can have a look at the evolution of those two variables in the euro area since the beginning of the nineties. Figures (1) and (2) display the dynamics of oil prices and the short-run interest rates. In the first graph, we plot the short-run interest rate [3]. It is rather difficult to recover the theoretical positive link between oil prices and interest rates during the nineties. Indeed, oil prices exhibited a rather stable trend until 1999 while interest rates decreased. The correlation coefficient is equal to 0.23 (0.34 with oil prices in U.S dollars). From the end of the nineties, the correlation is still present but we observe a delay in the monetary policy's reaction.

Figure 1: Real oil prices and interest rates in Europe (1990:1 - 2008:12)



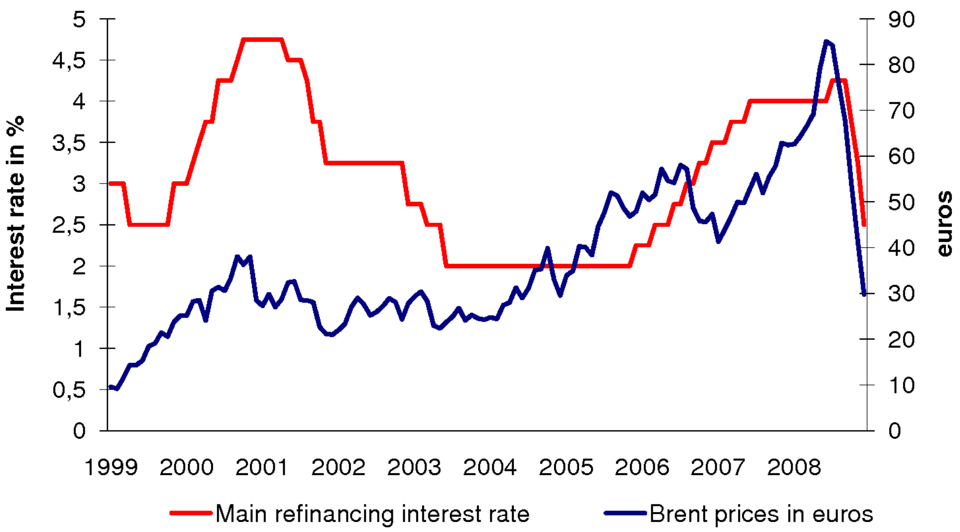
Sources: Data from OECD, IEA and IMF.

We zoom on this period which coincides with the beginning of the EMU in the graph (2). The figure confronts the main interest rates and oil prices still expressed in the domestic currency. We

[3]German between 1990 and EONIA between 1995 and 2008, since the behaviour of the Bundesbank has largely inspired the ECB) before 1999 and in the euro area since its completion.

note that if interest rate follows the oil shock of 1999, it remains unchanged between june 2003 and november 2005 in spite of an upward revival of oil prices in 2004. This long-lasting oil shock ends in july 2008 with a barrel of Brent equal to 133 dollars (84 euros). ECB modifies its monetary stance from december 2005 and progressively rises the main interest: 25 basis points every two months. We thus observe a delay in the response of monetary policy and the fluctuations of oil prices. We can interpret this delay in two ways. The delay could be first explained by the expectation of a temporary oil shock. The second explanation might be a pure disconnection between both variables. The monetary policy would be influenced by others factors like asset prices, labor costs or exchange rate. The second explanation appears more convincing for two reasons. Firstly, if oil prices constitute an indicator of future inflation, the Central Bank should react immediately by raising its interest rate to an increase in oil prices. However, oil prices have almost doubled between april 2003 and october 2004. Secondly, the disequilibrium on the oil market between supply and demand suggests that the increase in oil prices could not be transitory and that oil prices are on an upward trend. The tightening of the monetary policy corresponds to the improvement in economic situation in Europe. ECB referred to inflationary pressures of oil prices after 2006 for the next oil shock which happened between 2007 and 2008. ECB would achieve its initial objective of anchoring inflation expectations at a low level from the start of EMU by reacting immediately to inflationnary shock.

Figure 2: Oil prices and main refinancing interest rate in the euro area (1999:1 - 2006:12)



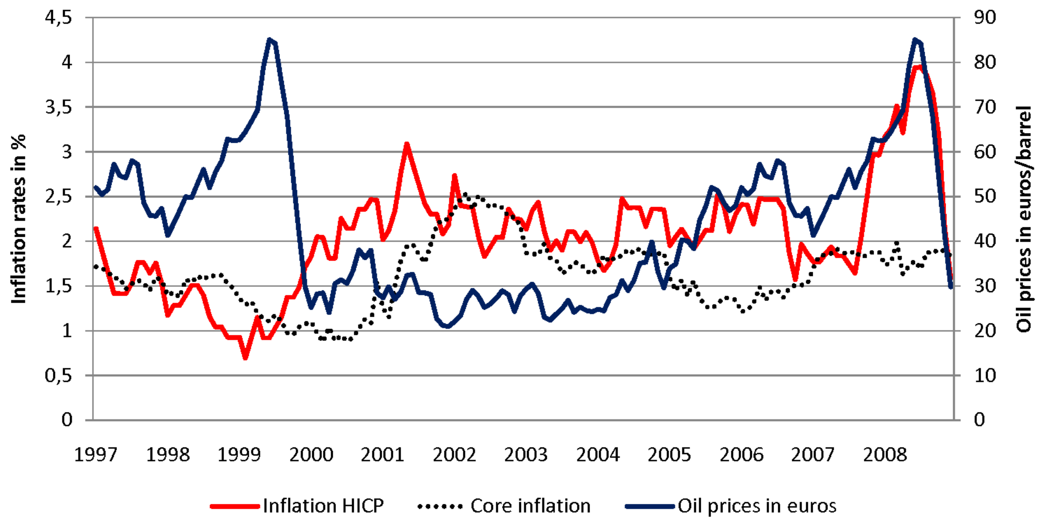
Sources: Data from OECD, IEA and IMF.

All in all, it appears that the correlation between interest rates and oil prices is not as obvious as suggested by theoretical considerations. The influence of oil prices in the ECB decision-making may have been hidden by other factors, especially the appreciation of the euro-dollar exchange rate (alleviating the costs of imports and imported inflationary pressures) and the low levels of economic growth during the years 2003 to 2005. The likelihood of high inflation pressures and second-round effects should be viewed as lower during low-growth periods.

More generally, we may wonder if energy prices are still a good indicator for future inflation in the euro area, and thus quickly pass-through into overall consumer price inflation or core inflation. Figure (3) displays the evolution of real oil prices, HICP inflation, and core inflation in the euro area[4].

It appears that HICP inflation fluctuated closely with the evolution of oil prices until 2005. In the same way, core inflation reacted with a slight lag to real oil prices and HICP inflation in the beginning of the period. However, the correlation between oil prices and HICP inflation seems to have weakened since 2005, and core inflation did not react to the strong and long-lasting rise of the oil prices. As suggested above, the weakening of the oil price-inflation relationship may come from the improvement in monetary policy by the gains in credibility, or from an alleviation of the wage-inflation spiral in European countries during low-growth periods.

Figure 3: Real oil prices, HICP inflation and core inflation in the euro area (1997:1 - 2008:12)



Sources: Data from OECD, IEA and IMF.

An econometric evaluation of the ECB reaction function would therefore be useful to investigate the effective role played by oil prices in its monetary policy strategy, taking into account the evolution of other inflationary indicators such as the output gap and money growth.

[4]We define core inflation as the overall Consumer Price Index without energy and unprocessed food prices.

3 GMM estimates of an extended Taylor rule

3.1 The framework

Our model relies on a Taylor rule to describe the behaviour of Central Banks, which has become a standard since the seminal paper from Taylor (1993). This reaction function relates the shifts in the short-term nominal interest rate to the deviations of inflation and output from their target levels. The basic Taylor rule thus takes the following form:

$$i_t = \bar{i} + \beta(\pi_t - \pi^*) + \gamma(y_t - y^*) \tag{1}$$

where i_t^* is the desired short-term nominal interest rate, $\bar{i}$ its long-run equilibrium value, π_t the inflation rate and y_t the output gap. π^* and y^* are respectively the targets for the inflation rate and the output gap, which are both supposed constant over time. The coefficients β and γ can be interpreted as the relative weights assigned by the Central Bank to inflation and output stabilization respectively. We must note that the β coefficient plays a major role in the ability of the Central bank to temper inflation, and further in the stability of the system, as illustrated by Taylor (1999) and Woodford (2001). Taylor "principles" say that β must be higher than unity for central Banks that focus on price stability in their monetary strategy.

Clarida, Gali & Gertler (1998) try to improve the standard framework to get a more realistic rule in two dimensions. Firstly, they propose a forward-looking variant of the Taylor rule, in order to take into account the prospective behaviour of central bankers[5]. However, we do not want to use such a forward-looking rule in our investigations, since we are interested in the specific role played by oil prices in the strategy of the ECB. In fact, taking an expected inflation term in the ECB reaction function would entail a problem of collinearity with current oil prices, which are essentially an indicator for future inflation. That's why we concentrate in this Section on the estimation of a contemporaneous reaction function for the ECB, with only current values of all variables.

Secondly, Clarida *et al.* (1998) introduce a smoothing component in the interest-rate setting behaviour of central bankers. The monetary authorities indeed try to avoid a disturbing volatility of interest rates, since overly abrupt and frequent changes may create trouble in the equity and bond markets, and also affect the credibility of central bankers[6]. A reaction function incorporating such a smoothing behaviour may be written as:

$$i_t = \rho i_{t-1} + (1-\rho)[\bar{i} + \beta(\pi_t - \pi^*) + \gamma(y_t - y^*)] \tag{2}$$

[5]Since monetary policy only affects output and inflation after several months, it is likely that central bankers focus on expected future inflation rather than current or past inflation.

[6]Sack & Wieland (2000) provide a deeper investigation of the reasons explaining the need for interest rates smoothing.

where the ρ parameter (with $0 \leq \rho < 1$) measures the degree of interest rate smoothing.

Since our objective is to assess the role of oil prices in the ECB monetary policy strategy, we can not simply use this standard reaction function, but instead we have to choose an extended Taylor rule intended to be closer to the official "two-pillar strategy" designed by the ECB. That's why we include in our baseline reaction function four additional indicators supposed to convey information about future inflation: money growth (Δm_t) that constitutes the "*monetary-analysis pillar*" of the ECB's strategy, the euro-dollar nominal exchange rate (Δe_t), an interest rate spread (s_t) and an indicator for oil prices (Δo_t) that are contained in the "*economic-analysis pillar*". The extended reaction function thus takes the following form:

$$i_t = \rho i_{t-1} + (1-\rho)[\bar{i}_t + \beta(\pi_t - \pi^*) + \gamma(y_t - y^*) + \theta \Delta m_t + \eta \Delta e_t + \kappa s_t + \lambda \Delta o_t] \quad (3)$$

An empirical variant of our reference interest rate rule (3) may be written as:

$$i_t = \alpha_1 + \alpha_2 i_{t-1} + \alpha_3(\pi_t - \pi^*) + \alpha_4 y_t + \alpha_5 \Delta m_t + \alpha_6 \Delta m_t + \alpha_7 \Delta e_t + \alpha_8 s_t + \alpha_8 \Delta o_t + \varepsilon_t \quad (4)$$

The dependent variable i_t is a proxy for the target short-term nominal interest rate, namely the monthly average of the EONIA (*Euro OverNight Index Average*), the day-to-day interest rate in the euro area. π_t is the *inflation gap*, *i.e.* the difference between the monthly annualized HICP inflation rate and the inflation target of the ECB set to 2%. y_t is the output gap, measured as the monthly deviation of the Index of Industrial Production (IPI) from a trend calculated using the Hodrick-Prescott filter with a smoothing parameter set to 14 400 (standard value for monthly data). Δm_t is money growth minus the ECB target equal to 4.5%, constructed as the 12-month growth rate of the monetary aggregate M3. Δe_t is the monthly averaged change rate of the bilateral exchange rate. Finally, s_t is the difference between two different terms: long-run interest rates (10-years government bonds) and the 3-months interest rate (Euribor).

Finally, Δo_t is an indicator for oil price variations. Since our aim is to investigate the role of oil prices in the ECB monetary strategy and assess a potential asymmetric *and/or* nonlinear behaviour of the ECB regarding oil prices, we construct several indicators that will be alternatively introduced in our reaction function. Our baseline indicator is the 12-month variation of nominal oil prices expressed in euros (denoted as Δo_t). To investigate for potential asymmetries in the ECB reaction to oil prices, we distinguish between increases and deceases of nominal oil prices, *i.e.* between positive (Δo_t^+) and negative (Δo_t^-) values of our baseline indicator[7]. Finally, we construct an indicator for Net Oil Price Increases (*NOPI*), as initiated by Hamilton (1996), to assess a potential non-linear reaction of the

[7] These two measures are also used by Mork (1989) to evaluate the linearity of the oil price-output relationship after the big decrease in real oil prices in 1985.

ECB to oil prices increases. It allows for a distinction between oil price increases that really account for a shock relative to recent experience and increases that simply reverse recent decreases[8]. We build the symmetric indicator with decreases called: *NOPD*.

We also test the robustness of our results with alternative variables of activity and inflation. We replace the industrial production by the unemployment rate on which we apply the Hodrick and Prescot filter to obtain the fluctuations around its trend. HICP inflation is replaced by the core inflation indicator that excludes prices of energy and food. A second exercise of robustness consists in including additional variables that enter in the second pillar and influence ECB's decisions: asset prices (with the EUROSTOXX 50 index) and the interest rate spread between the U.S. and the euro zone. A detailed description of the series and data sources is provided in Appendix A.

The regression coefficients of Equation (4) are related to implied coefficients in Equation (3) according to the following form: $\alpha_1 = (1-\rho)\bar{i}$; $\alpha_2 = \rho$; $\alpha_3 = (1-\rho)\beta$; $\alpha_4 = (1-\rho)\gamma$; $\alpha_5 = (1-\rho)\theta$; $\alpha_6 = (1-\rho)\eta$; $\alpha_7 = (1-\rho)\kappa$; and $\alpha_8 = (1-\rho)\lambda$.

Finally, ε_t is an error term which reflects stochastic disturbances, *i.e.* monetary policy shocks. Those disturbances represent the part of shifts in interest rates that are not explained by deviations of prices, output, money growth and oil prices.

The estimation of the reaction function is based on the Generalized Method of Moment (GMM) estimator in order to avoid some econometrics caveats relative to more traditional methods and particularly OLS and Two-Stage Least Squares (TSLS). Firstly, the OLS estimator hurts to a problem of likely correlation between contemporaneous variables and the error term, which leads to biased estimates of the related coefficients. Moreover, several explanatory variables (notably current inflation and the output gap) are probably unobservable for the ECB in real time. That's why those variables need to be instrumented. Secondly, unlike traditional instrumental variables estimators such as the TSLS, GMM estimators do not require any assumption about the exact distribution of the error terms (*i.e.* normality, non-autocorrelation and homoskedasticity)[9].

We specifically use here the two-step efficient GMM estimator, initiated by Hansen (1982) and Hansen & Singleton (1982). Standard errors associated with coefficient estimates are computed using the procedure defined by Newey & West (1987), which provide a consistent estimator in case of heteroskedasticity and autocorrelation of unknown form (HAC covariance).

The only required condition for GMM estimates is the selection of instruments uncorrelated with the residual term. Good instruments should also be highly correlated with our right-hand side vari-

[8]Hamilton (1996) uses this indicator to investigate non-linearity in the relationship between oil prices and output, and shows that it helps recovering the Granger-causality in this relationship.

[9]GMM estimators nest and generalise many common estimators such as OLS and TSLS, as explained in Wooldridge (2001).

ables. In our estimates, we use two lags of all explanatory variables as instruments. The choice of a small number of instruments is intended to minimize the potential small-sample bias that may arise when too many over-identifying restrictions are imposed. The relevance of instruments is assessed using the Hansen-Sargan test, which is a test of over-identifying restrictions. The joint null hypothesis is that the instruments are valid instruments (*i.e.* orthogonal to the residuals) and that the estimated model is correctly specified. Under the null, the test statistics follows a chi-squared distribution with the number of over-identifying restrictions for degrees of freedom.

3.2 The ECB reacts asymmetrically to oil prices

The period of observation begins in January 1999 and finishes in December 2008. We thus have 120 observations. The results are reported in Table 1. The first column displays the results of the standard rule, the second includes the variation rate of oil prices Δo_t, and the last two columns are related to the "asymmetric" and "non-linear" indicators of oil prices.

We shall note that the fit of our regressions is quite good since the adjusted R^2 is always around 0.98[10]. The choice of instruments seems to be relevant since the *p-value* of the Hansen-Sargan test indicates that we can never reject the joint null hypothesis of valid instruments and correct specification of the model. The p-value of the Cragg-Donald test indicates however that the instrument set is sometimes weak (in [2] and [4]).

The estimation of a reaction function without oil prices can be used as a benchmark. It appears that the coefficients associated to ρ, β and γ are in line with the results reached in other recent empirical studies devoted to the ECB monetary policy rule[11]. It appears that the coefficient on inflation is positive but never significant. As for the coefficients associated to the output gap and exchange rate, they are perfectly in line with previous findings and theoretical assumptions. The ECB thus seems to use cyclical developments to assess future inflation and reacts accordingly in order to maintain price stability. The instantaneous reaction of the ECB to the output gap is rather great since it exceeds 0.5 (the reference according to Taylor "principles"). We note that the response of the ECB to exchange rate variations is in line with theoretical assumptions since it expresses the quantity of foreign currency for a unity of domestic currency. The central Bank thus rises the interest rate when the exchange rates depreciates in order to maintain the value of the currency. The money growth rate is only significant in the third regression, whereas the interest rate spread does not enter significantly.

[10]The lagged value of the short-run interest rate plays a key role.

[11]*Cf.* for example Fourçans & Vranceanu (2004, 2007), Gerdesmeier & Roffia (2004, 2005) and Sauer & Sturm (2007).

Table 1: **Extended Taylor rule - GMM estimates (1999:1-2008:12)**[a]

	[1]	[2]	[3]	[4]
Constant	**0.319*** **	0.127	**0.204***	-0.0183
	(0.108)	(0.104)	(0.112)	(0.137)
i_{t-1}	**0.890*** **	**0.943*** **	**0.919*** **	**0.964*** **
	(0.0283)	(0.0263)	(0.0310)	(0.0328)
$(\pi - \pi^*)$	0.0017	-0.0179	0.0017	0.0017
	(0.0320)	(0.0257)	(0.0244)	(0.0363)
y	**0.0866*** **	**0.0729*** **	**0.0925*** **	**0.0739** **
	(0.0194)	(0.0254)	(0.0204)	(0.0308)
Δm	0.0187	0.0115	0.0069	**0.0214** **
	(0.0126)	(0.0099)	(0.0097)	(0.0108)
Δe	**-0.0073*** **	-0.0117	**-0.0231***	**-0.0299** **
	(0.0026)	(0.0180)	(0.0119)	(0.0145)
s	-0.0045	0.0026	-0.0064	0.0328
	(0.0299)	(0.0308)	(0.0294)	(0.0373)
Δo		**0.0013** **		
		(0.0006)		
Δo^+			**0.0015** **	
			(0.0007)	
Δo^-			-0.0012	
			(0.0025)	
NOPI				**0.0239** **
				(0.0117)
NOPD				0.0129
				(0.0166)
Implied coefficients				
ρ	**0.89**	**0.943**	**0.919**	**0.964**
β	0.0155	-0.3140	0.021	0.0472
γ	**0.7873**	**1.2789**	**1.142**	**2.0528**
λ	-	**0.0228**	-	-
λ^+	-	-	**0.0185**	**0.6639**
λ^-	-	-	-0.0148	0.3583
Observations	117	117	117	117
$\bar{R}^2$	0.976	0.978	0.975	0.962
Hansen J-test	5.436	7.48	8.624	6.003
	[0.365][b]	[0.169]	[0.281]	[0.0671]
Cragg Donald Stat	34.91	10.83	29.87	14.61
	[0.000][c]	[0.146]	[0.001]	[0.539]

[a] We report the results reached using the two-step GMM estimator with the Newey & West (1987) correction. Standard errors are in brackets. ***, ** and * denote significance at the 1%, 5%, and 10% respectively.

[b] *p-value* of the Hansen test for the null hypothesis of valid instruments.

[c] *p-value* of the Cragg-Donald test for the null hypothesis of weakness of instruments.

The introduction of oil prices in the ECB reaction function suggests that this variable influences significantly the monetary policy in the euro area. The results demonstrate that the variation rate of oil prices plays a role in the ECB's decisions regarding interest rates: an increase in oil prices would be a risk to price stability for upcoming months. The third regression confirms our assumption of an asymmetric behaviour of the ECB, since the simultaneous introduction of variables Δo_t^+ and Δo_t^- (for increases *versus* decreases in the oil price) yield significant parameters. It thus illustrates a non-linear reaction of the Central Bank: the ECB reacts only when price stability is threatened, *i.e.* in case of rising oil price. Column 4 suggests that the ECB is really sensitive to the greatest oil price increases considered like true oil shocks and captured by the *NOPI* indicator, and not to the biggest decreases (*NOPD*). The difference between Δo_t^+ and *NOPI* is large since in the first case, a 200% increase in oil prices is needed to see a 25 basis points increase in main interest rate, whereas a 10% increase in *NOPI* is enough for the same monetary tightening.

The estimated coefficients allow for the evaluation of the impact of the monetary policy on output after an oil shock. A 50% increase in oil prices entails a rise in interest rate equal to 7.5 basis points. According to the Area Wide Model (AWM) from Fagan *et al.* (2001)[12], the impact of a 100 basis points increase in interest rate would lower the real GDP from 0.34 percentage points below its reference value the first year, and 0.71 percentage points the two next years. Such a policy would also cut inflation rate from 0.15 percentage points the first year, 0.30 and 0.38 the second and third years. We can thus assess the impact of the monetary tightening on activity to 0.05 percentage points during the two first years. In return, such a monetary policy reduces the inflation rate to 0.08 percentage points below the target, in the same delay. Even if the impact on output seems low, we have to remember that it constitutes a partial and transitory effect[13].

Results of the alternative estimates can be found in Tables 9, 10, 12 and 11 in Appendix B. In Table 9, it appears that oil price are less significant. The coefficient associated to the price of Brent is however greater in the second regression [2] (0.0039). The ECB remains watchful to (Δo_t^+) but not anymore to (*NOPI*). In Table 10, the estimates reveal a major role for the unemployment gap: when current unemployment is above its trend level, the ECB is more inclined to an accommodative monetary policy. Oil prices demonstrate a greater role in the definition of the monetary policy when the authorities are worried by the unemployment rate. The three additional variables demonstrate a relative proximity with the baseline results. We note that the coefficient associated to the smoothing parameter diminishes, that oil prices are less significant when we include the interest rate spread with the U.S. All these findings allow us to conclude to a quite good robustness of our results, and give some credit to an asymmetric and non-linear behaviour from the monetary authorities regarding oil prices.

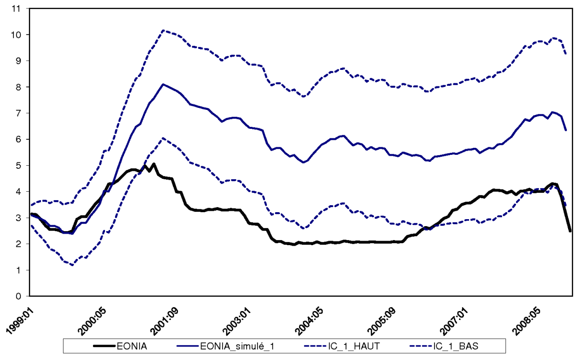
Finally, we evaluate the predictive power of our models by comparing the estimated interest rate

[12] See papers from Morgan & McAdam (2001) and van Els *et al.* (2001) for a larger comparison of the effects.

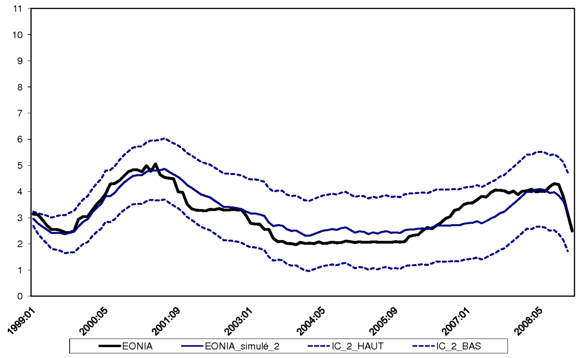
[13] Impacts would be higher with the coefficient associated to the *NOPI*.

and the actual one. We analysis it based on a graphic way and statistical indicators of the discrepancy between the estimation and the observation. Figure (4) provides a dynamic forecasting of the short-term interest rate using our reference reaction function with confidence intervals. We first observe that oil prices improve the EONIA forecasting. The path of the EONIA is far from the actual interest rate while it is closer in the three other models. The second model seems to be the better model because it has well predicted both the accommodative stance in 2001 and the tightening at the end of the period (with a small delay). Model [3] underestimates the low interest rate between 2003 and 2005, whereas model [4] overestimates the tightening monetary policy in 2007. It suggests that ECB remains relatively insensitive to the oil prices.

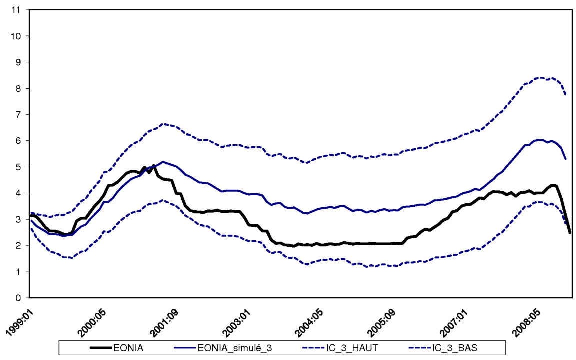
Figure 4: Out-of-sample dynamic forecasting



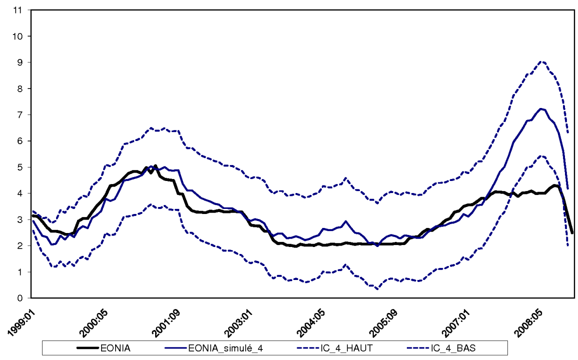
Model [1]



Model [2]



Model [3]



Model [4]

Statistical indicators of the errors of predictions reported in the table2 corroborate the observations from graphs above. The second model presents the lower average error whereas the model [1] displays the worst statistics of discrepancy between estimated interest rate and the observed interest rate.

Table 2: Indicators of predicting errors

	Model [1]	Model [2]	Model [3]	Model [4]
Root Mean Square Error	1.254	0.463	0.519	0.567
Mean Absolute Error	0.989	0.366	0.426	0.399
Mean Absolute Percentage Error en %	36.238	18.338	14.646	12.441

In spite of its success, *GMM* contains a drawback associated to the instrumentation. In the next section, we use another methodology which allows for estimating the interest rate directly activated by the ECB: an ordered Probit Model.

4 Ordered Probit estimates

Another way to investigate the role of oil prices in monetary policy decisions is to estimate the reaction function using an Ordered Probit model. In fact, GMM estimates of our extended reaction function were using the monthly average of the EONIA as the instrument of the ECB. For large samples, this is likely to be a good approximation, since the ECB controls the overall path of the day-to-day rate. However, there are temporary deviations of the EONIA from the rate of the Main Refinancing Operations (MRO) directly under the ECB control, and those deviations are rather hard to explain, as noted by Carstensen (2006). Therefore, the use of the EONIA interest rate may have entailed an additional noise in our regressions, especially on a small sample as ours. That's why we want to check our results in this Section using directly the ECB MRO rate. Since this rate is always set at multiples of 25 basis points, a simple regression model for continuous dependent variable would not be appropriate. We thus use an Ordered Probit model that is designed for "censored" dependent variables. Since the seminal paper from Eichengreen *et al.* (1985), the estimation of monetary policy reaction functions by means of Ordered Probit models has become increasingly popular. Examples of their diffusion include Gali *et al.* (2004), Carstensen (2006) and Gerlach (2007).

4.1 The Ordered Probit model

Within our Ordered Probit model, the monthly decision of the ECB regarding its interest-rate setting is represented as a choice among three modalities: a cut in the MRO rate (-1), no change (0) and an increase of the MRO rate (+1). Table 3 indeed shows that the ECB did not modify its main refinancing rate very often during the period 1999:1-2008:12 (only 27 times for 110 observations). Since the number of 25-basis-point cuts and 50-basis-point increases is very limited, we decide not to discriminate between the scope of increases and decreases, and thus only model three possibilities, like Heinemann & Huefner (2004). We finally get 16 increases and 11 decreases.

Table 3: **Shifts in the monetary policy instrument (1999:1-2008:12)**

	25 basis points	50 basis points	Total
Increases	14	2	16
Decreases	3	8	11
Statu-quo	-	-	93

The decision of the ECB is therefore defined as a choice among three possibilities:

$$\begin{aligned} \Delta i_t &= -1 && \text{if} \quad i_{t-1} - n_2 < i_t^* < i_{t-1} - n_1 \\ \Delta i_t &= 0 && \text{if} \quad i_{t-1} - n_1 < i_t^* < i_{t-1} + p_1 \\ \Delta i_t &= 1 && \text{if} \quad i_{t-1} + p_1 < i_t^* < i_{t-1} + p_2 \end{aligned} \tag{5}$$

where i_t^* would be the optimal interest rate if it could be set on a continuous scale, which is consequently unobserved. p_i (n_i) represents the scope of the positive (negative) shift in the interest rate.

The specification of the ECB reaction function is very close to the specification used for GMM estimates in the previous Section. Nevertheless, we regress the interest rate on the lagged value of inflation, output gap and monetary growth. We assume that those variables are currently unobservable and that no instrumentation is used here. The expression of the target level for the interest rate i_t^T is simply:

$$i_t^T = c + \alpha_1(\pi_{t-1} - \pi^*) + \alpha_2 y_{t-1} + \alpha_3 \Delta m_{t-1} + \alpha_4 \Delta e_t + \alpha_5 s_t + \alpha_6 \Delta o_t + v_t \tag{6}$$

Assuming that the ECB proceeds to a gradual adjustment of the actual interest rate, as in Judd & Rudebusch (1998), we get the following dynamic expression for the desired interest rate i_t^*:

$$i_t^* - i_t = \beta_0(i_t^T - i_{t-1}) + \beta_1 \Delta i_{t-1} + \varepsilon_t \tag{7}$$

Combining (6) and (7) and incorporating the fact that the ECB only sets its interest rate in steps yield the following expression:

$$i_t^* - i_t = \gamma_1(\pi_{t-1} - \pi^*) + \gamma_2 y_{t-1} + \gamma_3 \Delta m_{t-1} + \gamma_4 \Delta e_t + \gamma_5 s_t + \gamma_6 \Delta o_t - \beta_0(i_{t-1}) + \beta_1 \Delta i_{t-1} + \varepsilon_t \tag{8}$$

where the constant term is omitted, $\gamma_i = \alpha_i \beta_0$ for i=1 to 4, and $\varepsilon_t = \beta_0 v_t$. i_t^* may therefore be defined as a latent unobservable variable, and Equations (5) and (8) constitute the Ordered Probit model which can be estimated since all regressors are observed.

4.2 An oil price increase rises the probability of restrictive monetary policy

Table 4 reports the results of our estimates. The main results are rather in line with those discussed in the previous Section on the basis of GMM estimates, especially regarding the role of the output gap and oil prices in the ECB interest-rate setting process[14]. The exchange rate's fluctuations lost their influence, whereas the inflation deviation, the monetary growth and the interest spread remain non-significant. The inclusion of oil prices in the reaction function does not entail major changes to the baseline results, though slightly improving the fit of the model. The results suggest an asymmetric behaviour of the ECB with respect to oil prices, since the coefficient related to increases (*pos*) is significant, while the one related to decreases (Δo_t^-) is still non significant (column 3). However, the results reached using the Ordered Probit model do not yield a particular role for the *NOPI* indicator (column 4).

Table 5 displays the marginal effects for each variable and specification. The marginal effects are the change in the probability of each modality (-1, 0 and +1, *i.e.* respectively decrease, no change and increase in the MRO rate) for a one-unit change (a one-percentage-point change in our case) in the explanatory variable (calculated for mean values of explanatory variables). The computation of marginal effects thus allows us to interpret and compare the impact of small changes of each variable on the ECB decision[15]. For example, it appears that a one-percentage-point increase in the output gap reduces the probability of a cut in the interest rate by 0.055 and increases the probability of a tightening of monetary policy by 0.087, if we refer to our baseline specification without oil prices. In the other specifications, we observe that rising oil prices raise significantly the probability of a tightening of monetary policy (0.002 in [2]) and reduce the probability of a more accommodative stance (-0.001). The asymmetric pattern is confirmed in the third regression where only Δo_t^+ affects the probabilities of a modification in interest rates. Beyond the validation of GMM results, we recover the hierarchy of the tasks dedicated to the ECB. Indeed, the european authority excludes an accommodative policy and promotes the stability price. The ECB would not fear the deflation pressure associated to a decrease in oil prices but only the inflationnary effect of an oil shock.

[14]It also appears that the interest rate *level* influence the ECB decisions: the Governing Council may be more inclined to increasing its key interest rate when it is initially low, and conversely to cut it when the initial level is rather high. On the other hand, the parameter related to *lagged change* in the interest rate is not significant whatever the specification, suggesting that a change in the key interest rate would not influence the decision of the following month.

[15]Obviously, the most probable event is in each case that the ECB keeps unchanged its MRO interest rate, as clearly indicated by the last line of Table 5.

Table 4: **An extended Taylor rule: Ordered Probit estimates (1999:1-2008:12)[a]**

	[1]	[2]	[3]	[4]
i_{t-1}	**-0.708***	**-0.631***	**-0.682***	**-0.663***
	(0.222)	(0.218)	(0.226)	(0.230)
Δi_{t-1}	0.281	-0.0099	-0.0009	0.218
	(0.256)	(0.254)	(0.255)	(0.265)
$(\pi_{t-1} - \pi^*)$	-0.186	-0.356	-0.344	-0.185
	(0.291)	(0.296)	(0.299)	(0.286)
y_{t-1}	**0.517***	**0.460***	**0.477***	**0.476***
	(0.138)	(0.146)	(0.148)	(0.160)
Δm_{t-1}	-0.0189	0.0828	0.0693	-0.0027
	(0.0791)	(0.0850)	(0.0869)	(0.0781)
Δe	-0.0640	-0.0348	-0.0326	-0.0709
	(0.0506)	(0.0502)	(0.0490)	(0.0505)
s	-0.351	-0.350	-0.408	-0.351
	(0.298)	(0.287)	(0.284)	(0.303)
Δo		**0.0163***		
		(0.0043)		
Δo^+			**0.0180***	
			(0.0057)	
Δo^-			0.0093	
			(0.0135)	
NOPI				0.0059
				(0.0307)
NOPD				0.0581
				(0.0446)
Observations	119	119	119	119
Pseudo R^{2b}	0.170	0.241	0.243	0.179
Log-likelihood[c]	-68.02	-62.20	-62.08	-67.29
Correct predictions[d]	94	97	99	95

[a] Standard errors are in brackets. ***, ** and * denote significance at the 1%, 5%, and 10% respectively.

[b] The pseudo-R^2 is the Mac Fadden R^2, which is appropriate to assess the quality of the estimation.

[c] LR statistic for testing the restricted model against the most general model.

[d] Number of observations for which the model has well predicted the decision of ECB.

Table 5: **Marginal effects**[a]

	[1]			[2]			[3]			[4]		
	-1	0	1	-1	0	1	-1	0	1	-1	0	1
i_{t-1}	**0.0747****	0.0449	**-0.1200*****	**0.0506****	0.0382	**-0.0888*****	**0.0535****	0.0419	**-0.0954*****	**0.0715****	0.0377	**-0.1090*****
	(0.0299)	(0.0328)	(0.0373)	(0.0242)	(0.0291)	(0.0338)	(0.0255)	(0.0295)	(0.0343)	(0.0308)	(0.0311)	(0.0370)
Δi_{t-1}	-0.0297	-0.0178	0.0475	0.0008	0.0006	-0.0014	0.0000	0.0001	-0.0001	-0.0235	-0.0124	0.0359
	(0.0285)	(0.0210)	(0.0449)	(0.0204)	(0.0154)	(0.0358)	(0.0200)	(0.0157)	(0.0357)	(0.0299)	(0.0180)	(0.0446)
$(\pi_{t-1}-\pi^{*})$	0.0196	0.0118	-0.0314	0.0286	0.0216	-0.0502	0.0270	0.0211	-0.0481	0.0200	0.0105	-0.0305
	(0.0299)	(0.0196)	(0.0475)	(0.0242)	(0.0235)	(0.0415)	(0.0236)	(0.0234)	(0.0418)	(0.0301)	(0.0179)	(0.0456)
y_{t-1}	**-0.0545*****	-0.0327	**0.0872*****	**-0.0370****	-0.0279	**0.0648*****	**-0.0374****	-0.0293	**0.0667*****	**-0.0513****	-0.0270	**0.0784*****
	(0.0184)	(0.0241)	(0.0232)	(0.0159)	(0.0203)	(0.0206)	(0.0158)	(0.0205)	(0.0210)	(0.0203)	(0.0224)	(0.0245)
Δm_{t-1}	0.0019	0.0012	-0.0032	-0.0067	-0.0050	0.0117	-0.0054	-0.0043	0.0097	0.00029	0.0002	-0.0005
	(0.0084)	(0.0051)	(0.0134)	(0.0071)	(0.0062)	(0.0121)	(0.0069)	(0.0063)	(0.0124)	(0.0084)	(0.0044)	(0.0129)
Δe	0.0068	0.0041	-0.0108	0.0028	0.0021	-0.0049	0.0026	0.0020	-0.0046	0.0077	0.0040	-0.0117
	(0.0054)	(0.0044)	(0.0086)	(0.0041)	(0.0032)	(0.0069)	(0.0039)	(0.0032)	(0.0068)	(0.0055)	(0.0044)	(0.0083)
s	0.0371	0.0223	-0.0593	0.0281	0.0212	-0.0493	0.0321	0.0251	-0.0572	0.0379	0.0200	-0.0579
	(0.0329)	(0.0243)	(0.0509)	(0.0253)	(0.0245)	(0.0441)	(0.0257)	(0.0248)	(0.0433)	(0.0342)	(0.0239)	(0.0512)
Δo				**-0.0013****	-0.0009	**0.0023*****						
				(0.0005)	(0.0008)	(0.0008)						
Δo^{+}							**-0.0014****	-0.0011	**0.0025*****			
							(0.0006)	(0.0008)	(0.0009)			
Δo^{-}							-0.0007	-0.0006	0.0013			
							(0.0010)	(0.0010)	(0.0019)			
$NOPI$										-0.0006	-0.0003	0.0010
										(0.0033)	(0.0018)	(0.0051)
$NOPD$										-0.0063	-0.0033	0.0096
										(0.0052)	(0.0037)	(0.0077)
$P(Y_i)$	0.051	0.854	0.095	0.036	0.889	0.075	0.036	0.890	0.074	0.053	0.855	0.092

[a] standard errors are in brackets. ***, ** and * denote significance at the 1%, 5%, and 10% respectively. The marginal effects in each category sum to zero, as described by Heinemann & Huefner (2004). The last line shows the predictive probability of the event.

As with the GMM estimator, we examine the robustness of our results for alternative indicators of inflation and activity, namely core inflation and the unemployment gap. The results are reported in Tables 13, 14, 15 and 16 in Appendix C. The estimates are very close to those reached with our benchmark indicators. All in all, it appears that our conclusions relative to oil price indicators are rather robust. The more important modifications are found with the core inflation. We observe that core inflation coefficients are significant in [1] and [4], with a counter-intuitive sign. Exchange rate and the monetary growth deviation enter significantly. Both interest rate spread with the U.S and asset prices influence the decision of the ECB. The increase in asset prices and higher U.S interest rates conduct the european Bank to lead a more restrictive monetary policy. Oil prices play an important role in the interest-rate setting process of the ECB, and their effect seems to be asymmetric: oil price increases influence its decision setting (and tend to increase the probability of a tightening of monetary policy), not oil prices decreases.

Table 6: **Actual ECB decisions *versus* predictions of Ordered Probit models**[a]

[1]	*Realized*				
		-1	0	1	Total
	-1	**2**	0	0	2
Predicted	0	9	**92**	16	117
	1	0	0	**0**	0
	Total	11	92	16	119

[2]	*Realized*				
		-1	0	1	Total
	-1	**3**	0	0	3
Predicted	0	8	**92**	14	112
	1	0	2	**2**	4
	Total	11	92	16	119

[3]	*Realized*				
		-1	0	1	Total
	-1	**2**	0	0	2
Predicted	0	9	**90**	13	112
	1	0	2	**3**	5
	Total	11	92	16	119

[4]	*Realized*				
		-1	0	1	Total
	-1	**2**	1	0	3
Predicted	0	9	**91**	16	116
	1	0	0	**0**	0
	Total	11	92	16	119

[a] The bold numbers describe the coincidences between the prediction of the model and the effective decision of the ECB.

In order to assess the quality of prediction of our models, we report in Table 6 a summary of predictions of each model against effective ECB's decisions. The models help in predicting the decisions of the ECB to leave unchanged its interest rate, but overestimate the probability of this modality (with between 112 and 117 predictions of *status quo*, against 92 observations of no-change in the MRO rate). Conversely, Ordered Probit models largely underestimate the probabilities of an increase or decrease of the MRO interest rate. Over 16 increase and 11 decreases, our models predict only three shifts (3 decreases in the first model and three increases in the third regression) All in all, it appears that the model is not very efficient in predicting shifts in the monetary stance, which is in line with previous results from Carstensen (2006) and Gerlach (2007).

5 Two potential explanations of the asymmetric response

The asymmetric reaction of the monetary authorities can be explained in two ways. First, the ECB could expect a nonlinear relationship between energy prices and overall inflation or expected inflation. Then, Central Bank could have asymmetric preferences and be particularly watchful to price level. We assess those two potential explanations.

5.1 Oil prices and expected inflation

The variation of oil prices lead policymakers to revise their inflation expectation. Rising oil prices create inflation pressures that could force the authorities to conduct a restrictive policy. On the other hand, it does not fear deflation when the energy prices declines. We perform a bivariate Granger causality test (Granger, 1969) for each oil prices indicator constructed and prices' expectations included in the SPF (1 and 2 years ahead) and *The economist* data set. This test will be informative on the potential causal relation and notifies the way in which energy prices translate into expectations.

$$\pi_t^f = \alpha_1 + \sum_{i=1}^{l} \zeta^{(l)} \pi_{t-l}^f + \sum_{i=1}^{l} \theta^{(l)} o_{t-l} + \varepsilon_{1,t} \tag{9}$$

$$o_t = \alpha_2 + \sum_{i=1}^{l} \omega^{(l)} o_{t-l} + \sum_{i=1}^{l} \xi^{(l)} \pi_{t-l} + \varepsilon_{2,t} \tag{10}$$

where l is the maximum number of lagged observations whose contributions are displayed by the coefficients ζ, θ, ω and ξ.

To examine Granger causality from oil prices on expectations, we only test the following hypothesis:

$$\theta^{(l)} = 0$$

If it could not be rejected, inflation expectations are independent from oil prices. Indeed, the past values of oil prices change are not statistically different from zero and thus do not explain the current level of inflation anticipations. We are therefore in a purely autoregressive process since only past values of expectations affect the current expectation. If we reject the hypothesis, there is causality from the former variable to the latter. The results of the tests critically depend on the lags we retain (see Thornton & Batten (1985)). In this paper, we set the number of lags (l) to unity. We economically justify our choice by the delay during which expectations could be affected by the evolution of oil prices. We can accept this assumption because oil prices can shift immediately the predictions of policymakers. It will be longer concerning the actual inflation rate. Moreover, this specification minimizes the AIC criteria. Table 7 reports the results of the test.

We can reject the null hypothesis that oil prices do not Granger-Cause inflation expectations in three of the four cases. We note that crude oil prices change rates (Δo_t, Δo_t^+ and Δo_t^-) turn out to be good predictors of expectations since the significance levels of the associated statistics are below 5%. Only the *NOPI* indicator, with a P-value above 10%, would Granger-Cause the anticipated inflation of the SPF two years ahead. The two others indicators do not display any asymmetric response to Δo_t^+ and Δo_t^-. Those results indicate that oil prices do not influence asymmetrically the construction of the expectations of the future price level. The justification of the ECB's asymmetric behaviour is thus elsewhere.

Table 7: **Bivariate Granger-Causality tests for oil prices and inflation expectations[a]**

H_0	SPF one year ahead	SPF two years ahead	*The Economist*
Δo does not "granger" cause π^f	**11.0497*** **	1.08236	**9.23935*** **
Δo^+ does not "granger" cause π^f	**7.49422** **	1.05518	**4.10485** **
Δo^- does not "granger" cause π^f	**9.45812*** **	0.54312	**19.1923*** **
NOPI does not "granger" cause π^f	1.52211	**5.10047** **	**4.18974** **
NOPD does not "granger" cause π^f	0.16084	0.45426	**9.62645*** **

[a] The statistic represents a F-test of $\theta = 0$ in (9), with 1 the number of lags and 118 degrees of freedom.

5.2 Is there a preference for price stability?

The second explanation holds on the preferences of European policymakers. Indeed, policymakers could assign different weights to their objectives of inflation and output gap in the setting of the policy. We know for instance that price stability is the main objective in the euro area, and that authorities are more concerned about overshooting inflation target (π^*). We can thus think that the dilemma created by a supply shock like an oil shock is not so difficult to solve. It is more plausible that the ECB apply a restrictive policy when oil prices raise rather than an accommodative policy which would maintain the activity around its potential. We evaluate the supposed "inflation bias" of the ECB on the basis of the work of Surico (2004) and an optimization problem. The quadratic loss function follows:

$$L_t = \frac{1}{2}[(\pi_t - \pi^*)^2 + \frac{\eta}{3}(\pi_t - \pi^*)^3] + \frac{\lambda_y}{2}[y_t^2 + \frac{\kappa}{3}y_t^3] + \frac{\lambda_i}{2}(i_t - i^*)^2 \quad (11)$$

The cubic specification allows treating positive and negative deviations of inflation and output from the target and the potential level. We expect a positive sign for η since overshooting π^* generates a loss for policymakers. Conversely, κ should be negative since authorities are more concerned by an output contraction (*i.e* a negative output gap) which diminishes the welfare.

This function is minimized regarding two constraints representing the functioning of the economy:

$$\pi_t = \Theta E_t \pi_{t+1} + \psi y_t + \varepsilon_t^s$$
$$y_t = E_t y_{t+1} - \phi(i_t - E_t \pi_{t+1}) + \varepsilon_t^d \tag{12}$$

They correspond respectively to an aggregate supply and an aggregate demand relation. The first equation is a New-Keynesian Phillips curve which captures the feature of a Calvo-type prices in which each firm adjusts its price with a constant probability in any given period independently from the last change. The second equation, in turn is an IS schedule which exhibits the notion of smoothing adjustment since the output gap is a positive function of the value expected in the next period.

The problem of the Central Bank is to set the interest rate at the period t upon the information available in *t-1*. It gives:

$$\min_{i_t} E_{t-1} \sum_{\tau=0}^{\infty} \delta^\tau L_{t+\tau} \tag{13}$$

Where δ is a discount factor and L stands for the period loss function.

We obtain the first order conditions[16]:

$$-\psi\phi E_{t-1}(\pi_t - \pi^*) - \frac{\eta\psi\phi}{2} E_{t-1}(\pi_t - \pi^*)^2 - \phi\lambda_y E_{t-1} y_t - \frac{\phi\kappa\lambda_y}{2} E_{t-1} y_t^2 + \lambda_i(i_t - i^*) = 0 \tag{14}$$

We finally estimate the reduced form of the resulting equation which looks like an optimal Taylor rule extended with quadratic terms:

$$i_t = \alpha_0 + \alpha_1 E_{t+k}[\pi - \pi^*] + \alpha_2 y_t + \alpha_3 (E_{t+k}[\pi - \pi^*])^2 + \alpha_4 y_t^2 + \rho i_{t-1} + v_t \tag{15}$$

We only regress the interest rate on inflation gap (difference between the actual inflation rate and the inflation target 2%) and the output gap to recover the seminal rule of Taylor (1993). Inflation term is under a forward-looking specification since we consider that the ECB react to the inflation rate expected. We use this forward looking specification because we want to assess different horizons regarding to inflation objective. The ECB determines the monetary policy and expects effects on the

[16] For calculation details, see Surico (2007). We only report here the reduced form of the estimated equation.

economy between six and 12 months later[17]. The parameters capturing nonlinearity on inflation (η) and on activity (κ) are respectively contained in α_3 and α_4:

$$\alpha_3 \equiv \frac{\eta\phi\psi}{2\lambda_i} \quad and \quad \alpha_4 \equiv \frac{\lambda_y\kappa\psi}{2\lambda_i}$$

We estimate equation (15) using the General Method of Moments (GMM) with a Newey-West estimate of the covariance matrix. Two lags of each explanatory variable and two lags of the main interest rate are set as instruments. The table 8 presents the results.

Table 8: **Nonlinear Taylor rule (1999:1-2008:12)[a]**

	k=k'=6	k=k'=12	k=6; k'=3	k=12; k'=6
α_0	0.1178	0.0440	**0.1567*****	0.0412
	(0.0964)	(0.0764)	(0.0536)	(0.0605)
ρ	**0.9266*****	**0.9814*****	**0.9374*****	**0.9994*****
	(0.0399)	(0.0306)	(0.0212)	(0.0254)
α_1	**0.4807*****	**0.1935****	0.1168	0.0098
	(0.1213)	(0.0974)	(0.0892)	(0.1285)
α_2	**0.1269*****	-0.0010	**0.1351*****	0.0403
	(0.0287)	(0.0211)	(0.0327)	(0.0541)
α_3	**0.2051*****	-0.1088	**0.1070*****	-0.1591
	(0.0536)	(0.0789)	(0.0338)	(0.0457)
α_4	-0.0212	0.0029	-0.0112	0.0033
	(0.0195)	(0.0175)	(0.0115)	(0.0119)
Observations	111	105	111	105
$\bar{R}^2$	0.9125	0.9683	0.9655	0.9769
Hansen J-test	3.089	6.084	5.832	6.767
	0.543[b]	0.193	0.212	0.149

[a] We report the results reached using the two-step GMM estimator with the Newey & West (1987) correction. Standard errors are in brackets. ***, ** and * denote significance at the 1%, 5%, and 10% respectively.
[b] *p-value* of the Hansen test for the null hypothesis of valid instruments.

We first compare two equations with two different horizons (k=k'=6 and 12) with k the horizon for inflation and k' for output gap. We also estimate the nonlinear Taylor rule by differentiating the horizons (k=6, k'=3) and (k=12, k'=6). The second regression does not demonstrate any asymmetric preferences. But the first one with inflation expectation of 6 month ahead shows that the ECB is particularly sensitive to the evolution of the level of price. Indeed, α_3, associated to the quadratic

[17] No other variable (like oil prices) will influence inflation expectations.

term of inflation is significant whereas the coefficient capturing nonlinearity in activity is not. We precise that α_3 displays the predictive positive sign. We recover this nonlinear preference when inflation expectations are set to 6 months and output gap to 3 months. The results confirm that european policymakers are more preoccupied by an inflation deviation from its target than an output contraction since it is more costly in for the authorities' welfare. The inflationary pressures generated by an oil price increase conduct the authorities to lead a tighter monetary policy in spite of the negative effects of the shock on activity. This conclusion is of course valid for all kind of supply shock and thus for oil shock.

The asymmetric behaviour relative to oil prices found in the two previous sections are mainly justified by nonlinear preferences of the ECB on price stability. The oil prices which affect inflation expectations do not translate asymmetrically since both positive and negative change rates help Granger-Cause the predictions. The deviation of inflation rate from the target entails a welfare loss in a greater magnitude than an output contraction. This result validates the ECB's alarms when oil prices increase and explains why it rather insists on the risks for the price level and not with output. The ECB's behaviour can be justified by the distribution of tasks assigned to authorities by the political process of the EMU. The monetary authority manages with the common hand of the oil shock, inflation pressures, but let fiscal policies of the EMU members face to real effects (specific hand). Moreover, an accommodative stance would limit recession consequences for some countries but reinforce the inflation increase in others due to asymmetrical effects of the monetary policy in the EMU.

6 Conclusion

This paper was intended to evaluate the role played by oil prices in the ECB monetary policy strategy. To this end, we perform estimates of the ECB reaction function using an extended specification of a Taylor rule, incorporating alternative indicators of oil prices. It appears that oil prices play a rather important role in the ECB interest-rate setting process, as expected and announced by the ECB itself when the Members of the ECB Board claim that oil prices are an important element of the "economic analysis" and a relevant indicator of future inflation. However, the ECB seems to react asymmetrically: only oil price increases influence its decision setting, not oil prices decreases. Those results are rather robust since they hold for the two alternative methodologies used in this paper for the estimation of the ECB reaction function: a GMM framework and an Ordered Probit model. This behaviour is explained by the preference of the ECB on inflation deviation from the target. The energy prices can push up the inflation rate above the 2% and force the authorities to react to preserve the stability price. Our estimates assess that the response of the ECB, after an oil price increase equal of 50%, "costs" 0.05 percentage points of the real GDP relative to its potential level in two years, while it reduces the inflation rate from 0.08 percentage points in the same delay.

This paper thus reports evidence of a nonlinear and asymmetric behaviour of the ECB as regards the evolution of oil prices. Those results do not mean however that European policymakers are at the root of the asymmetry in the relationship between oil prices and output. Monetary policy may rather be viewed as an element of transmission and amplification of this asymmetry.

In future works, we intend to extend and deepen this analysis in several directions. Firstly, it would be interesting to assess the existence of a threshold in oil price growth which warns policymakers and decides them to modify the monetary stance in order to avoid inflation. Secondly, it would be useful to compare our results reached using monthly data on a rather short-time sample with estimates on pre-euro data. Quarterly data on a "fictive" euro area, extended to the eighties and nineties, would be instructive. In the same way, a comparison with the practice of the U.S. Federal Reserve as regards the evolution of oil prices should provide some interesting insights into the difference in the conduct of their monetary policy. Finally, the construction and the estimation of an explicit model of the economy, with aggregate demand and supply reactions to the monetary policy, would help in investigating the interactions between oil prices, inflation, monetary policy and economic activity.

Appendix A: Data and the construction of oil indicators

For GMM estimates, we use the monthly average of the EONIA (*Euro OverNight Index Average*) as a proxy for the short-term nominal interest rate. For the Ordered Probit modelling, we use the rate of Main Refinancing Operations (MRO), which is the key interest rate of the ECB. Data are provided on the ECB Website.

We use the HICP inflation index (all items) basis 100 in 2005 and comes from the *OECD Main Economic Indicators*. For robustness checks, we also use an indicator of core inflation, which is the Harmonized Index of Consumer Prices eXcluding food and energy prices (HICPX). Those series are not adjusted for seasonality and are extracted from the same database. The forecast of inflation rate in the euro area is extracted from the ECB's survey data through the Survey of Professional Forecasters (SPF), and from the review *"The Economist"*. For the SPF, a questionnaire asks for a point estimate of what specialists expect inflation, real GDP growth and unemployment to be over specific time horizons, together with probabilities for different outcomes.

As for our indicator of economic activity, it is constructed using the Index of Industrial Production (IPI), which is available at a monthly frequency (unlike GDP, only available on a quarterly basis). Our baseline proxy for the output gap is the monthly deviation of the IPI from a trend calculated using the Hodrick-Prescott filter with a smoothing parameter set to 14 400 (standard value for monthly data). For robustness checks, we also use a measure of the "unemployment gap", calculated as the monthly deviation of the unemployment rate from a trend obtained with the Hodrick-Prescott filter. Seasonally-adjusted series of IPI and unemployment rate are extracted from the *OECD Main Economic Indicators*.

The "monetary analysis" indicator is constructed as the 12-month growth rate of the monetary aggregate M3, which is provided on the ECB website.

The "economic analysis" pillar is represented by the euro-dollar nominal exchange rate and the interest spread between long-run and short-run interest rates. We use the monthly average growth rate of the bilateral exchange rate. The spread results from the difference between each monthly value of the Yield 10-years government bond and the 3-month EURIBOR. All data are extracted from the *OECD Main Economic Indicators*.

Finally, oil prices are extracted from the International Energy Agency (IEA) database and represent the Brent spot prices on the Rotterdam market. Our baseline indicator is the 12-month variation of nominal oil prices expressed in euros (denoted as Δo_t). To investigate for potential asymmetries in the ECB reaction to oil prices, we distinguish between increases and decreases of nominal oil prices, *i.e.* between positive (Δo_t^+) and negative (Δo_t^-) values of our baseline indicator. We also construct an indicator for Net Oil Price Increases (*NOPI*), as initiated by Hamilton (1996), to assess a potential nonlinear reaction of the ECB to oil prices increases. It allows us to filter out oil prices increases in a context of high volatility which can affect the perception of the actors. When the oil price level of the current month exceeds the value of the previous year's maximum level, the NOPI is equal to the percentage change between the two "peaks". For all other values of oil price variations (negative as positive), the NOPI indicator is equal to zero.

The robustness checks lead us to include additionnal variables: asset prices, the spread of interest rate between the U.S and the euro zone. We use the EUROSTOXX 50 index (basis 100 in 2005) as a proxy of the first variable and the difference between the day-to-day interest rate of the euro area (EONIA) and the Fed Funds rates set by the Federal Reserve. The data still come from the *OECD Main Economic Indicators*.

Appendix B: Robustness checks for GMM estimates

Table 9: **GMM estimates with core inflation**[a]

	[1]	[2]	[3]	[4]
Constant	0.111	0.134	0.226	0.0142
	(0.148)	(0.165)	(0.165)	(0.179)
i_{t-1}	**0.931*** **	**0.934*** **	**0.911*** **	**0.957*** **
	(0.0329)	(0.0349)	(0.0383)	(0.0375)
$\tilde{\pi}$	-0.0579	0.1090	0.0130	0.0426
	(0.0550)	(0.1090)	(0.0580)	(0.0718)
y	**0.0937*** **	**0.0813*** **	**0.0991*** **	**0.0802** **
	(0.0265)	(0.0310)	(0.0210)	(0.0311)
Δm	**0.0177***	0.0126	0.0068	**0.0252***
	(0.0103)	(0.0132)	(0.0103)	(0.0130)
Δe	-0.0253	-0.0269	**-0.0252***	**-0.0467*** **
	(0.0212)	(0.0223)	(0.0128)	(0.0164)
s	0.0337	0.0086	-0.0076	0.0348
	(0.0319)	(0.0422)	(0.0387)	(0.0473)
Δo		**0.0039***		
		(0.0022)		
Δo^{+}			**0.0017***	
			(0.0010)	
Δo^{-}			-0.0019	
			(0.0027)	
$NOPI$				0.0263
				(0.0167)
$NOPD$				0.0274
				(0.0192)
Implied coefficients				
ρ	**0.931**	**0.934**	**0.911**	**0.957**
β	-0.8391	1.6515	0.1461	0.9907
γ	**1.358**	**1.2318**	**1.1135**	**1.8651**
λ	-	**0.0591**	-	-
λ^{+}	-	-	**0.0191**	0.6116
λ^{-}	-	-	-0.0213	0.6372
Observations	117	117	117	117
$\bar{R}^2$	0.974	0.968	0.974	0.948
Hansen J-test	3.426	0.327	3.477	2.184
	[0.489]	[0.042]	[0.000]	[0.454]
Cragg Donald Stat	10.14	9.885	26.48	7.792
	[0.071]	[0.955]	[0.001]	[0.479]

[a] See notes in Table 1.

Table 10: **GMM estimates with unemployment gap**[a]

	[1]	[2]	[3]	[4]
Constant	**0.583*** **	**0.337*** **	**0.344** **	0.378
	(0.155)	(0.123)	(0.149)	(0.250)
i_{t-1}	**0.849*** **	**0.902*** **	**0.898*** **	**0.890*** **
	(0.0345)	(0.0256)	(0.0366)	(0.0626)
$(\pi - \pi^{*})$	**0.0626** **	0.0047	0.0116	0.0479
	(0.0292)	(0.0265)	(0.0305)	(0.0457)
$U - U^{*}$	**-0.0549*** **	**-0.0409*** **	**-0.0444*** **	**-0.0434** **
	(0.0083)	(0.0061)	(0.0089)	(0.0212)
Δm	**-0.0271** **	-0.0104	-0.0112	-0.0161
	(0.0117)	(0.0099)	(0.0113)	(0.0161)
Δe	**-0.0291** **	-0.0078	**-0.0146***	**-0.0265** **
	(0.0138)	(0.0124)	(0.0085)	(0.0124)
s	-0.0505	-0.0398	-0.0378	-0.0335
	(0.0369)	(0.0303)	(0.0327)	(0.0334)
Δo		**0.0020*** **		
		(0.0004)		
Δo^{+}			**0.0021*** **	
			(0.0006)	
Δo^{-}			0.0014	
			(0.0022)	
NOPI				**0.0193***
				(0.0106)
NOPD				0.0033
				(0.0124)
Implied coefficients				
ρ	**0.849**	**0.902**	**0.898**	**0.89**
β	**0.4146**	0.048	0.1137	0.4355
γ	**-0.3636**	**-0.4173**	**-0.4353**	**-0.3945**
λ	-	**0.0204**	-	-
λ^{+}	-	-	**0.0206**	**0.1755**
λ^{-}	-	-	0.0137	0.03
Observations	117	117	117	117
$\bar{R}^2$	0.972	0.980	0.978	0.966
Hansen J-test	3.893	9.205	9.632	4.967
	[0.421]	[0.001]	[0.000]	[0.113]
Cragg Donald Stat	21.52	23.85	56.17	11.65
	[0.000]	[0.002]	[0.210]	[0.548]

[a] See notes in Table 1.

Table 11: **GMM estimates with asset prices**[a]

	[1]	[2]	[3]	[4]
Constant	0.0264	**0.236***	**0.334****	0.0886
	(0.133)	(0.124)	(0.166)	(0.145)
i_{t-1}	**0.974*****	**0.898*****	**0.876*****	**0.928*****
	(0.0353)	(0.0344)	(0.0466)	(0.0360)
$(\pi - \pi^*)$	0.0421	-0.0737	-0.0243	-0.0271
	(0.0318)	(0.0499)	(0.0346)	(0.0460)
y	**0.0614****	**0.0968*****	**0.107*****	**0.0938*****
	(0.0276)	(0.0207)	(0.0258)	(0.0302)
Δm	0.0056	0.0206	0.0059	**0.0255****
	(0.0098)	(0.0130)	(0.0116)	(0.0121)
Δe	-0.0162	**-0.0252***	**-0.0292****	**-0.0334****
	(0.0146)	(0.0137)	(0.0140)	(0.0149)
s	0.0309	0.00921	-0.0268	0.0329
	(0.0283)	(0.0323)	(0.0386)	(0.0353)
Δa	0.00217	-0.0185	-0.0107	-0.0125
	(0.0012)	(0.0145)	(0.0117)	(0.0109)
Δo		**0.0015****		
		(0.0006)		
Δo^+			**0.0022****	
			(0.0009)	
Δo^-			-0.0034	
			(0.0031)	
$NOPI$				**0.0224****
				(0.0112)
$NOPD$				0.0087
				(0.0099)
Implied coefficients				
ρ	**0.974**	**0.898**	**0.876**	**0.928**
β	1.6192	-0.7225	-0.1959	-0.3764
γ	**2.3615**	**0.9490**	**0.8629**	**1.3028**
λ	-	**0.0147**	-	-
λ^+	-	-	**0.0177**	**0.3111**
λ^-	-	-	-0.0274	0.1208
Observations	117	117	117	117
$\bar{R}^2$	0.978	0.963	0.968	0.956
Hansen J-test	6.853	4.679	7.543	6.653
	[0.335]	[0.699]	[0.247]	[0.102]
Cragg Donald Stat	14.83	9.135	11.44	14.60
	[0.038]	[0.359]	[0.479]	[0.574]

[a] See notes in Table 1.

Table 12: **GMM estimates with interest rate spread with the U.S**[a]

	[1]	[2]	[3]	[4]
Constant	**0.0126****	0.0713	0.132	-0.0267
	(0.1153)	(0.108)	(0.117)	(0.120)
i_{t-1}	**0.9692*****	**0.962*****	**0.949*****	**0.978*****
	(0.0241)	(0.0223)	(0.0274)	(0.0263)
$(\pi - \pi^*)$	**0.0766***	0.0059	0.0256	**0.0767****
	(0.0393)	(0.0501)	(0.0486)	(0.0335)
y	**0.0588*****	**0.0576*****	**0.0699*****	**0.0535****
	(0.0160)	(0.0149)	(0.0179)	(0.0235)
Δm	0.0042	0.0072	-0.0021	0.0079
	(0.0095)	(0.0099)	(0.0091)	(0.0095)
us	**-0.0461*****	-0.0101	-0.0084	**-0.0432*****
	(0.0111)	(0.0189)	(0.0199)	(0.0142)
s	-0.0434	0.0092	-0.0099	0.0461
	(0.0317)	(0.0341)	(0.0368)	(0.0312)
Δo		0.0012		
		(0.0008)		
Δo^+			**0.0017***	
			(0.0010)	
Δo^-			-0.0015	
			(0.0023)	
$NOPI$				0.0021
				(0.0125)
$NOPD$				0.0050
				(0.0139)
Implied coefficients				
ρ	**0.969**	**0.962**	**0.949**	**0.978**
β	**2.488**	0.154	0.499	**3.474**
γ	**1.917**	**1.515**	**1.363**	**2.422**
λ	-	0.03		
λ^+	-		**0.033**	0.096
λ^-	-		-0.029	0.228
Observations	119	119	119	119
$\bar{R}^2$	0.979	0.980	0.979	0.979
Hansen J-test	6.445	10.06	13.24	8.261
	[0.265][b]	[37.34]	[0.067]	[0.220]
Cragg Donald Stat	13.009	6.982	3.313	0.534
	[0.000][c]	[0.000]	[0.000]	[0.337]

[a] See notes in Table 1.

Appendix C: Robustness checks for the Ordered Probit

Table 13: **Probit estimates with core inflation**[a]

	[1]	[2]	[3]	[4]
i_{t-1}	**-0.931*** **	**-0.909*** **	**-0.866** **	**-0.886** **
	(0.340)	(0.335)	(0.342)	(0.344)
Δi_{t-1}	0.0262	-0.0860	-0.103	-0.113
	(0.283)	(0.271)	(0.266)	(0.309)
$(\tilde{\pi}_{t-1})$	**-0.856** **	-0.562	-0.618	**-0.893** **
	(0.418)	(0.432)	(0.464)	(0.427)
y_{t-1}	**0.608*** **	**0.579*** **	**0.565*** **	**0.527*** **
	(0.177)	(0.180)	(0.186)	(0.192)
Δm_{t-1}	**0.168***	**0.173***	**0.192** **	**0.192** **
	(0.0930)	(0.0914)	(0.0962)	(0.0938)
Δe	**-0.0424***	**-0.0387***	**-0.0400***	**-0.0479** **
	(0.0225)	(0.0228)	(0.0228)	(0.0213)
s	-0.172	-0.228	-0.165	-0.196
	(0.320)	(0.303)	(0.317)	(0.323)
Δo		**0.0096***		
		(0.0056)		
Δo^{+}			0.0076	
			(0.0076)	
Δo^{-}			0.0155	
			(0.0132)	
NOPI				-0.0189
				(0.0316)
NOPD				0.0753
				(0.0501)
Observations	119	119	119	119
Pseudo-R^2	0.262	0.282	0.283	0.279
Log-Likelihood	-60.49	-58.87	-58.79	-59.09

[a] Standard errors are in brackets. ***, ** and * denote significance at the 1%, 5%, and 10% respectively.

[b] The pseudo-R^2 is the Mac Fadden R^2, which is appropriate to assess the quality of the estimation.

[c] LR statistic for testing the restricted model against the most general model.

Table 14: **Probit estimates with unemployment gap**[a]

	[1]	[2]	[3]	[4]
i_{t-1}	**-1.284*****	**-1.311*****	**-1.395*****	**-1.186*****
	(0.287)	(0.315)	(0.335)	(0.316)
Δi_{t-1}	0.528**	0.186	0.200	**0.466***
	(0.246)	(0.256)	(0.257)	(0.260)
$(\pi_{t-1} - \pi^*)$	0.146	-0.0351	-0.0097	0.125
	(0.273)	(0.302)	(0.309)	(0.275)
$U_{t-1} - U^*$	**-0.343*****	**-0.367*****	**-0.379*****	**-0.313*****
	(0.0833)	(0.0964)	(0.0951)	(0.0981)
Δm_{t-1}	**-0.212****	-0.0960	-0.120	**-0.179****
	(0.0875)	(0.0959)	(0.103)	(0.0868)
Δe	-0.0520	-0.0341	-0.0306	-0.0540
	(0.0535)	(0.0516)	(0.0518)	(0.0523)
s	**-0.801*****	**-0.803*****	**-0.900*****	**-0.758****
	(0.304)	(0.310)	(0.330)	(0.303)
Δo		**0.0190*****		
		(0.0042)		
Δo^+			**0.0213*****	
			(0.0058)	
Δo^-			0.0099	
			(0.0149)	
NOPI				0.0134
				(0.0314)
NOPD				0.0470
				(0.0429)
Observations	119	119	119	119
Pseudo-R^2	0.156	0.250	0.252	0.162
Log-Likelihood	-69.20	-61.48	-61.30	-68.67

[a] Standard errors are in brackets. ***, ** and * denote significance at the 1%, 5%, and 10% respectively.
[b] The pseudo-R^2 is the Mac Fadden R^2, which is appropriate to assess the quality of the estimation.
[c] LR statistic for testing the restricted model against the most general model.

Table 15: **Probit estimates with asset prices**[a]

	[1]	[2]	[3]	[4]
i_{t-1}	-0.264	-0.292	-0.340	**-0.663*** **
	(0.300)	(0.291)	(0.338)	(0.230)
Δi_{t-1}	-0.462	**-0.577***	**-0.563***	0.218
	(0.309)	(0.312)	(0.314)	(0.265)
$(\pi_{t-1} - \pi^*)$	0.591	0.423	0.433	-0.185
	(0.364)	(0.375)	(0.370)	(0.286)
y_{t-1}	**0.317***	**0.313***	0.328	**0.476*** **
	(0.182)	(0.188)	(0.200)	(0.160)
Δm_{t-1}	0.0203	0.0889	0.0780	-0.0027
	(0.0880)	(0.0937)	(0.0938)	(0.0781)
Δe	0.00157	0.0148	0.0170	-0.0709
	(0.0567)	(0.0564)	(0.0552)	(0.0505)
s	-0.177	-0.210	-0.267	-0.351
	(0.316)	(0.311)	(0.324)	(0.303)
Δa	**0.0508*** **	**0.0465*** **	**0.0468*** **	
	(0.0114)	(0.0122)	(0.0123)	
Δo		**0.0113** **		
		(0.00488)		
Δo^+			**0.0127** **	
			(0.0064)	
Δo^-			0.0062	
			(0.0151)	
NOPI				0.0059
				(0.0307)
NOPD				0.0581
				(0.0446)
	(1.401)	(1.371)	(1.504)	(1.094)
Observations	119	119	119	119
Pseudo-R^2	0.322	0.348	0.348	0.179
Log-Likelihood	-55.57	-53.46	-53.41	-67.29

[a] Standard errors are in brackets. ***, ** and * denote significance at the 1%, 5%, and 10% respectively.
[b] The pseudo-R^2 is the Mac Fadden R^2, which is appropriate to assess the quality of the estimation.
[c] LR statistic for testing the restricted model against the most general model.

Table 16: **Probit estimates with the interest rate spread with the U.S**[a]

	[1]	[2]	[3]	[4]
i_{t-1}	**-0.489****	**-0.505****	**-0.525****	**-0.459***
	(0.244)	(0.239)	(0.256)	(0.253)
Δi_{t-1}	-0.171	-0.275	-0.269	-0.206
	(0.325)	(0.314)	(0.312)	(0.336)
$(\pi_{t-1} - \pi^*)$	**0.809****	0.541	0.541	**0.791****
	(0.357)	(0.381)	(0.381)	(0.353)
y_{t-1}	**0.443*****	**0.438*****	**0.445*****	**0.411*****
	(0.138)	(0.144)	(0.152)	(0.159)
Δm_{t-1}	0.0740	0.128	0.124	0.0801
	(0.0892)	(0.0881)	(0.0916)	(0.0876)
us	**-0.618*****	**-0.529*****	**-0.526*****	**-0.610*****
	(0.133)	(0.154)	(0.154)	(0.134)
s	0.161	0.0478	0.0241	0.150
	(0.324)	(0.317)	(0.320)	(0.329)
Δo		**0.0107****		
		(0.0049)		
Δo^+			**0.0113***	
			(0.0064)	
Δo^-			0.0083	
			(0.0150)	
NOPI				0.000
				(0.0317)
NOPD				0.0376
				(0.0412)
Observations	119	119	119	119
Pseudo-R^2	0.291	0.314	0.314	0.294
Log-Likelihood	-58.14	-56.26	-56.25	-57.88

[a] Standard errors are in brackets. ***, ** and * denote significance at the 1%, 5%, and 10% respectively.

[b] The pseudo-R^2 is the Mac Fadden R^2, which is appropriate to assess the quality of the estimation.

[c] LR statistic for testing the restricted model against the most general model.

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