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Inflation, oil prices and exchange rates. The Euro's dampening effect

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Abstract

This paper aims to analyse the relationship between the euro/dollar exchange rate and oil prices and examine what effect this relationship had on the transmission of oil price fluctuations to headline inflation in the euro area since the currency's creation. We estimate an augmented Phillips curve including changes in oil price, through which we study the role of the exchange rate in oil price pass-through by using different specifications. The main findings reveal a positive relationship between the euro/dollar exchange rate and oil prices, such that an increase in the price of oil is followed by an appreciation in the euro. We also find that the transmission of oil price fluctuations to headline inflation in the euro area has been partially dampened by this appreciation in the euro/dollar exchange rate. These results do not hold for other economies with internationally relevant currencies, such as Japan and the United Kingdom. These findings have important implications for the implementation of monetary policy in the euro area in the face of oil price shocks.

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1. Introduction

The European Central Bank sets the inflation target for the euro area at 2% year-on-year[1] and uses two pillars of analysis to establish its monetary policy strategy: the economic analysis and the monetary analysis (ECB, 2011). In the economic analysis, the price of oil is one of the fundamental variables used to gauge the dynamics of inflation due to its influence on the cyclical variations of inflation in oil-importing countries (Blanchard & Gali, 2007; Forbes, Hjortsoe, & Nenova, 2018). Changes in the price of oil not only have a direct impact on inflation through the price of energy products but also generate indirect effects when they alter inflation expectations or when wages and capital are indexed to past inflation (Álvarez, Hurtado, Sánchez, & Thomas, 2011; Peersman & Van Robays, 2009).

Traditionally, the ECB has been very sensitive to changes in inflation caused by oil price shocks. Examples of this are its actions in July 2008 when, during the period of liquidity problems in the interbank market prior to the financial crisis, the ECB raised the reference rate by 25 basis points in response to soaring oil prices that reached 132 dollars per barrel; and when, in the midst of the euro area sovereign debt crisis, the interest rate was increased by 50 basis points due to the rise in inflation caused by commodities, including oil, even though core inflation was below the 2% target (Rostagno et al., 2019). These two examples, together with numerous statements by governors in relation to this issue (Trichet, 2006, 2007, 2008; Draghi, 2016) show the sensitivity of the European monetary authority to the inflationary pressures caused by fluctuations in the price of oil; hence, the importance of studying all the factors that affect the relationship between the price of oil and inflation.

The transmission of oil price shocks to inflation depends on several factors, such as the source of the oil price shock (Enders & Enders, 2017; Kilian, 2009), the phase of the business cycle (Donayre and Wilmot, 2016) or the inflationary environment in which the economy finds itself (Sekine, 2020; Garzon and Hierro, 2021). One of the factors affecting the relationship between the price of oil and inflation that has not been studied is the possible indirect effect through the impact of oil price changes on the exchange rate. If increased oil prices trigger a hike in the dollar, the effect on inflation would be amplified by the depreciation of the local currency, and vice-versa. Should the dollar depreciate vis-à-vis the local currency, the impact on inflation would be attenuated. Recent literature finds a positive relationship between the price of oil and the euro/dollar exchange rate (Reboredo, 2012; Thalassinos and Politis, 2012; Reboredo et al., 2014; Thurham et al., 2014), such that this dampening effect may be occurring in the euro area. Indeed, given that oil is traded internationally in dollars, any appreciation of the euro against the dollar will reduce the increase in the price of oil in euros. The impact of oil prices on inflation would thus be lower than if the exchange rate remained unchanged. In addition, an appreciation of the exchange rate generated by the increase in the price of oil may reduce the price of other imported goods invoiced in dollars, thereby generating deflationary pressures on these goods, which would also cushion the initial effect triggered by the rise in oil price.

Although many studies have explored the relationship between the price of oil and the exchange rate of different currencies (see Beckmann, Czudaj, & Arora, 2020 for a survey), its implications for the transmission of oil prices to inflation and for the implementation of monetary policy have received little attention. In this paper, we try to fill this gap by examining

[1] Since its Strategic Review in 2003, the ECB has targeted a year-on-year inflation rate below but close to 2%. Following its 2021 Strategic Review, the target has changed to a symmetric 2% year-on-year inflation rate.

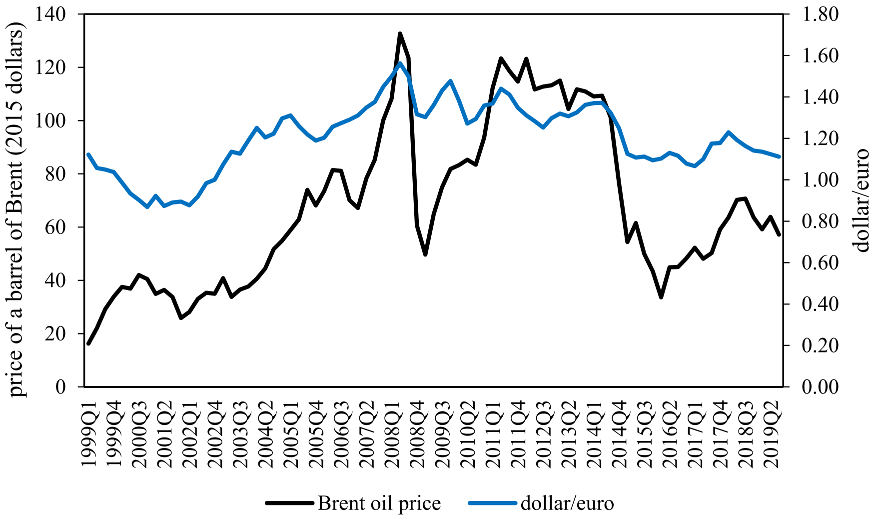

Figure 1. Quarterly evolution of Brent oil price and the dollar/euro exchange rate.
Source: U.S. Energy Information Administration and IMF International Financial Statistics.

the role played by the relationship between the price of oil and the exchange rate in the transmission of oil price changes to inflation in the euro area. This is key to correctly designing monetary policy reaction to oil price shocks.

Figure. 1 displays the evolution of the dollar/euro exchange rate and the Brent oil price, showing the positive relationship between the two variables mentioned above, such that an increase in the price of oil is accompanied by an appreciation of the euro vis-à-vis the dollar. This singularity is even more relevant if we take into account that studies exploring the relationship between oil price and the German mark's exchange rate, the strongest legacy currency of the euro, found a negative relationship between them, such that the mark depreciated in the face of a rise in international oil prices (Amano, Norden, & S, 1998a; Chaudhuri & Daniel, 1998; Chen & Chen, 2007). The same result is also found in Clostermann and Schnatz (2000), who analyse the relationship between oil prices and the exchange rate of a synthetic euro, built from the weighted values of the legacy currencies of the euro before its introduction.

The aim of this paper is to provide empirical evidence on the role of the exchange rate in the transmission of oil prices to inflation in the euro area and to test whether the single European currency has benefited or suffered in terms of the effect on inflation since its creation. For this purpose, based on an augmented Phillips curve framework, including oil price variations, we estimate the impact of the euro/dollar exchange rate on oil price-inflation pass-through using two complementary specifications: first, converting international oil prices into domestic currency, such that its fluctuations include contemporary exchange rate movements; and second, including the euro/dollar exchange rate in the augmented Phillips curve together with oil price fluctuations in dollar terms so as to control for the effects of exchange rate movements on inflation. Finally, we statistically compare the pass-through coefficients to test whether significant differences emerge when including the euro/dollar exchange rate. In addition, in order to consider the possibility of a time-varying relationship, we estimate the Phillips curve through rolling regressions. For comparative purposes, we also estimate the same specifications for the United Kingdom and Japan, two economies with highly internationally traded currencies (BIS,

2019) like the euro, and which therefore might have experienced a similar relationship with regard to oil prices.

The results obtained for the period spanning from 1999Q1 to 2019Q3 show that the euro/dollar exchange rate fluctuations have dampened oil price pass-through into the inflation rate. Thus, variations in the euro/dollar exchange rate are seen to have reduced the impact of oil prices on inflation in the euro area by around 15% during the period studied. Furthermore, this effect has been maintained throughout the period analysed, although it has intensified over time. These results contrast with those found for the United Kingdom and Japan, where no significant relationship was found to exist in terms of movements in their currency exchange rates vis-à-vis the dollar in oil price transmission to inflation.

These results have implications for monetary policy in the euro area. The ECB must consider the reaction of the euro/dollar exchange rate when quantifying the response of inflation to oil price shocks since, should it fail to do so, it might overreact, generating greater volatility in inflation and economic activity with its monetary policy decisions. At the same time, when the ECB analyses the response of inflation to fluctuations in the exchange rate in order to define its monetary policy stance, it must consider the source of the exchange rate fluctuation, in line with the recent literature on shock-dependent exchange rate pass-through (Shambaugh, 2008; Forbes, 2018), since if this is triggered by an increase in the price of oil, inflation will rise while the euro appreciates, showing a pass-through with the opposite sign to that expected after an exogenous exchange rate shock.

The remainder of the work is structured as follows: section 2 provides a review of the literature on the relationship between oil prices, exchange rates and inflation; section 3 explains the methodology and data used; section 4 presents the results, and section 5 discusses the implications for monetary policy, ending in section 6 with the main conclusions.

2. Literature review

Oil price shocks has traditionally had a significant effect on inflation (Brown, Oppedahl, & Yücel, 1995; Hamilton & Herrera, 2004; Hooker, 2002; Mork, 1994; Cuñado and Perez de Gracia, 2003). The channels through which fluctuations in oil prices are transmitted to inflation rates are diverse (Peersman and Van Robays, 2009). One direct effect stems from the transmission of oil prices to the prices of energy products geared towards consumption, within which petroleum products have an enormous weight. The indirect channel works through production input costs. Finally, when oil price fluctuations substantially alter inflation rates, second-round effects may appear, which are triggered by the inflationary spiral associated with income indexation to inflation (Peersman and Van Robays, 2009; Alvarez et al., 2011).

The empirical literature has found that the oil price pass-through into inflation has decreased over the last few decades, especially after the 1980 s (Clark & Terry, 2010; Herrera & Pesavento, 2009; Hooker, 2002; LeBlanc & Chinn, 2004). The main causes posited for this decline in transmission include: low oil consumption intensity (Blanchard & Gali, 2007; De Gregorio et al., 2007; Van de Noord and André, 2007; Choi, Furceri, Loungani, Mishra, & Poplawski-Ribeiro, 2018; Lyu, 2021), a reduction in wage indexation (Blanchard & Riggi, 2013), improved monetary policy (Blanchard & Gali, 2007; Chen, 2009; Choi et al., 2018), or a more stable inflation environment (De Gregorio et al., 2007; Van den Noord & André, 2007).

Nevertheless, two other explanations related to the objective of our work have also been put forward: a lower transmission of exchange rate fluctuations to inflation De Gregorio et al., 2007 and an appreciation of domestic currency exchange rates (Chen, 2009). Indeed, in addition to the aforementioned transmission channels, an additional transmission channel arises due to the fact that fluctuations in oil price may also affect inflation through its impact on the exchange rate. Oil is invoiced in dollars and may therefore affect the exchange rate of other currencies. In fact, there are multiple studies that have analysed the existence of a relationship between the dollar exchange rate and the price of oil (see Beckman et al., 2020).

Since the dollar is the denomination currency of oil prices, many studies have explored the relationship between the price of oil and the dollar's effective exchange rate. Coudert and Mignon (2016) show that a structural break in this relationship occurred in the mid-2000 s. Prior to this date, a positive relationship between the two variables was found; that is, an increase in oil prices was correlated with an appreciation of the dollar (Amano & Van Norden, 1998b; Bénassy-Quéré, Mignon, & Penot, 2007; Coudert, Mignon, & Penot, 2007). However, more recent studies, which include the subsequent period, have found that a depreciation of the dollar is related to a rise in oil prices (Beckmann & Czudaj, 2013b; McLeod & Haughton, 2018).

Beckmann & Czudaj (2013a) consider it more appropriate to analyse the relationship between oil prices and each country's bilateral exchange rate, since this may provide more information. When studying the relationship between bilateral exchange rates and the price of oil, the main result found is a positive relationship between exchange rates against the dollar and the price of oil (Reboredo, 2012; Aloui et al., 2013; Reboredo et al., 2014; Chen et al., 2016; Su et al., 2016; Yang et al., 2018) that has intensified since the Great Recession (Reboredo, 2012; Reboredo et al., 2014; Malik and Umar, 2019), although certain works do find a negative relationship for the exchange rates of some importing countries (Lizardo & Mollick, 2010; Beckman et al., 2016). Other studies suggest the existence of asymmetric (Ahmad & Hernandez, 2013; Atems, Kapper, & Lam, 2015; Beckmann et al., 2016) and non-linear relationships (Basher, Haug, & Sadorsky, 2016; Su et al., 2016) between the exchange rate and oil prices. As regards the causal relationship, some studies indicate that this runs from oil prices to exchange rates (Atems et al., 2015; Basher et al., 2016), while others find the opposite relation (Beckmann and Czudaj, 2013a; Jawadi, Louhichi, Ameur, & Cheffou, 2016). In the case of the euro, most of the literature (Zhang et al., 2008; Thalassinos and Politis, 2012; Aloui et al., 2013; Reboredo et al., 2014; Beckmann and Czudaj, 2013b; Su et al., 2016; Yang et al., 2018; Mollick and Sakaki, 2019) agrees that an increase in oil prices is related to a depreciation of the dollar against the euro.

On the other hand, the effect of exchange rate fluctuations on the transmission of oil prices to inflation also depends on the degree of transmission of exchange rate fluctuations to consumer prices. Exchange rate transmission to inflation has also decreased since the 1980 s in advanced countries, a fact linked to greater price stability (Taylor, 2000; Choudhri and Hakura, 2006; Shintani et al., 2013) resulting from a more effective monetary policy (Gagnon and Ihrig, 2004). Marazzi et al. (2005) suggest that part of the exchange rate transmission to inflation occurs through commodity prices, such that the lower pass-through observed since the 1980 s, in the case of the US, is due to a lower share of imports of products that are intensive in the use of commodities. However, for euro area countries, several works show that there has been no reduction in this transmission since the introduction of the euro (Campa & Goldberg, 2005; Campa & Mínguez, 2006; Cheikh & Rault, 2016). Finally, recent literature suggests that many exchange rate fluctuations are not exogenous, such that the degree of transmission of exchange rate fluctuations to inflation also depends on the source triggering the exchange rate movements (Forbes et al., 2018, Ha et al., 2020; García-Cicco and Garcia-Schmidt, 2020). In euro area countries, it is monetary policy and exchange rate shocks that cause a higher transmission to prices (Comunale & Kunovac, 2017). However, these papers do not analyse the transmission of exchange rate fluctuations caused by oil price shocks.

The literature review highlights the lack of empirical studies exploring the role of the exchange rate in the transmission of oil prices to inflation in the euro area and whether the single European currency might have proved beneficial or harmful in terms of the effects on inflation for member countries.

3. Methodology and data

3.1. Methodology

We base our empirical work on an augmented Philips curve, where oil price fluctuations are included:

$$\pi_t = \beta E_t \pi_{t+1} + \gamma gap_t + \theta_1(L) Poil^{\$}{}_t + \epsilon_t \tag{1}$$

where π_t represents the inflation rate, $E_t\pi_{t+1}$ represents expectations of future inflation, gap_t is a measure of the slack in the economy, $Poil_t{}^{\$}$ represents oil price variations in dollars, (L) is the polynomial lag operator, and ϵ_t is the error term (iid). To empirically analyse the final effect of oil price fluctuations on importing countries, as is the case of the euro area, we replace the price of oil in dollars with the price of oil in domestic currency. Equation (1) is thus transformed into the following formula:

$$\pi_t = \beta E_t \pi_{t+1} + \gamma gap_t + \theta_2(L) Poil^{dom}{}_t + \epsilon_t \tag{2}$$

where $Poil_t{}^{dom}$ represents oil price fluctuations in domestic currency. Changes in the price of oil in domestic currency can be separated into fluctuations in the price of oil in dollars and fluctuations in the currency exchange rate against the dollar: $Poil^{dom}{}_t = Poil^{\$}{}_t + er_t$, where er_t is the variation of the exchange rate against the dollar, such that an increase in er_t corresponds to a depreciation of the currency against the dollar. In this way, we can rewrite our augmented Phillips curve as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \gamma gap_t + \theta_2(L)(Poil^{\$}{}_t + er_t) + \epsilon_t \tag{3}$$

The impact of oil price movements on inflation thus occurs both through fluctuations in the international price of oil, in dollars, as well as through fluctuations in the exchange rate that occur at the same time. If a positive relationship between the price of oil in dollars and the currency exchange rate against the dollar exists, such that an increase in $Poil^{\$}$ is followed by a decrease in er_t, fluctuations in $Poil_t{}^{dom}$ would be softened. If this relationship holds, then $\theta_2 > \theta_1$, since the transmission of oil price movements is reduced by the appreciation of the currency against the dollar.

In this paper, we study this relationship for the role played by the euro in the transmission of oil prices to inflation in the euro area. We estimate the following specification, based on the Phillips curve framework with backward-looking expectations, as described above:

$$\pi_t = \alpha + \beta E_t \pi_{t+1} + \gamma (y_t - \bar{y}_t)/\bar{y}_t + \sum_{i=0}^{4} \theta_i Poil^{\$}{}_{t-i} + VAT_t + \epsilon_t \tag{4}$$

where π_t is the quarterly inflation rate, seasonally adjusted, y_t is real GDP, seasonally adjusted, and $\bar{y}_t$ is potential GDP, such that $(y_t - \bar{y}_t)/\bar{y}_t$ represents the output gap. $Poil^{\$}{}_t$ is the percentage change in the price of oil, expressed in dollars. We include this variable with four lags so that we can estimate the long-run pass-through, following other works such as Lablanc and Chinn (2004) and De Gregorio et al., 2007. VAT_t is a dummy variable which takes the value 1 for periods when value added tax (VAT) are raised. $E_t\pi_{t+1}$ represents the expected future inflation in the current period. Following Ball and Mazumder (2011)) and Coibion and Gorodnichenko (2015), we calculate the backward-looking expectations as the average inflation rate for the past four quarters.

To analyse the final impact of oil prices on inflation, controlling for the impact of the exchange rate, we first substitute the price of oil in dollars for the price in domestic currency. Finally, we estimate a third specification, in which we include the price of oil in dollars and add the exchange rate fluctuations in order to control for the impact of exchange rate fluctuations transmitted through oil price fluctuations and, additionally, estimate the exchange rate pass-through into inflation. The specification is as follows:

$$\pi_t = \alpha + \beta E_t\pi_{t+1} + \gamma(y_t - \bar{y}_t)/\bar{y}_t + \sum_{i=0}^{4}\theta_i Poil^{\$}{}_{t-i} + \sum_{i=0}^{4}\delta_i er_{t-i} + VAT_t + \epsilon_t \tag{5}$$

where θ_1 and δ_1 represent short-run oil prices and exchange rate pass-through into inflation, respectively. The long-run pass-through of oil prices and exchange rate are represented by $\varnothing$ and φ, respectively:

$$\varnothing = \frac{\sum_{i=0}^{4}\theta_i}{1-\beta};\varphi = \frac{\sum_{i=0}^{4}\delta_i}{1-\beta} \tag{6}$$

Finally, we compare the coefficients of the contemporary transmission of oil price to inflation between the baseline model and the augmented model with the exchange rate. Using the test developed by Clogg, Petkova, and Haritou (1995), we test whether the coefficients are statistically different. The rejection of the null hypothesis of equality of the coefficients means that when the exchange rate is included as a control variable the coefficients of the transmission of oil prices in dollars change substantially, implying that the exchange rate affects this transmission.

To test the robustness of the results, we made some modifications to the model specification. First, we replace the output gap with the unemployment gap, as a measure of the slack in the labour market and price pressure. Secondly, we replace the backward-looking expectations, represented by the average inflation rate of the past four quarters, by the inflation rate of the past four quarters individually, which better represents the inertia of inflation (Gordon, 1997, 2011). Inflation persistence or inertia is estimated as the sum of the four individual coefficients of past inflation rates. Finally, McLeay and Tenreyro (2020) suggest the presence of endogeneity caused by the simultaneity, which arise between the inflation rate and the output gap measures. If monetary policy reacts endogenously, stabilizing both the output gap and the deviation of inflation from its target, and its targeting rule reacts to changes in the inflation rate induced by cost-push shocks, the estimated relationship between inflation and the output gap will be underestimated by the reduced-form Phillips curve. Even though the inclusion of variables capturing cost-push shocks, such as fluctuations in oil prices, improves the estimation of this relationship and reduces the implicit bias, we additionally estimate the initial model trough the GMM estimator, in order to correctly identified the exogenous changes of the output gap and address the presence of endogeneity. Following Fitzgerald and Nicolini (2014), we use four lags of the output gap as instruments, as well as the rest of exogenous variables previously included in the model.

The preceding methodology is also applied to Japan and the United Kingdom in order to assess whether there are substantial differences in behaviour in the transmission of oil prices to inflation. We select these two countries because their currencies, the yen and the pound, are the third and fourth most traded currencies in the world, after the dollar and the euro (Bank for International Settlements BIS, 2019).

3.2. Data

We use quarterly data, spanning a period from 1999Q1 to 2019Q3. For the inflation rate π_t, the quarterly variation of the seasonally adjusted Harmonized Consumer Price Index (HICP) is used. To calculate the output gap, $(y_t - \bar{y}_t)/\bar{y}_t$, we calculate the potential GDP $\bar{y}$ applying the Hodrick-Prescott filter to the seasonally adjusted real GDP, $\bar{y}$. For the unemployment gap, $(u_t - \bar{u}_t)/\bar{u}_t$, we also apply the Hodrick-Prescott filter to the seasonally adjusted unemployment rate, u_t, to obtain the natural rate of unemployment $\bar{u}_t$. The variation in the exchange rate, er_t is defined as the percentage variation of the bilateral currency exchange rate against the dollar, expressed in unit of domestic currency per dollar. Finally, for the price of oil in dollars, $Poil^{\$}{}_t$ we use the dollar price of a barrel of Brent oil, in nominal dollars, while we obtain the price of oil in domestic currency, $Poil^{dom}{}_t$ by multiplying the latter by the already defined domestic currency/dollar exchange rate. Both variables are expressed in percentage variations. Data has been obtained from Eurostat, OCDE, IMF and U.S. Energy Information Administration.

4. Results

Table 1 shows the estimates of the augmented Phillips curve, estimated through OLS with HAC robust standard errors using the Newey-West estimator.

Columns 1–3 in Table 1 show the estimate of the baseline model. In the case of the euro area, the coefficient of inflation expectations is found to be positive and significant. In addition, the output gap shows a positive and significant relationship with the inflation rate, in line with the Phillips curve theory. As regards oil price in dollars, a significant contemporary effect on inflation is seen to exist, such that a 1% increase in the price of oil increases the quarterly inflation rate by 0.0156% points. In the long run, a 1% increase in the price of oil triggers an increase of 0.0317% in prices. In the case of the United Kingdom and Japan, the short-run pass-through is lower. The long-run pass-through is higher in the United Kingdom, whereas in Japan it is lower and not significant.

The estimate of the model where the price of oil in dollars is replaced by the price of oil in domestic currency (Column 4–6) show that, in the case of the euro area, the persistence of inflation is higher than in the baseline model. With regard to the relation between the output gap and inflation, the coefficient remains similar to that estimated in column 1. On the other hand, the price of oil has a greater impact on the inflation rate when expressed in euros. The short-run transmission of a 1% increase is 0.0182% points, while the long-run pass-through is 0.0391. This implies that the transmission of increases in the international price of oil (invoiced in dollars) is dampened as a result of the appreciation of the euro against the dollar. Unlike what happens in the euro area, the transmission of oil prices in domestic currency in the United Kingdom and Japan does not differ significantly with respect to that estimated in the baseline model.

Table 1
Estimates of the augmented Phillips curve with the output gap (1999Q1–2019Q3.

	Baseline model			Oil prices in domestic currency			Augmented model		
	Euro area	**UK**	**Japan**	**Euro area**	**UK**	**Japan**	**Euro area**	**UK**	**Japan**
$E_t\pi_{t+1}$	0.3604 **	0.5682 ***	0.3366 ***	0.5102 ***	0.5409 ***	0.3441 ***	0.5346 ***	0.5531 ***	0.3512 ***
	(0.010)	(0.000)	(0.009)	(0.000)	(0.000)	(0.007)	(0.000)	(0.000)	(0.008)
$(y_t - \bar{y}_t)/\bar{y}_t$	0.0666 ***	0.0150 (0.674)	0.0853 ***	0.0679 ***	0.0120 (0.710)	0.0752 ***	0.0677 ***	0.0326 (0.301)	0.0633 **
	(0.000)		(0.001)	(0.000)		(0.003)	(0.000)		(0.027)
$Poil^{\$}_t$	0.0156 ***	0.0101 ***	0.0052 ***				0.0185 ***	0.0110 ***	0.0059 ***
	(0.000)	(0.000)	(0.003)				(0.000)	(0.000)	(0.001)
$Poil^{dom}_t$				0.0182 ***	0.0115 ***	0.0056 ***			
				(0.000)	(0.000)	(0.002)			
er_t							0.0244 ***	0.0074 (0.374)	0.0028
							(0.001)		(0.748)
$\varnothing$	0.0317 ***	0.0411 ***	0.0137 (0.114)	0.0391 ***	0.0456 (0.000)	0.0168 *	0.0397 ***	0.0523 ***	0.0213 *
	(0.000)	(0.001)		(0.000)		(0.092)	(0.000)	(0.000)	(0.058)
φ							0.0460 (0.231)	0.1048 ***	0.0357
								(0.003)	(0.210)
R2	0.7646	0.6185	0.5916	0.8148	0.6201	0.5929	0.8198	0.6863	0.6072
Adjusted R2	0.7410	0.5743	0.5443	0.7963	0.5761	0.5457	0.7866	0.6226	0.5274
F-statistic	32.4766 ***	13.9849 ***	12.4953 ***	43.9970 ***	14.0811 ***	12.5593 ***	24.6454 ***	10.7695 ***	7.6105 ***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
d							-0.0028 * **	-0.0007	-0.0007
t							-2.8071	-0.4247	-1.5279
p-value							0.006	0.672	0.131

Source: authors' own compilation. Note: * , * *, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively. p-values in parenthesis. HAC robust standard errors through the Newey-West estimator. $d = \theta_0^{base} - \theta_0^{aum}$ represents the difference between the coefficients of $Poil^{\$}_t$ in the baseline model and the augmented model, $t = d/s(d)$ is the t-student statistic and $s(d)$ is the standard deviation of d (see Clogg et al., 1995).

Finally, we estimate the augmented model where the exchange rate and the price of oil are included simultaneously, which allows us to compare the coefficients of the pass-through estimated in columns 1–3 and 7–9, and therefore, estimate the direct effect of oil price on inflation. For the euro area, the results evidence a coefficient that is very similar to those found in the model using oil prices in domestic currency. The short-run oil pass-through is 0.0185% points in the inflation rate, reaching a long-run pass-through of 0.0397. This coefficient is higher than that found in the baseline model, whose short-run and long-run pass-through are 0.0156 and 0.0317, respectively. In order to determine whether these differences are statistically significant, we performed the test developed by Clogg et al. (1995). This test is calculated for the contemporary effect of oil prices on inflation, and the results allow us to reject the null hypothesis of coefficient equality at a 1% level. Finally, fluctuations in the exchange rate also have a significant impact on inflation, such that a 1% appreciation of the euro against the dollar (which corresponds to a decrease in er_t) reduces the inflation rate by 0.0244% points, with a long-run impact of 0.046.

In the case of the United Kingdom and Japan, the differences in the contemporary pass-through coefficients between the baseline and augmented model are found to be non-significant, which means that the variations in the exchange rate have not softened the impact of oil prices on inflation in these countries.

4.1. Alternative specifications

To test the robustness of the results, we estimate three alternative specifications. We first replace the output gap by the unemployment gap as a measure of slack in the labour market. Second, we use an additional specification where backward-looking expectations are replaced by inflation inertia. For this, we include the inflation rates of the past four quarters individually in the Phillips curve. Finally, in order to take into account the possible existence of endogeneity in the Phillips curve due to the relationship between inflation and the output gap, we estimate the Phillips curve specified above through the GMM estimator.

The results of the alternative estimates are in line with those found in the benchmark specification.[2] Oil price pass-through as well as the effect of exchange rate fluctuations in this transmission shows very similar coefficients, allowing us to conclude that our findings do not depend on the specification of the model.

4.2. Has the relationship varied over time?

It has been argued that the oil price-exchange rate relationship has intensified since the onset of the Great Recession (Reboredo, 2012; Reboredo et al., 2014; Malik and Umar, 2019). Furthermore, Coudert and Mignon (2016) found a structural break in the relationship between the US dollar and oil prices in the mid-2000 s, which later turned negative. In this section, we examine whether the role of the exchange rate in oil price pass-through into inflation has changed during the period under analysis. For this purpose, we estimate rolling regressions of the baseline and augmented specifications using a ten-year window (40 quarters), following Marazzi et al. (2005), such that the number of observations is enough to adequately estimate the parameters of our model. Figure 2 shows the time-varying oil price pass-through into inflation

[2] These results are available from the authors upon request.

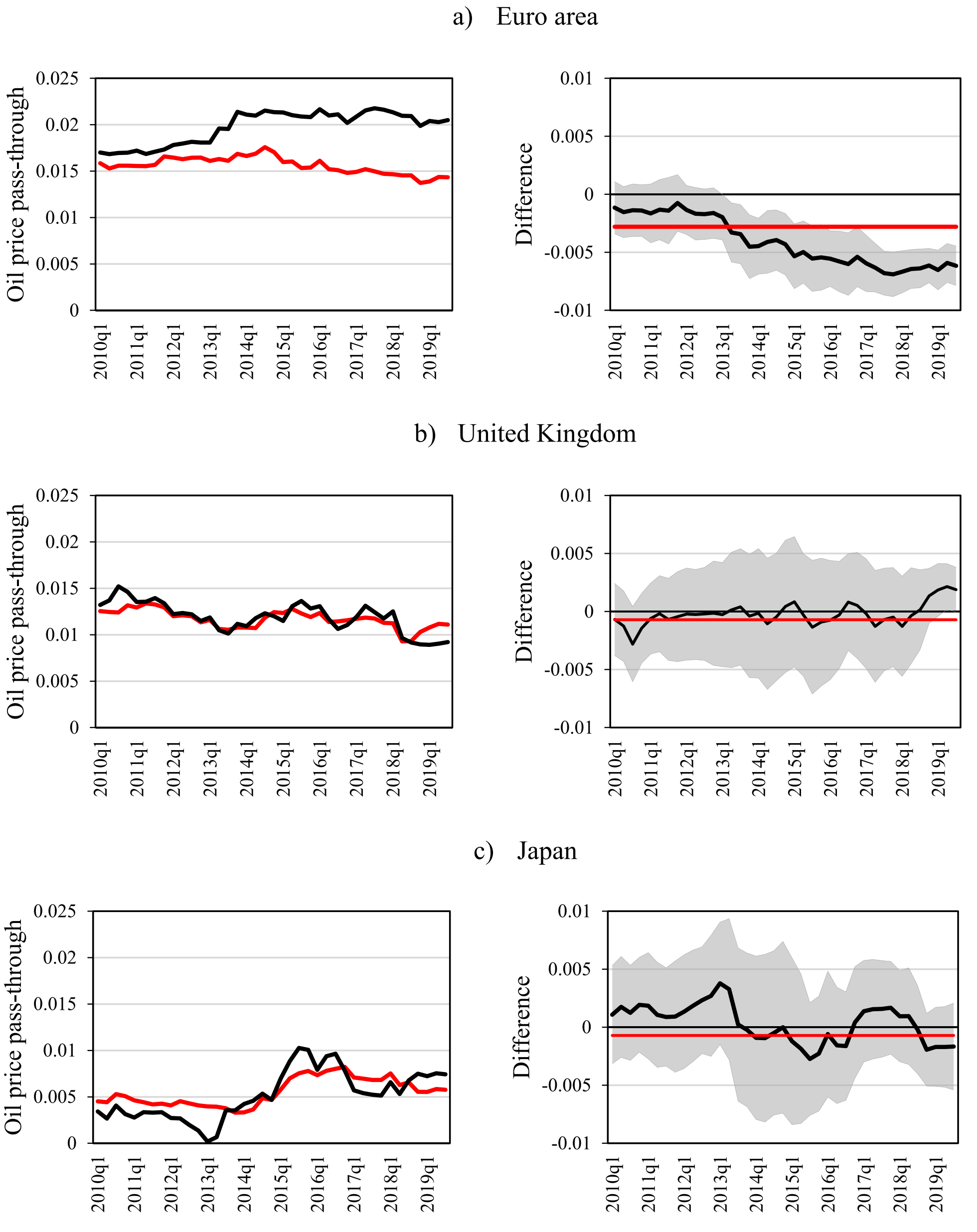

Figure 2. Ten year rolling-window estimates of contemporaneous oil price pass-through to inflation in the baseline and in the augmented model. Column 1 shows the time varying oil price pass-through. The red line represents the time varying pass-through in the baseline model. The black line represents pass-through in the augmented model. Column 2 shows the differences in the time varying pass-through. The black line represents the time-varying differences in pass-through. The shaded areas represent the 95% confidence bands for the time-varying differences in pass-through. The red line represents the average difference in the time-invariant pass-through estimated in section 4. The date on the x-axis represents the end of the rolling sample.

estimated in the baseline model and in the augmented model in which we control for the effect of exchange rate fluctuations, as well as the evolution of the difference in oil price pass-through between the baseline and the augmented model, as described in Section 3, which represents the effect of the exchange rate on the transmission of oil price fluctuations to inflation.

The results displayed in Figure 2 show that, for the euro area, oil price pass-through remained fairly stable over the whole sample, while the role of the exchange rate in the transmission of oil prices to inflation has always been negative: in other words, it has reduced the pass-through, although its effect has intensified over time. At the beginning of the period, the effect of exchange rate fluctuations on oil price pass-through is not statistically significant. This period corresponds to the rolling samples which include the period 2000–2003, when the relationship between the euro/dollar exchange rate and oil prices was found to be negative in previous works. However, its effect increases over time, and is higher than the average effect we found in the time-invariant estimates. The increasing role of the exchange rate commences around the mid-2000 s, coinciding with the date when other works set the structural break in the relationship between the euro/dollar exchange rate and oil prices (Coudert & Mignon, 2016). In the same vein, these results support the fact that the correlation between oil prices and the euro/dollar exchange rate has intensified since the Great Recession. In contrast, we find that the role played by the exchange rate in the transmission of oil prices in the United Kingdom and Japan was not statistically significant over the whole period.

5. Implications for monetary policy

The results of this paper show the importance of taking into account the reaction of the exchange rate to changes in the price of oil when analysing their impact on inflation, since the existence of a relationship between the exchange rate and the price of oil distorts the evaluation of the total impact of oil price shocks on inflation in the euro zone in quantitative terms.

Interest in this issue is greater the higher the sensitivity of the monetary authority to oil price shocks and the exchange rate. This is the case of the ECB. The ECB has been very sensitive to changes in the price of oil. Statements by ECB presidents regarding this issue (Trichet, 2006, 2008; Draghi, 2016) show how the European monetary authority is especially sensitive to inflation generated by fluctuations in the price of oil and that it has reacted with changes in its monetary policy stance in the face of oil shocks, even in situations in which economic circumstances advised against it (Rostagno et al., 2019).

ECB sensitivity to the price of oil has been based on the fact that it has set its inflation target numerically at 2%, which makes cyclical variations in inflation crucial when setting monetary policy. Variations in the price of oil have a direct impact on inflation through the price of energy products and generate indirect effects when they affect inflation expectations or if wages and capital income are indexed to past inflation and produce cyclical variations in inflation. These cyclical variations in inflation in oil-importing countries, such as euro area countries, (Blanchard & Galí, 2007; Forbes et al., 2018) stem from fluctuations in the price of oil, thus making this a key variable in the pillar of the economic analysis that supports ECB monetary policy (ECB, 2011).

Given the relevance of oil price in the ECB's decision making, it is essential to fine-tune the estimation of the effects of oil price shocks on inflation and to take into account circumstances such as variations in oil price that alter the euro exchange rate. Fine-tuning the ECB's monetary policy reactions depends on this.

According to our estimates, the appreciation of the euro associated with the impact of oil prices on the euro/dollar rate reduces by some 15% the impact of changes in the price of oil on inflation that would occur if the exchange rate remained constant. As a consequence of this, the ECB, which is responsible for the monetary policy of the euro area, must take into account this impact when reacting to increases in inflation caused by the price of oil. Raising interest rates in an effort to reduce inflationary pressure may lead to the euro appreciating even more and, therefore, trigger a higher than estimated reaction as a result of the deflationary pressure on other imported goods invoiced in dollars, which can be reflected in the inflation rate and generate greater macroeconomic volatility.

Another relevant issue to be considered by the monetary authority is that the relationship between the price of oil and the euro/dollar exchange rate is not stable over time. Economic circumstances affect the relationship, as evidenced by the fact that the relationship has intensified since the mid-2000 s (Bénassy-Quéré et al., 2007; Coudert & Mignon, 2016), particularly after the Great Recession (Reboredo, 2012). The origin of these changes and their permanence over time is a matter to be studied and may be related to variations in the financial and commercial flows of oil-exporting countries.

We find no dampening effect on the yen, in the case of Japan, or on the pound, for the United Kingdom. However, our study does not cover other currencies, which is why other central banks should take into account the European case and examine their currency's relationship with the price of oil in order to pinpoint any possible dampening or amplifying effects of the exchange rates of their currencies.

The relationship between the price of oil, the exchange rate and inflation must also be considered when the monetary authority adjusts monetary policy to changes in the exchange rate. The recent literature on the shock-dependent exchange rate pass-through to inflation (Shambaugh, 2008; Comunale et al., 2017; Forbes, 2018; García-Cicco and García-Schmidt, 2020; Ha et al., 2020; Corbo and Di Casola, 2022) shows that there may be responses of inflation contrary to those expected, depending on the shock triggering the exchange rate fluctuation. Our results show that in the face of an increase in the price of oil, inflation rises at the same time as the exchange rate of the euro against the dollar appreciates. In other words, the partial cushioning effect of exchange rate changes in the face of oil price shocks causes the exchange rate pass-through to inflation to show a sign contrary to what is expected. This means that in order to correctly define monetary policy, the central bank, in its future inflation projections, must consider fluctuations in the exchange rate based on the shock that caused it. This implies that in the case of the ECB it should not consider changes in the exchange rate as exogenous when they are caused by oil price shocks, since inflation would evolve in the opposite direction.

6. Conclusions

This work focuses on exploring the role played by fluctuations in the bilateral exchange rate of the euro against the dollar in the transmission of oil prices to inflation in the euro area. We analyse the transmission of changes in oil prices in headline inflation and the indirect effect of the euro/dollar exchange rate in the euro area for the period between 1999Q1 and 2019Q3 by estimating an augmented Phillips curve. Furthermore, we estimate the same model for Japan and the United Kingdom so as to compare the effect of the euro to that of other highly relevant international currencies. Results show that, during the period studied, the transmission of oil prices in the euro area is significantly higher after controlling for the impact of the exchange rate. In other words, the euro/dollar exchange rate has a negative indirect effect on inflation. This implies that an increase in the price of oil in dollars is followed by an appreciation of the euro against the dollar, which makes the barrel of oil cheaper in the domestic currency.

As a consequence, fluctuations in the euro/dollar exchange rate partially dampen the impact of changes in the dollar price of oil on inflation. According to our estimates, the exchange rate reduces dollar oil price pass-through into inflation by about 15% in the euro area. Chen (2009) suggests that the appreciation of domestic currencies against the dollar may have contributed to a lower oil price pass-through. However, this dampening effect is found neither in the Japanese yen nor in the British pound. Therefore, the dampening effect of the exchange rate on the transmission of oil prices appears as a singularity shown by the euro, and not as a general relationship between the main international currencies and the dollar.

Furthermore, our findings show that the euro's dampening effect has intensified throughout the period. This can be explained by the fact that the positive relationship between the oil prices and the euro/dollar exchange rate appears from the mid-2000 s onwards (Bénassy-Quéré et al., 2007; Coudert & Mignon, 2016). Previously, the relationship between the euro/dollar exchange rate (expressed as the weighted average of the legacy currencies of the euro) and the price of oil was found to be negative (Bénassy-Quéré et al., 2007; Clostermann & Schnatz, 2000). One possible explanation for this break is the emergence of the euro as an international currency, such that a share of the financial and trade flows of the oil-exporting countries shifted towards assets and goods denominated in euros, giving rise to a positive relationship between oil revenues and the euro/dollar exchange rate.

In sum, the euro has acted as a buffer against the impact of oil prices on inflation in the euro area, since its appreciation has reduced the oil bill in domestic currency. This fact has implications for monetary policy, since the price of oil, as well as the exchange rate, are relevant variables for the economic analysis of the ECB's monetary policy (ECB, 2011).

Declaration of competing interest

None.

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