Instituto Complutense de Análisis Económico

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Ligia Topan
Departamento de Análisis Económico y Economía Cuantitativa,
Instituto Complutense de Análisis Económico,
Universidad Complutense de Madrid

Miguel Jerez
Departamento de Análisis Económico y Economía Cuantitativa,
Instituto Complutense de Análisis Económico,
Universidad Complutense de Madrid

Sonia Sotoca
Departamento de Análisis Económico y Economía Cuantitativa,
Instituto Complutense de Análisis Económico,
Universidad Complutense de Madrid

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The impact of oil prices on products groups inflation: is the effect asymmetric?

Ligia Topan*[2], Miguel Jerez†[2], and Sonia Sotoca‡[2]

[2]Department of Economic Analysis II, Universidad Complutense de Madrid, Spain

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Abstract

In this paper we assess the oil price pass-through into both, the global inflation in Spain and the inflation derived from the non-deterministic prices of the standard European classification of product groups, during the period 2002-2018. To this end we fit a transfer function to inflation in each group, extended to allow for an asymmetry in the transmission of positive/negative oil cost shocks, that is, a "rockets and feathers effect". Our results show that most often there is a significant asymmetry, which can be explained by the degree of competition in each market.

Keywords: oil price, products groups inflation, asymmetric effects, transfer function.

1 Introduction

Many studies test for asymmetric effects of oil price shocks. Some of them investigate their effect on macroeconomic and financial activity, while others concentrate in the pass-through of oil cost into gasoline price. The presence of asymmetry in the latter case is known as "rockets and feathers" effect.

The effect of these shocks on macroeconomic and financial activity has been investigated by Dhaoui et al. (2018), who show an asymmetric long-run impact of oil prices on the stock markets of Poland, the US and Austria. Huang et al. (2017) discuss whether an oil price shock could have an asymmetric response by the stock market in China. They conclude that there is no such effect. Gately and Huntington (2001) estimated the effects on energy and oil demand of changes in income and oil prices, for

*Corresponding author. E-mail: ligiatop@ucm.es
†E-mail: mjerezme@ucm.es
‡E-mail: sotoca@ccee.ucm.es

96 of the largest countries in the world. They found that oil demand often reacts more to increases in oil prices than to decreases. Rahman and Serletis (2010) investigate the asymmetric effects of oil price shocks and monetary policy on macroeconomic activity in the United States. They find that oil price volatility is a major determinant of the US macroeconomic activity, with a stronger effect on output growth in the high-volatility regime of oil price than in the low volatility regime. Moshiri (2015) results indicate that positive and negative oil price shocks generate asymmetric and heterogeneous effects on GDP growth across oil-exporting countries. Donayre and Wilmot (2016) show that inflation evolves differently after positive and negative oil price shocks in Canada. In particular, the reduction in inflation due to a negative oil price shock is larger than the increase in inflation after a positive innovation. Rahman and Serletis (2011) show, with US data, that increased uncertainty about changes in the real oil price are associated with a lower average growth rate of real economic activity. Finally, Alvarez et al. (2011) assesses the impact of oil price changes on Spanish and euro area consumer price inflation. Their results show that the inflationary effect of oil price changes in both economies is limited, even though crude oil price fluctuations are a major driver of inflation variability.

The literature about the effect of oil price shocks on gasoline prices builds on the seminal paper by Bacon (1991), who coined the term “rockets and feathers”. This expression means that gasoline prices tend to shoot up “as rockets” when oil prices increase, but usually fall “like feathers” when crude costs go down. Kristoufek and Lunackova (2015) re-investigated this effect in a framework considering fractional integration, long-term memory and borderline (non)stationarity, for seven developed countries, finding no statistical evidence of asymmetry. Radchenko (2005), detected a significant asymmetric transfer of oil price variations on gasoline prices, perhaps due to the market power of large retailers in U.S. Tappata (2009) and Lewis and Marvel (2011) focus on the demand side of the market. They argue that the explanation of the “rockets and feathers” effect is that the consumers search “the best deal” less intensively when the gasoline price is going down than when is raising. Last, Borenstein and Shepard (2002) argue that wholesale gasoline prices respond with a lag to cost shocks because it is costly for firms to adjust production and inventory.

Therefore, there is a large literature about the potentially asymmetric effects of oil price shocks on the macroeconomic activity, in general, and gasoline prices in particular. However, studies about the sensitivity of product group prices to crude costs are lacking. In this paper we will analyze this sensitivity and will test whether the response to positive and negative shocks is roughly the same.

Our main objectives are: (a) building econometric models for the total inflation and products groups inflation in Spain as a function of oil prices; (b) obtaining a quantitative measure of the potential asymmetries between positive and negative shocks in oil prices, and (c) using the estimated models to compute the oil price pass-through into inflation and analyze possible inter-groups asymmetries.

In “rockets and feathers” studies, it is frequent to use a VAR-error correction framework (Engle and Granger, 1987). Despite this, we opted for an alternative approach based on transfer function models (Box et al., 2015). There are two reasons for this choice. First, we will be working with seasonal time series, for which transfer function models with ARIMA errors are better suited. Second, the transfer function assumes unidirectional causality and allows for instantaneous relation parameters. Both features are adequate in our case because: (a) Spanish inflation and oil prices show unidirectional dynamic (Granger) causality from the former variable to the latter, with no significant feedback, and (b) the instantaneous correlation between inflation and oil cost can be safely attributed to the same causal relationship, as Spain is a rather small economy in the global framework, with no significant oil production.

Our basic hypothesis is that a positive shock in oil prices may have a different effect than a negative one over product inflation. An extended idea of our main hypothesis is that inter-groups asymmetries also could exist. To define product groups we use the European Classification of Individual Consumption by Purpose (hereafter ECOICOP) disaggregation of the Consumer Price Index provided by the Spanish Institute of Statistics.

The structure of the paper is as follows: Section 2 describes the dataset and the econometric methodology employed. Section 3 presents and discusses the positive vs. negative oil shocks effects for the general inflation rate. Section 4 does the same for the inflation in each product group. In Section 5 we estimate the oil price pass-through into inflation and analyze inter-groups asymmetries. and, finally, Section 6 summarize the main conclusions of this work.

2 Data and methods

2.1 Dataset and variables

The dataset employed in this work includes the general and ECOICOP Consumer Price Index provided by INE, as well as the Brent[1] price published by the U.S. Energy Administration (hereafter EIA). The ECOICOP Consumer Price Index is a functional disaggregation of the general Consumer Price Index (hereafter CPI). For that purpose, the shopping basket products are classified in 12 groups:

1. Aliments and non-alcoholic drinks
2. Alcoholic drinks and tobacco
3. Clothing and footwear
4. Dwelling and supplies
5. Furniture and household goods
6. Health
7. Transport
8. Communications

[1]Brent oil price per barrel in US Dollars (USD).

9. Entertainment and culture
10. Education
11. Restaurants and hotels
12. Others goods and services

We excluded four groups (Alcoholic drinks and tobacco, Health, Communications and Education) because, in Spain, the corresponding prices are essentially determined by the government and are therefore deterministic.

As crude oil prices are originally quoted in US Dollars (USD), we also used the USD/EURO exchange rate published by the European Central Bank (hereafter ECB). All the time series are observed in a monthly frequency from January 2002 to November 2018, for a total of 203 observations. Table 1 provides further details about this dataset.

Table 1: Definition of the dataset.

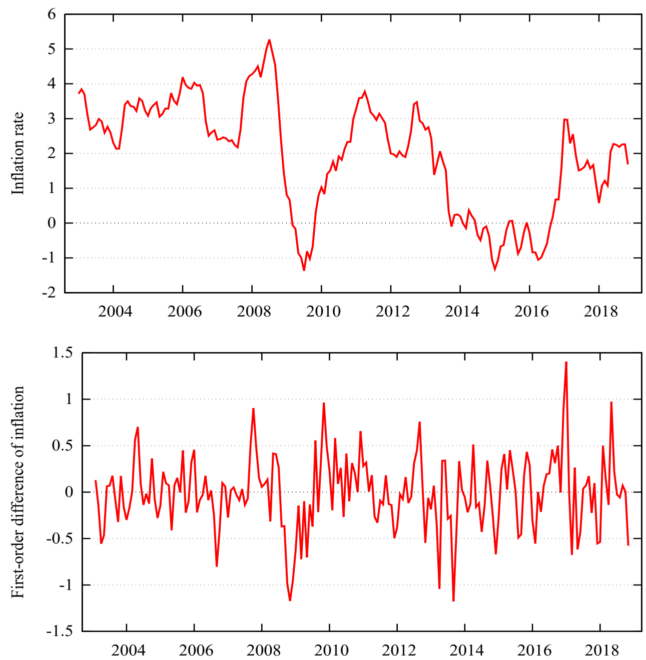
Notation	Variable	Source
P_t^i	General and ECOICOP CPI	Spanish Institute of Statistics, INE
O_t^{USD}	Brent Oil Price in USD	US Energy Administration, EIA
ER_t	EUR/USD exchange rate	European Central Bank, ECB
O_t^{EUR}	Brent Oil Price in EURO	EIA and ECB

The original values of these variables were transformed to annual percent rates, which are the actual variables to be analyzed. To denote this transformation we consider that, for any variable, X_t, $r^{12}(X_t)$ is the corresponding annual rate, defined as:

$$r^{12}(X_t) = (\frac{X_t}{X_{t-12}} - 1) \times 100$$

Figure 1 displays the general inflation rate and its first-order difference. It can be interpreted as the monthly change in annual inflation and, therefore, can be interpreted as a monthly acceleration , if positive, or deceleration, if negative. Figure 2 does the same for the annual variation rate of oil prices in euros.

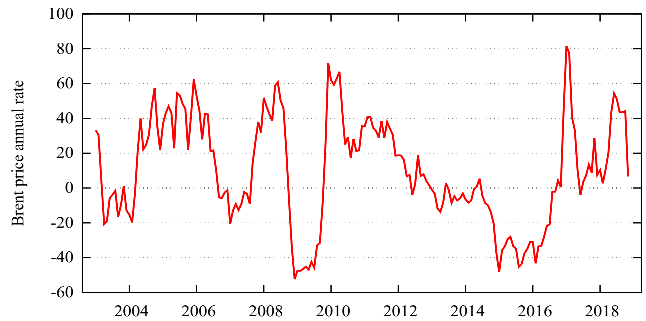
Figure 1: General inflation rate $r^{12}(P_t^G)$ and its stationary transformation (acceleration in annual inflation) $\nabla r^{12}(P_t^G)$.



In both cases, the annual rates are non-stationary and requires an additional difference to show a stable mean.The series $r^{12}(O_t^{USD})$ and $r^{12}(ER_t)$, not shown here for brevity, have the same properties. stationary transformation for all the variables considered in our dataset can be interpreted as the monthly acceleration of the annual growth rate.

The Dickey-Fuller (ADF) and Kwiatkowski, Phillips, Schmidt y Shin (KPSS) tests, see (Dickey and Fuller, 1981) and (Kwiatkowski et al., 1992), confirm that these variables are stationary in the mean (Table 2). Note that, the null hypothesis of ADF test is that the series has a unit root, while KPSS test assumes that it is stationary. Statistical testing is more decisive when rejecting the null and, because of this, these tests supplement each other. In particular, ADF and KPSS are more decisive when the series is stationary and non-stationary respectively.

Figure 2: Annual percent changes for Brent price per barrel in euros $r^{12}(O_t^{EUR})$ and its stationary series (acceleration) $\nabla r^{12}(O_t^{EUR})$.



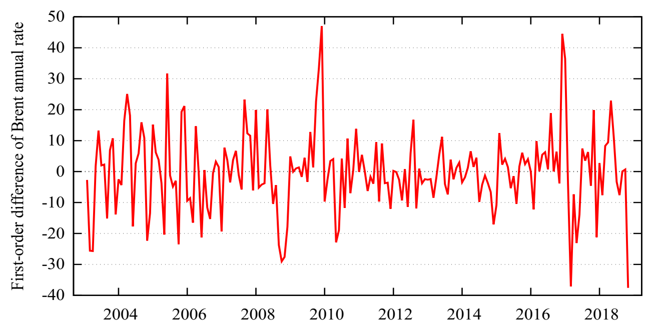


Table 2: Unit-root tests for the first order difference series of: inflation $\nabla r^{12}(P_t^G)$; Brent price per Barrel in euros $\nabla r^{12}(O_t^{EUR})$ and dollars $\nabla r^{12}(O_t^{USD})$; and exchange rates EUR/USD $\nabla r^{12}(ER_t)$.

	$\nabla r^{12}(P_t^G)$	$\nabla r^{12}(O_t^{EUR})$	$\nabla r^{12}(O_t^{USD})$	$\nabla r^{12}(ER_t)$
ADF	-4.9200	-6.1905	-6.7559	-10.2662
	(<0.01)	(<0.01)	(<0.01)	(<0.01)
KPSS	0.0473	0.0256	0.0296	0.2183
	(>0.10)	(>0.10)	(>0.10)	(>0.10)

Note: ADF is the Augmented Dickey and Fuller (1981) statistic, computed allowing for a constant term, first-order autocorrelation and no time trend. KPSS is the Kwiatkowski *et al.* (1992) statistic, computed allowing for a constant term, first-order autocorrelation and no time trend. The figures in parentheses are the p-values for the corresponding statistic.

Table 3 summarizes the main descriptive statistics of the stationary transformed series, as well as the p-values for the Jarque Bera normality test. Note that the standard deviations for the oil price series and the coefficient of variation are considerably larger respect to the inflation series. This fact indicates that oil prices are very volatile during the period considered. The Jarque Bera test rejects normality in all the cases except the EUR/USD exchange rate.

Table 3: Descriptive statistics for the stationary series of inflation $\nabla r^{12}(P_t^G)$, Brent price per Barrel in euros $\nabla r^{12}(O_t^{EUR})$ and dollars $\nabla r^{12}(O_t^{USD})$ and exchange rates EUR/USD $\nabla r^{12}(ER_t)$.

Statistical	$\nabla r^{12}(P_t^G)$	$\nabla r^{12}(O_t^{EUR})$	$\nabla r^{12}(O_t^{USD})$	$\nabla r^{12}(ER_t)$
Mean	-0.0107	-0.1398	-0.3016	-0.0003
Std. Dev.	0.3921	13.0080	13.8890	0.0179
C.V.	36.7560	93.0533	46.0532	56.9940
Minimum	-1.1780	-37.5620	-39.0623	-0.0560
Maximum	1.4050	47.0352	44.4961	0.0561
p-value JB	<0.01	<0.01	<0.01	0.1484

2.2 Univariate analysis and Transfer function

Our basic model is a transfer function (Box et al., 2015). A transfer function model is a flexible and efficient representation for a unidirectional causal relationships, allowing for instantaneous and lagged effects, seasonal autocorrelation and intervention variables could be easily added if were required.

A transfer function captures the instantaneous and lagged relationship between an endogenous variable or output, with one or more exogenous variables, and then adds an ARIMA model for the errors. In our particular case, the transfer functions considered link different inflation series with oil prices. In this way, the relationship model captures the influence of oil price changes to inflation, while the part of inflation explained by other unspecified factors is represented by the error term model.

To parameterize the transfer function, we employed the Box *et al.* (2015) methodology as follows:

1. We first performed an univariate analysis of the inflation and oil price series,
2. ...to filter them using the univariate model for the input (oil price),
3. ...and we computed the sample cross correlation function between the series prewhitened in this way, and finally,
4. ...the error term was modelled with the ARIMA structure of inflation.

3 Asymmetric effects between positive and negative oil shocks for general inflation

3.1 Univariate models

Following Box et al. (2015) the standard univariate identification analysis suggest an ARIMA $(1,1,0) \times (0,0,1)_{12}$ specification for the series $r^{12}(P_t^G)$, $r^{12}(O_t^{USD})$ and $r^{12}(O_t^{EUR})$. These models are the base for the transfer function construction and forecasting. The main results of these estimations are shown in Table 4.

In these models all the coefficients are statistically significant. The Ljung-Box test suggest that absence of residuals autocorrelation cannot be rejected. Furthermore, the residual Autocorrelation Function, and Partial Autocorrelation Function, not shown here for brevity, do not show significant values on relevant lags, so they confirm the models are adequate. However, the Jarque Bera test rejects the residuals normality hypothesis for the inflation and dollar oil prices models. This could be partially explained by outliers.

Table 4: ARIMA modeling results corresponding to ARIMA $(1,1,0) \times (0,0,1)_{12}$ process for $r^{12}(P_t^G)$, $r^{12}(O_t^{EUR})$ and $r^{12}(O_t^{USD})$.

	Variable		
Coefficient	$\nabla r^{12}(P_t^G)$	$\nabla r^{12}(O_t^{EUR})$	$\nabla r^{12}(O_t^{USD})$
$\hat{\phi}_1$	0.3929	0.1937	0.2543
	(<0.01)	(<0.01)	(<0.01)
$\hat{\Theta}_1$	-0.8193	-0.6358	-0.6602
	(<0.01)	(<0.01)	(<0.01)
$\hat{\sigma_a}$	0.2764	10.8959	11.3383
$Q(39)$ (p-value)	18.1547 (0.9961)	32.9328 (0.6602)	39.3869 (0.3636)
JB (p-value)	0.0622 (0.9694)	9.2096 (0.0100)	2.8739 (0.2376)

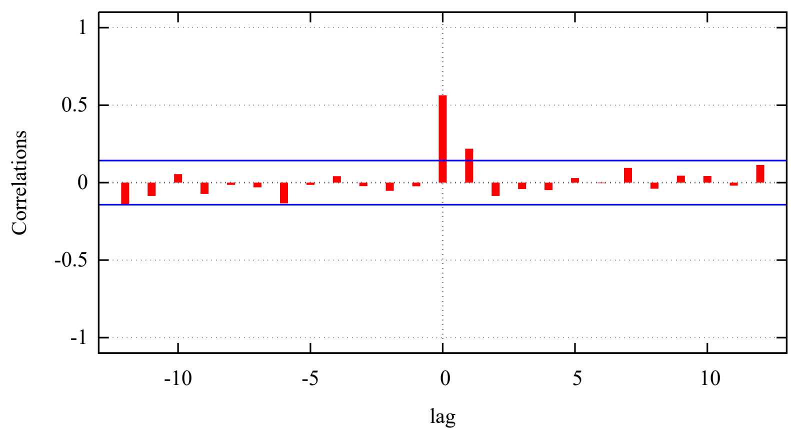
Note: The figures in parentheses are the corresponding p-values. The $Q(39)$ statistic is the Ljung-Box portmanteau test for the null of no residual autocorrelation, computed with the first 39 residual autocorrelations.

3.2 Symmetric and asymmetric transfer function estimations

To build the transfer function, first we filtered the series $\nabla r^{12}(P_t^G)$ to shocks in $\nabla r^{12}(O_t^{EUR})$[2], using the model for the later, and then we computed the sample cross-correlation function (CCF) between both series, which is shown in Figure 3. The cross-correlation corresponding to positive lags are proportional to the impulse response function of $\nabla r^{12}(P_t^G)$ to shocks in $\nabla r^{12}(O_t^{EUR})$, see Box et al. (2015). Negative lags correspond to the inverse causality relationship.

[2]The input to the transfer function is expressed in euros, while original oil prices are quoted in USD. Hereafter we develop our analysis using the oil price in euros, although one may think this specification may confound variations in oil prices and exchange rates. Castro et al. (2016) separated the change in inflation due to oil price from that due to exchange rate fluctuations. They found that the effect of the exchange rate is not statistically significant for the Eurozone. Following Castro et al. (2016) we develop a similar analysis for the Spain inflation, not included here for brevity. The results we obtained were coincident with their findings, so the exchange rate is not an statistically significant factor in Spain.

Figure 3: Cross correlations between the prewhitened series of inflation in Spain, $\nabla r^{12}(P_t^G)$ and the lagged annual variation rate of Brent prices in euros. Note that negative lags are actually leads for $\nabla r^{12}(O_t^{EUR})$.



This cross-correlation function:

(i) ...has no significant values in the negative lags, which means that there is no inverse causality relationship between oil prices and inflation.

(ii) ...under the assumption that the instantaneous (0-lag) correlation corresponds to the effect of oil prices over inflation, suggests that a shock in $\nabla r^{12}(O_t^{EUR})$ has a positive and significant effect over $\nabla r^{12}(P_t^G)$ and $\nabla r^{12}(P_{t+1}^G)$.

Previous results suggest a transfer function specification relating inflation with the contemporary and first lagged values of the annual variation of oil prices and an error term with the ARIMA $(1,1,0)\times(0,0,1)_{12}$ structure of the endogenous variable. This transfer function corresponds to the symmetric approach, since this specification assumes that the magnitude of the effects on inflation are equals (in absolute values), both for negative and positive shocks in oil prices. The main estimation results for this transfer function are:

$$r^{12}(P_t^G) = (\underset{(<0.01)}{0.0148} + \underset{(<0.01)}{0.0088}L)r^{12}(O_t^{EUR}) + \hat{N}_t \tag{1}$$

$$(1 - \underset{(<0.01)}{0.2631}L)\nabla\hat{N}_t = (1 - \underset{(<0.01)}{0.6465}L^{12})\hat{a}_t \tag{2}$$

$$\hat{\sigma}_a = 0.2239 \qquad log - lik = 11.3802$$

$$AIC = -12.7606$$

where L denotes the lag operator, $log-lik$ is the (log) value of the Gaussian likelihood function on convergence and AIC stands for the Akaike (1974) Information Criterion. The figures in parentheses are the corresponding p-values.

To take into account the potential existence of asymmetric effects on inflation, we build an alternative transfer function that allows positive shocks in oil prices to have a different effect than negative ones:

$$r^{12}(P_t^G) = (\underset{(<0.01)}{0.0135} + \underset{(<0.01)}{0.0075}L)r^{12}(O_t^{EUR}) + (\underset{(<0.01)}{0.0105} + \underset{(<0.01)}{0.0109}L)r_{neg}^{12}(O_t^{EUR}) + \hat{N}_t \quad (3)$$

$$(1 - \underset{(<0.01)}{0.2057})\nabla\hat{N}_t = (1 - \underset{(<0.01)}{0.7803}L^{12})\hat{a}_t \quad (4)$$

$$\hat{\sigma}_a = 0.2038 \quad log - lik = 26.7775$$

$$AIC = -39.5549$$

where we define a new variable as follows:
$r_{neg}^{12}(O_t^{EUR}) = r^{12}(O_t^{EUR})$ if $r^{12}(O_t^{EUR})$ is less or equal to 0 or,
$r_{neg}^{12}(O_t^{EUR}) = 0$ otherwise

All the parameters in (1)-(2) and (3)-(4) are significant and the residuals do not show relevant autocorrelations, so we consider them statistically adequate. But, in (3)-(4) the parameters corresponding to negative shocks are statistically significant, so there is a significant asymmetric effect. Furthermore, the AIC[3] values are consistently smaller than those in the symmetric model, so (3)-(4) fits better than (1)-(2).

The symmetric transfer function implies that:

(*i*) the value of inflation in any month is affected by the annual change in Brent price in the same and previous month;

(*ii*) the effect of changes in oil prices over inflation is transient;

(*iii*) the expected total response of inflation to a 1 percentage point (p.p.) increase in $r^{12}O_t^{EUR}$ would be $\hat{g} = 0.0146 + 0.0088 = 0.0236$ p.p. Obviously this total response, which is known in the time series literature as the transfer function gain, provides a measure of the sensitivity of the inflation level to changes in oil prices.

(*iv*) the total response of inflation to a 1 p.p. decrease in $r^{12}O_t^{EUR}$ would be -0.0236 p.p., which is the same magnitude as in the case of a positive increase in absolute values.

The asymmetric transfer function implies that:

(*i*) the value of inflation in any month is affected by the annual change in Brent price in the same and previous month;

(*ii*) the effect of changes in oil prices over inflation is transient;

(*iii*) the expected total response of inflation to a 1 p.p. increase in $r^{12}O_t^{EUR}$ would be $\hat{g} = 0.0135 + 0.0075 = 0.0210$ p.p.

[3]The same conclusion is supported bu both, Schwarz (1978) and Hannan and Quinn (1979) Information Criteria, but we do not show the values for simplicity.

(*iv*) the total response of inflation to a 1 p.p. decrease in $r^{12}O_t^{EUR}$ would be $\hat{g} = -(0.0135 + 0.0075 + 0.0105 + 0.0109) = -0.0424$ p.p. In absolute value, this gain doubles the one corresponding to a positive increase. Therefore, inflation is more sensitive to negative shocks in oil prices.

Table 5 displays a summary of the estimations results for the symmetric and asymmetric transfer function models as well as the corresponding long-term gain and the LR test [4].

Table 5: Summary of estimates, long-term gains and goodness-of-fit measures for the symmetric and asymmetric transfer function models

	Transfer function models	
Coefficient	Symmetric	Asymmetric
$\hat{\phi}_1$	0.2631	0.2057
	(<0.01)	(<0.01)
$\hat{\Theta}_1$	0.6465	0.7803
	(<0.01)	(<0.01)
$r^{12}O_t^{EUR}$	0.0148	0.0135
	(<0.01)	(<0.01)
$r^{12}O_{t-1}^{EUR}$	0.0088	0.0075
	(<0.01)	(<0.01)
$r^{12}_{neg}(O_t^{EUR})$		0.0105
		(<0.01)
$r^{12}_{neg}(O_{t-1}^{EUR})$		0.0109
		(<0.01)
Long-term gain (positive shock)	0.0236	0.0210
Long-term gain (negative shock)	-0.0236	-0.0424
$\hat{\sigma}_a$	0.2239	0.2038
Log-lik	11.3802	26.7775
LR-test (*p*-value)	30.7946 (<0.01)	

Note: The figures in parentheses are the corresponding *p*-values.

[4] The *LR*-test is a likelihood ratio test, computed to compare the fit of the symmetric and asymmetric models. The null hypothesis of this test, in our models, is that the asymmetric model fit as well as the symmetric one.

4 Asymmetric effects between positive and negative oil shocks for ECOICOP inflation

As explained in previous sections, one of our main objectives is to test for asymmetric effects of oil prices on various products categories. Such an asymmetric behavior would be evidence of the different degrees of market competition. Our hypothesis is that on industries with higher level of competitiveness, a negative shock in oil prices produce a higher effect than a positive one, in absolute values. This means that if crude oil is a raw material for a very competitive industry, producers will find themselves forced to reduce prices more when a negative shock occurs than raise them when oil price increases, to ensure their permanence on the market. In the case of industries with lower level of competitiveness, producers will not translate their costs reductions to the prices of their products.

4.1 Symmetric and asymmetric transfer function estimations

In this section we present a summary of the estimations results for the symmetric and asymmetric transfer function models for each of the products groups. In all cases we use the same specification as in the general inflation rate, (1)-(2) for the symmetric model and (3)-(4) for the asymmetric one.

Table 6 displays a summary of the results for the groups where we found asymmetric effects. We show the corresponding long-term gain, both for positive and negative shocks and the LR goodness test that confirms in each case that de asymmetric model fits better than the symmetric one. Groups are sorted from more to less sensitive to negative shocks.

Table 6: Summary of sensitivity and goodness-of-fit results for the groups with asymmetric effects.

Products groups	Gain "+" shock	Gain "-"shock	*LR*-test (*p*-value)
Transport	0.1003	-0.1868	64.9784 (<0.01)
Dwelling and Supplies	0.0343	-0.0582	10.3422 (<0.01)
Global Inflation	**0.0210**	**-0.0424**	**30.7944 (<0.01)**
Restaurants and Hotels	0.0000	-0.0070	6.4969 (0.0388)
Clothing and Footwear	0.0000	-0.0059	14.8378 (<0.01)
Entertainment and culture	0.0078	0.0071	5.1798 (0.0750)

Note: The figures in parentheses are the corresponding p-values.

Note that:

(i) ...the groups “Transport” and “Dwelling and Supplies” display the higher asymmetrical responses and both of them are more sensitive to negative oil shocks than the total inflation.

(ii) ...the Transport group is the most sensitive to oil shocks, with a 0.100 percentage points increase and a -0.188 percentage points decrease as a reaction of positive and negative shocks of 1 percentage point.

(*iii*) ...the groups: "Restaurants and Hotels" and "Clothing and Footwear" show asymmetric effects, but their prices are less sensitive to negative oil shocks than the total inflation. In these two cases, a positive shock in crude oil price has a null effect on their own prices. This suggest that the producers avoid translate to their products prices the costs increases, so we could conclude that there is a high level of competitiveness on this industries.

(*iv*) ..."Entertainment and Culture" prices seems to be asymmetrically affected by oil price variations. Note that in this case the sign of a negative shock is positive, contrary to the total inflation behavior when oil prices drops. This particular response may be due to the heterogeneity of the products included in this group, but this issue deserves further research.

The results in "Aliments and Non-alcoholic drinks", not included here for brevity, show that a positive shock is similar in absolute terms to a negative one, so this group is affected by oil shocks symmetrically. The LR test confirms that there is no improvement in the goodness of the asymmetric model. In the group Furniture and household goods we found a significant asymmetric effect over this group inflation of a shock in $r^{12}_{neg}(O^{EUR}_{t-1})$ and $r^{12}_{neg}(O^{EUR}_{t-2})$, but the LR test show no improvement on the goodness of the asymmetric model. The prices in the group Other goods and services are not affected by oil price variations. Detailed results for all the groups can be checked on Appendix 1.

5 Asymmetric effects of oil shocks between groups

5.1 General inflation oil price pass-through and variance decomposition

As explained in previous sections "the gain" of the transfer function provides a measure of the sensitivity of the inflation level to changes in oil prices. But, the expected pass-through effect is given by the product of the parameters and the corresponding changes in oil prices. In the case of the general inflation rate, that is:

$$r^{12}(\hat{P}_t^{O}) = (0.0135 + 0.0075L)r^{12}(O_t^{EUR}) + (0.0105 + 0.0109L)r^{12}_{neg}(O_t^{EUR}) \qquad (5)$$

so the part due to other factors F would be:

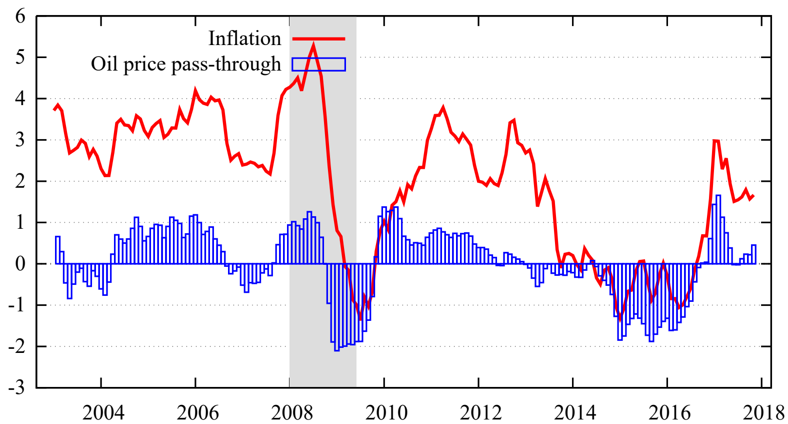
$$r^{12}(\hat{P}_t^{F}) = r^{12}(P_t^{G}) - r^{12}(\hat{P}_t^{O}) \qquad (6)$$

Figure 4 displays the profile of the Spanish inflation versus the pass-through component computed according to [5].

Note that:

(*i*) ...both series display a high degree of comovement (their sample correlation is 0.75).

Figure 4: General inflation rate $r^{12}(P_t^G)$ vs. the estimated oil price pass-through $r^{12}(\hat{P_t}^O)$.



(*ii*) ...the contribution of oil prices to inflation ranges from +1.66 to -2.10 points in some months.

(*iii*) ...the oil price pass-through is a major determinant of the deflation spells observed in 2009 and 2014-2016.

Variance decomposition in a dynamic model is difficult because one should take into account the dynamic influence of the inputs on the output. However, the value of $r^{12}(\hat{P_t}^O)$ given by [6] accumulates all these effects into and, therefore, can be used to compute a simplified variance decomposition for the stationary transformation of inflation.

Re-ordering the terms in [6] and multiplying both sides by the regular difference operator ∇, we obtain:

$$\nabla r^{12}(P_t^G) = \nabla r^{12}(\hat{P_t}^O) + \nabla r^{12}(\hat{P_t}^F) \tag{7}$$

where all the variables are stationary, so they have stable means and variances. The percentage of the variance of $\nabla r^{12}(P_t^G)$, which is explained by $\nabla r^{12}(\hat{P_t}^O)$, would be the determination coefficient of a linear regression of the former variable on the latter. In our case, the main LS results are:

$$\nabla r^{12}(P_t^G) = \underset{(0.6574)}{-0.0111} + \underset{(<0.01)}{0.9888}\nabla r^{12}(\hat{P_t}^O) + \hat{\epsilon} \tag{8}$$

$$R^2 = 0.5036$$

So, in the period considered, 50.36% of the variance of monthly changes of inflation were explained by the corresponding changes in Brent price.

5.2 ECOICOP inflation oil price pass-through and variance decomposition

We repeated the same analysis for each group we found is affected by oil prices. Table 7 show the maximum and minimum contribution of oil prices to each group inflation and the corresponding variance. Groups are sorted from more to less variance.

Table 7: Contribution of oil prices to inflation

Products groups	Maximum	Minimum	Variance
Transport	7.9196	-9.2030	0.6953
Global Inflation	**1.6600**	**-2.1000**	**0.5036**
Dwelling and Supplies	2.7207	-2.9567	0.1367
Clothing and footwear	0.1885	-0.3880	0.0735
Aliments and non-alcoholic drinks	0.3584	-0.2304	0.0480
Restaurants and hotels	0.0000	-0.3880	0.0303
Entertainment and culture	0.6533	0.0039	0.0246

Note that:

(*i*) ...the highest contribution of oil prices to inflation measured both, by the range and variance corresponds to the Transport group.

(*ii*) ...the percentage of the variance explained by Brent prices is considerably smaller in all the other groups in relation to the global inflation.

(*iii*) ...although the groups: “Clothing and Footwear”, “Aliments and Non-alcoholic drinks”, “Restaurants and Hotels” and “Entertainment and Culture” are affected by oil prices, the range of oil pass-through is close to zero in the period considered. This suggests that crude price is not a major driver of these groups inflation/deflation.

6 Conclusion and policy implications

The results in previous sections show that a shock in oil prices in a given month creates a transient effect of the same sign on the inflation in the current and next month. In the long-term, the total expected effect of an increase in oil price of one percentage (p.p.) point is about 0.021 p.p. in inflation, while a decrease of the same magnitude brings down inflation by -0.042 p.p. Therefore, the sensitivity of inflation to negative shocks in oil price is almost twice than the corresponding response to positive innovations. This is especially important for monetary policy, since the risk of deflation due to negative oil shocks is bigger than the risk of inflation due to positive oil shocks.

Per product groups, there are important differences in the effects of oil price shocks into inflation. For example, in “Aliments and non-alcoholic drinks” the effect is symmetric. On the other hand, prices of “Furniture and household goods” and “Other goods and services” are not sensitive to changes in oil price. All the other groups display asymmetric effects, being “Transport” the one receiving a larger impact, with a 0.100 p.p. increase and a 0.187 p.p. decrease as a reaction of positive and negative shocks of 1 p.p.

Inter-groups asymmetries also exist. Analyzing the pass-through of oil prices into inflation, we found different levels in the contribution of oil prices to products groups inflation. The higher one, measured by the range between the gains, corresponds to Transport. The percentage of variance explained by Brent prices for Transport inflation es 69.53%, while for the Global Inflation is 50.36%.

In the groups "Clothing and footwear", "Aliments and non-alcoholic drinks", "Restaurants and hotels and Entertainment and Culture", the range of oil pass-through is close to zero in the period considered and their variance explained by oil prices is less than 10%. This could indicate that crude price is not a major driver of these groups inflation/deflation.

Our results show that per product groups there is a significant asymmetry between positive and negative oil shocks. These results could be evidence of the different degrees of market competition. Besides providing a more accurate description of the pass-through effect, our methodology can be used by policy makers as a level indicator of markets competitivness and for monitoring oil price shocks effects on inflation in real time.

Compliance with ethical standards

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Data availability statement

The data used in this work can be download from: http://www.ine.es; http://www.ecb.europa.eu; and http://www.eia.gov

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Appendix 1: Estimations, sensitivity and goodness results from the symmetric and asymmetric transfer function models

Table 8 display the estimations results for the groups "Transport" and "Dwelling and supplies".

Table 8: Summary of estimates, gains and goodness-of-fit results for the symmetric and asymmetric transfer function models for the groups: "Transport" and "Dwelling and supplies".

	Transfer function models			
	Transport		Dwelling and supplies	
Coefficient	Sym	Asym	Sym	Asym
$\hat{\phi}_1$	0.0993	0.0196	0.0924	0.0694
	(0.1957)	(0.7931)	(0.2306)	(0.3663)
$\hat{\Theta}_1$	-0.6178	-0.8562	-0.7868	-0.8882
	(<0.01)	(<0.01)	(<0.01)	(<0.01)
$r^{12}O_t^{EUR}$	0.0721	0.0633	0.0186	0.0185
	(<0.01)	(<0.01)	(<0.01)	(<0.01)
$r^{12}O_{t-1}^{EUR}$	0.0411	0.0370	0.0168	0.0158
	(<0.01)	(<0.01)	(<0.01)	(<0.01)
$r^{12}_{neg}(O_t^{EUR})$		0.0548		0.0087
		(<0.01)		(0.2389)
$r^{12}_{neg}(O_{t-1}^{EUR})$		0.0317		0.0239
		(<0.01)		(<0.01)
Gain ("+")	0.1132	0.1003	0.0354	0.0343
Gain ("-")	-0.1132	-0.1868	-0.0354	-0.0582
$\hat{\sigma}_a$	0.7735	0.6344	0.7455	0.7123
Log-lik	-222.5371	-190.0479	-218.4557	-213.2846
LR-test	64.9784 (<0.01)		10.3422 (<0.01)	

Note: The figures in parentheses are the corresponding *p*-values.

Table 9 show the main estimations results for: "Restaurants and Hotels", "Clothing and Footwear" and "Entertainment and Culture":

Table 9: Summary of estimates, gains and goodness-of-fit results for the symmetric and asymmetric transfer function models for the groups: “Restaurants and Hotels”, “Clothing and Footwear” and “Entertainment and Culture”.

	Transfer function models					
	Restaurants		Clothing		Entertainment	
Coefficient	Sym	Asym	Sym	Asym	Sym	Asym
$\hat{\phi}_1$	-0.0337	-0.0471	0.1648	0.1652	-0.3124	-0.3223
	(0.6731)	(0.5531)	(0.0244)	(0.0259)	(<0.01)	(<0.01)
$\hat{\Theta}_1$	-0.3999	-0.3828	0.3491	0.3547	-0.7219	-0.7333
	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(<0.01)
$r^{12}O_t^{EUR}$	0.0000	0.0000	0.0000	0.0015	0.0073	0.0078
	(0.9378)	(0.9992)	(0.9905)	(0.4089)	(0.0598)	(0.0431)
$r^{12}O_{t-1}^{EUR}$	0.0002	-0.0011	0.0027	-0.0005	-0.0036	-0.0041
	(0.8982)	(0.4379)	(0.1023)	(0.7942)	(0.3626)	(0.2909)
$r_{neg}^{12}(O_t^{EUR})$		-0.0005		-0.0083		-0.0149
		(0.8509)		(0.0568)		(0.0222)
$r_{neg}^{12}(O_{t-1}^{EUR})$		0.0070		0.0142		0.0073
		(0.0108)		(<0.01)		(0.2642)
Gain ("+")	0.0000	0.0000	0.0000	0.0000	0.0073	0,0078
Gain ("-")	0.0000	-0.0070	0.0000	-0.0059	-0.0073	0,0071
$\hat{\sigma}_a$	0.1966	0.1933	0.3230	0.3105	0.5871	0.5784
Log-lik	38.2314	41.4798	-55.4036	-47.9847	-171.9855	-169.3956
LR-test	6.4969 (0.0388)		14,8378 (0.0006)		5.1798 (0.0750)	

Note: The figures in parentheses are the corresponding p-values.

Table 10 show the estimations results for: "Aliments and non-alcoholic drinks", "Furniture and household goods" and "Others goods and services":

Table 10: Summary of estimates, gains and goodness-of-fit results for the symmetric and asymmetric transfer function models for the groups: "Aliments and Non-alcoholic drinks", "Furniture and Household goods" and "Other Goods and Services".

	Transfer function models					
	Aliments		Furniture		Others	
Coefficient	Sym	Asym	Sym	Asym	Sym	Asym
$\hat{\phi}_1$	0.3887	0.3838	0.3578	0.3574	0.2083	0.1878
	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(0.0114)
$\hat{\Theta}_1$	-0.6898	-0.7051	-0.5965	-0.5786	-0.5020	-0.5345
	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(<0.01)	(<0.01)
$r^{12}O_t^{EUR}$	0.0044	0.0040	-0.0009	-0.0011	-0.0015	-0.0020
	(0.0689)	(0.0979)	(0.2431)	(0.1790)	(0.2192)	(0.1054)
$r^{12}O_{t-1}^{EUR}$	0.0035	0.0034	-0.0007	-0.0012	-0.0001	-0.0006
	(0.1504)	(0.1654)	(0.4046)	(0.1432)	(0.9114)	(0.6250)
$r^{12}O_{t-2}^{EUR}$				-0.0007		
				0.3914		
$r^{12}_{neg}(O_t^{EUR})$		0.0045		-0.0005		0.0042
		(0.2954)		(0.7697)		(0.0855)
$r^{12}_{neg}(O_{t-1}^{EUR})$		0.0024		0.0039		0.0022
		(0.5658)		(0.0157)		(0.3666)
$r^{12}_{neg}(O_{t-2}^{EUR})$				0.0032		
				0.0387		
Gain ("+")	0.0044	0.0040	0.0000	0.0000	0.0000	0.0000
Gain ("-")	0.0044	-0.0040	0.0000	-0.0071	0.0000	-0.0042
$\hat{\sigma}_a$	0.3622	0.3606	0.1219	0.1193	0.1844	0.1826
Log-lik	-80.2105	-79.5929	126.8160	130.4675	49.5759	51.2118
LR-test	1.2351 (0.5393)		7.303 (0.1207)		3.2706 (0.2544)	

Note: The figures in parentheses are the corresponding p-values.

Appendix 2: Oil price pass-through into products groups inflation

Figure 5: “Transport” and “Dwelling and Supplies” inflation vs. the estimated oil price pass-through.

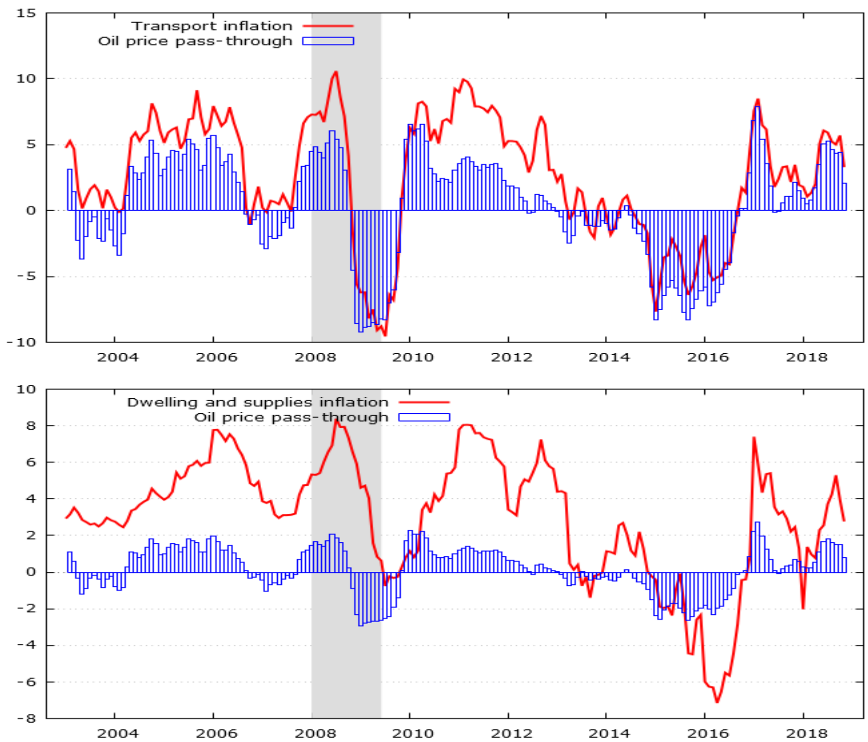

Figure 6: “Clothing and footwear”, “Aliments and non-alcoholic drinks”, “Restaurants and hotels” and “Entertainment and culture” inflation vs. the estimated oil price pass-through.