# THE IMPACT OF OIL PRICE CHANGES ON SPANISH AND EURO AREA CONSUMER PRICE INFLATION

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**Abstract**

This paper assesses the impact of oil price changes on Spanish and euro area consumer price inflation. We find, consistently with recent international evidence, that the inflationary effect of oil price changes is limited, even though crude oil price fluctuations are a major driver of inflation variability. The impact on Spanish inflation is found to be somewhat higher than in the euro area. Direct effects are increasing over time, reflecting the higher spending of households on refined oil products, whereas indirect ones, defined in broad terms, are losing importance.

**Keywords:** oil prices, consumer price inflation, Spanish and Euro area inflation, DSGE models.

**JEL classification:** E20, E31, E37.

# 1 Introduction

Sharp fluctuations in the price of oil in recent years have rekindled the interest in the nominal and real impacts of oil price shocks. The relevance of oil as a source of macroeconomic fluctuations was established as conventional wisdom after the oil shocks of the 1970s, when inflation reached two digits in industrialized economies and close to 25% in Spain.

However, more recent oil price shocks seem to have had a limited impact on prices and real activity. In fact, there is a growing body of evidence documenting this loss of relevance. Thus, Hooker (2002) found that oil price changes do not have a significant impact on US inflation measures that exclude energy products. Leblanc and Chinn (2004) find a modest role of oil price shocks on headline CPI inflation for the main global economies. De Gregorio et al. (2007) document a sizable reduction in the pass through of oil price changes to consumer prices, for a sample of 34 industrialized and emerging countries. Blanchard and Galí (2008) consider G-7 countries excluding Canada and conclude that the inflationary impact of oil price shocks is considerably lower from mid 1980s onwards. Nakov and Pescatori (2007a) estimate a DSGE model with an oil producing sector and find that the reduced oil share and the smaller size of oil price shocks are not the major drivers of the moderation in US inflation variability. Killian (2008) shows that the average contribution of an exogenous oil price shock on inflation in G7 countries is quite small and that of the 2002-2003 shock is negligible. Moreover, responses of the GDP deflator are more muted and less significant than the corresponding responses of CPI inflation, suggesting a very limited indirect impact of oil price shocks.

There are several reasons that may help explain the lower inflationary impact of oil price shocks in recent years. These include the higher energy efficiency of production processes, the relevance of globalization in shaping price setting, as well as changes in the conduct of monetary policy. A better knowledge of the transmission of supply shocks by central banks, greater independence and the more prominent role of price stability in the reaction function of monetary policy may have helped to reduce the nominal and real impact of oil price shocks. The aim of this paper is not to assess the relative role of each of these factors in accounting for the less relevant role of oil nowadays, but rather to determine the current impact of oil price changes on Spanish and euro area consumer price inflation.

After this introduction, the structure of this paper is as follows. Section 2 introduces the different transmission channels of oil price changes and descriptive evidence is presented in sections 3 (direct impact), 4 (indirect impact) and 5 (second-round effects). Section 6 is devoted to the quantitative results of a quarterly macro-econometric model for Spain, named MTBE [see Estrada et al. (2004), Ortega et al. (2007)], and Section 7 to a Dynamic Stochastic General Equilibrium (DSGE) model, called BEMOD [Andrés et al. (2007) and (2009)]. Other DSGE models have been used in the literature to address the impact of oil price shocks [e.g. Medina and Soto (2005), Hunt (2006) or Blanchard and Galí (2008)]. Two distinguishing aspects of our DSGE model is that it has separate sectors for tradables and non-tradables goods and considers two countries in a monetary union. According both to MTBE and BEMOD, the effect of an oil price shock on CPI inflation is relatively small. Following a 10% increase in the dollar price of crude oil (with a half-life of about

3 years), year-on-year CPI inflation rises by between 0.20 and 0.25 percentage points on average during the first year after the shock, and between 0.04 and 0.13 percentage points in the second year. Second-round effects from wage indexation are found to be quite modest in BEMOD, and somewhat larger in MTBE. Finally, section 8 presents the main conclusions.

## 2 Transmission channels of oil price changes on consumer price inflation

International oil prices are highly relevant to understand firm price setting behaviour, given that the share of household spending devoted to refined oil products is substantial and that oil and refined oil products are an input in the production of goods and services. The transmission mechanism linking international oil prices to consumer price inflation is quite complex and the strength and timing of the different channels depend on numerous factors, so it is conceptually useful (but empirically difficult) to break down the linkages into first-round (direct and indirect) and second-round effects.

The first-round effect of higher oil prices on consumer price indices can be broken down into a direct and an indirect effect. The direct effect reflects the fact that oil price changes are almost immediately passed through to the prices of refined oil products, such as fuels or heating oil, which are consumed by households.

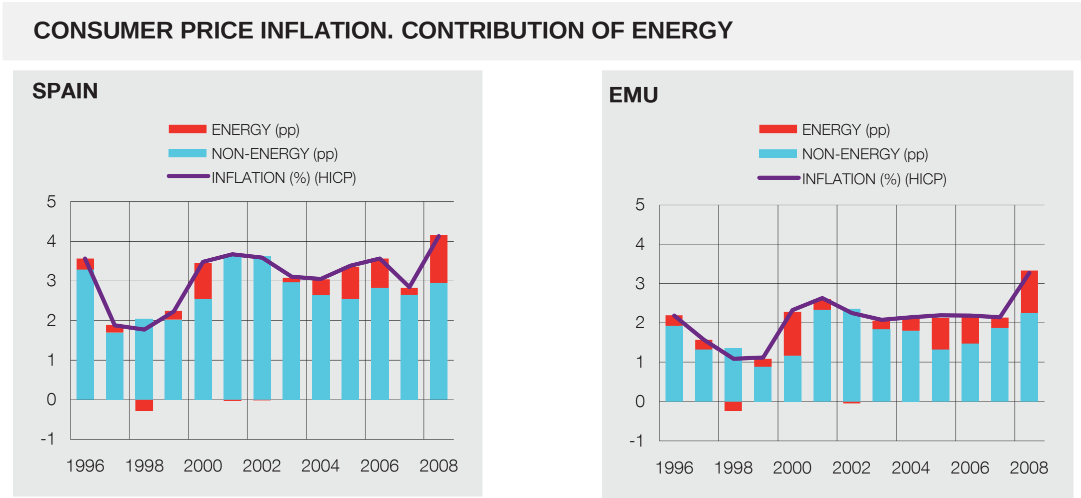
The indirect effect reflects the change in the cost of producing goods and services which use petroleum products as an input and its pass through to final prices. Industries which employ oil intensive technologies are particularly affected by changes in the price of oil, since their marginal costs vary to a larger extent. This transmission channel has a considerably lower speed of pass through than the direct impact and a strength that varies according to factors such as market competition, cyclical developments or the expected transitory or permanent nature of the shock.

On top of these first-round effects, consumer prices may also be affected by so-called second-round effects. These refer to the fact that first-round price changes may trigger a revision of inflation expectations that lead to a resetting of final prices, either directly or indirectly, through the wage-bargaining process. On the one hand, revisions in inflation expectations may entail price changes, to the extent that firms try to maintain profits in real terms. On the other hand, if nominal wages are reset as a result of an oil price shock, unit labour costs of firms vary and may be passed through to final prices. At any rate, inflation expectations of households and firms depend on how expectations of medium-term inflation are anchored by the monetary policy framework, so that inflation expectations can remain stable following an oil price shock if the central bank is credible enough.

## 3 The direct impact on consumer prices

The direct impact on consumer price inflation of changes in oil prices can be proxied by the contribution of consumer energy prices to the harmonized index of consumer prices (HICP). From the beginning of the monetary union, the average contribution of energy HICP to headline inflation in Spain has been 0.4 pp, slightly higher than in the euro area as a whole, (Figure 1 and table 1) and that of refined oil products 0.2 pp, as in the euro area. There is, however, substantial variability in the size of the contribution over time: in Spain the yearly contribution has ranged from -0.3 pp to 1.2 pp and in EMU from -0.2 pp to 1.1 pp. By product type, there are also some important differences: The higher contribution in Spain of price changes in refined oil products, such as fuels and heating oils, relative to the euro area has been offset by lower price rises for electricity and gas.

Figure 1




Sources: INE, Eurostat and Banco de España.

Table 1

**CONTRIBUTIONS TO INFLATION**

| | Spain | EMU | Germany | France | Italy |
|---|---|---|---|---|---|
| **ENERGY** | | | | | |
| Average 1996-2008 | 0.4 | 0.4 | 0.5 | 0.3 | 0.3 |
| Maximum year | 1.2 | 1.1 | 1.2 | 1.0 | 0.9 |
| Minimum year | -0.3 | -0.2 | -0.3 | -0.2 | -0.2 |
| **OIL REFINED PRODUCTS (a)** | | | | | |
| Average 1996-2008 | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 |
| Maximum year | 0.9 | 0.7 | 0.8 | 0.8 | 0.5 |
| Minimum year | -0.1 | -0.2 | -0.2 | -0.3 | -0.1 |

Sources: Eurostat and Banco de España
(a) Liquid fuels and fuels and lubricants for personal transport equipment.

As mentioned above, the direct impact of oil price changes depends, among other factors, on the expenditure share of households on refined oil products over total expenditure. The weight for 2008 in Spanish HICP of refined oil products is 6.2% (table 2). This corresponds to a weight of 5.7% for transport fuels and a weight of 0.5% for heating oil. The expenditure share on refined oil products is considerably higher in Spain than in the euro area (5.5%), reflecting the lower weight of transport fuels in the euro area (4.6%), only partly offset by the higher weight of heating oil (0.9%) in EMU, which reflects, among other factors, the lower average temperature in most European countries. At any rate, it has to be stressed that household spending on refined oil products has increased substantially both in Spain and in the euro area, thus leading to an increase over time in the direct impact on consumer prices of oil price changes. In Spain, the weight of refined oil products in the CPI was 1.5% in 1968, less than a quarter of its weight in 2008, an increase largely driven by the sharp increase in the total number of cars. In the euro area, this weight was 4.3% in 1996 -the first year for which there is information available- , more than 1 pp below the figure for 2008.

Table 2

**HICP WEIGHTS**

| | Spain | EMU | Germany | France | Italy |
|---|---|---|---|---|---|
| **REFINED OIL PRODUCTS (a)** | | | | | |
| (1) 1996 | 4.8 | 4.6 | 4.8 | 5.3 | 3.4 |
| (2) 2008 | 6.2 | 5.5 | 5.6 | 5.2 | 4.9 |
| (3)= (2)-(1) | 1.4 | 0.9 | 0.8 | -0.1 | 1.4 |
| **ENERGY** | | | | | |
| (1) 1996 | 7.5 | 9.1 | 10.3 | 9.3 | 6.8 |
| (2) 2008 | 9.9 | 9.8 | 11.9 | 8.7 | 8.2 |
| (3)= (2)-(1) | 2.3 | 0.8 | 1.6 | -0.6 | 1.4 |

Source: Eurostat.

(a) Liquid fuels and fuels and lubricants for personal transport equipment.

Besides the impact of oil price changes on mean consumer price inflation, it is interesting to analyze its impact on inflation variability. Table 3 presents the contributions to inflation variability of the main energy items, computed as the weighted covariance of these components with headline HICP. As can be seen, energy prices in Spain play a major role in explaining inflation fluctuations (but a minor role in explaining mean inflation). Specifically, energy prices account for 51.3% of HICP variability, of which 44.9% corresponds to fuels and heating oil. The major role of energy in driving inflation fluctuations is also seen in other countries, although to a smaller extent. 44.7% of the variance of euro area HICP inflation is explained by energy developments and 31.8% by fuels and heating oils. These results broadly agree with Blanchard and Gali (2008) who use a structural VAR and find that oil prices account for 61% of fluctuations in headline US inflation.

Table 3

**CONTRIBUTIONS TO INFLATION VARIABILITY**

| | Spain | EMU | Germany | France | Italy |
|---|---|---|---|---|---|
| **Overall** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Energy | 51.3 | 44.7 | 40.2 | 38.0 | 29.3 |
| Non-energy | 48.7 | 55.3 | 59.8 | 62.0 | 70.7 |

Sources: Eurostat and Banco de España.

This evidence is consistent with the standard use of core inflation measures that exclude energy and with results on micro price data that show that energy prices change considerably more frequently than the rest (Dhyne et al. (2006)). The more relevant role of energy prices in Spain vis-à-vis the euro area in explaining inflation fluctuations reflects the higher weight of oil refined products in Spanish HICP relative to the euro area, but also the different indirect taxation (table 4). In Spain, excise duties on transport fuels –which are lump sum- are lower than in other European countries, and the same happens with value added tax, which is proportional to the final price. In 2007, indirect taxes in Spain accounted for 52.6% of the retail price of petrol and 45.9% of the final price of diesel oil. In contrast, in the EU-15 excluding Spain, these shares were around 10 pp higher. Specifically, 63.1% and 55.7%, respectively. This differential taxation implies that for a given change in the price of oil in international markets, retail prices in Spain change to a higher extent than in the euro area, thus contributing to the higher variability of these prices.

Table 4

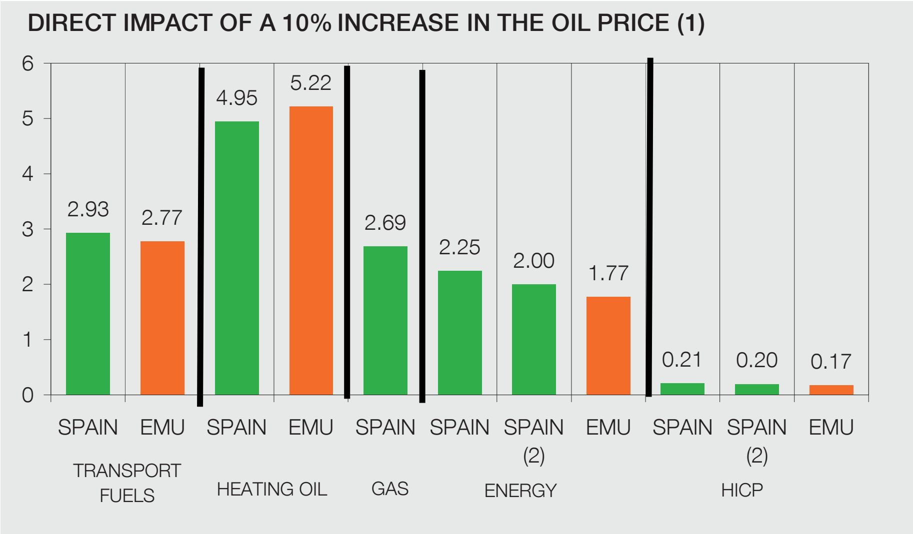
**RETAIL PRICES AND TAXES**

| | Spain | EU 14 (a) | Germany | France | Italy |
|---|---|---|---|---|---|
| **PETROL** | | | | | |
| Retail price | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Taxes | 52.6 | 63.1 | 65.0 | 63.7 | 60.1 |
| Price without taxes | 47.4 | 36.9 | 35.0 | 36.3 | 39.9 |
| **DIESEL OIL** | | | | | |
| Retail price | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Taxes | 45.9 | 55.7 | 56.5 | 55.4 | 52.8 |
| Price without taxes | 54.1 | 44.3 | 43.5 | 44.6 | 47.2 |

Source: European Commission.
(a) EU14: EU15 excluding Spain.

The direct impact is also affected by the pass through of the price of oil in international markets to final consumer prices, a process which is highly complex. There are different types of crude oil with different API gravities (a measure of density) and sulphur content and, correspondingly, different prices. Oil refineries jointly produce the different distillates, which can be grouped as light distillates (e.g. LPG, petrol, naphtha), middle distillates (e.g. kerosene, diesel), heavy distillates and residuum (e.g. fuel oil, tar). The joint production nature of the technological process implies that the optimal price of a given refined oil product is affected by the demand for all derivatives, which will generally vary over time. Moreover, there exist different refining technologies, which imply different distillate mixes. Finally, profit margins of wholesale and retail trade fluctuate over time, for instance in response to market competition.

Figure 2




(1) Total effect after 2 months, except for gas.

(2) Traditional macro model (MTBE).

Time series techniques can be used to approximate this complex process, typically under the assumption of a constant elasticity of each refined oil product with respect to the price of a reference crude, North Sea Brent crude in estimates for European countries. Time series models estimated by product category show that there is substantial heterogeneity by product type (table 5 and figure 2). Elasticities are highest for transport fuels and heating oil, where there is a contemporaneous and a one month lagged impact and are quite close in Spain and the euro area. Natural gas and butane gas prices are regulated. In Spain, their prices are set according to published formulae, which imply that only lagged effects are observed. The estimated total elasticity is 0.3. Electricity prices are also regulated, but they need not be closely linked to generation costs, in which petroleum plays a considerable less relevant role than for other energy products. These factors explain that no significant impact of oil prices is found in time series regressions explaining electricity prices.

Aggregation of these results shows a higher impact in Spain, reflecting the higher weight of oil refined products in the consumption basket. A 10% increase in the price of North Sea Brent increases the HICP energy component in Spain by 2.1 pp and by 1.7 pp in EMU.

Table 5. Time series models estimated by product category.

**Spain**

$$\Delta\, HICP transport\ \ fuels_t = \underset{(10.8)}{0.16}\,\Delta\, Pcrude_t + \underset{(9.2)}{0.13}\,\Delta\, Pcrude_{t-1}$$

Residual standard error= 1.43% $R^2$= 0.67

$$\Delta\, HICP\ heating\ oil_t = \underset{(8.0)}{0.23}\,\Delta\, Pcrude_t + \underset{(9.2)}{0.27}\,\Delta\, Pcrude_{t-1}$$

Residual standard error= 2.81% $R^2$= 0.59

$$\Delta P\ Bu\tan e\ gas_t = \underset{(8.8)}{0.37}(mm_3(Pcrude_t))_{t-2} / (mm_3(Pcrude_t))_{t-5}$$

Residual standard error= 1.88% $R^2$= 0.52

$$\Delta P\ Natural\ gas_t = \underset{(7.7)}{0.20}(mm_6(Pcrude_t^{\$}) / mm_3(Er_t))_{t-1} / (mm_6(Pcrude_t^{\$}) / mm_3(Er_t))_{t-4}$$

Residual standard error= 1.16% $R^2$= 0.45

**EMU**

$$\Delta \text{HICP transport fuels}_t = \underset{(10.7)}{0.16}\,\Delta \text{Pcrude}_t + \underset{(8.3)}{0.12}\,\Delta \text{Pcrude}_{t-1}$$

Residual standard error= 1.42% $R^2$= 0.64

$$\Delta \text{HICP heating oil}_t = \underset{(10.9)}{0.36}\,\Delta \text{Pcrude}_t + \underset{(5.0)}{0.16}\,\Delta \text{Pcrude}_{t\text{-}1}$$

Residual standard error= 3.17% $R^2$= 0.58

Definition of variables:

Pcrude: Price of crude oil (North Sea Brent) in euros
Er: euro dollar exchange rate
Pcrude$t : Price of crude oil in dollars
mm i : moving aerage of order i

Given that DSGE models do not typically consider separate sectors for oil and for the different refined oil products, estimated elasticities- which are considerably lower than 1- are useful to calibrate the initial impact of oil price changes in consumer prices, when conducting simulation exercises with such models, as in section 7.

# 4 Indirect effects on consumer prices

The indirect effect on consumer prices is considerably harder to estimate, so it is useful to consider different approaches. Among the different non-energy goods and services included in the CPI basket, oil and oil refined products are particularly relevant in the production process of some services, such as transport services. In Spain, prices of bus, underground and taxis are set by regional governments or city councils, which typically revise them once a year, and there is no clear link between the cost of providing these services and their retail prices. In contrast, air fares and railway prices are market determined and their prices are affected by developments in international oil markets. Indirectly, air fares are passed through to prices of travel packages. At any rate, the weight of air and rail transport in the HICP is only 0.5%, so its impact on headline HICP is quite limited. The small size of these effects is in line with short run elasticities of the main components of the CPI and HICP. The price of oil as an explanatory variable in short-run transfer function models, as in Álvarez and Burriel (2005), for non-energy goods and services prices (unprocessed and processed food prices, non-energy industrial goods and services prices) is not found to be significant. Further, as shown in section 6, in the quarterly macroeconomic model there is no direct impact of oil on non-energy consumer price inflation. This is in line with Hooker (2002) estimates for US core inflation or for other European countries (e.g. Jondeau et al. (1999) for France).

The lack of significant effects broadly agrees with the results of the survey on price setting behaviour carried out by the Banco de España on a sample of 2,008 industrial and services firms [Álvarez and Hernando (2007)]. One of the issues addressed in the survey questionnaire referred to the main factors driving price changes. Firms were asked to assess the importance of several factors, including energy costs, that could lead firms to increase or decrease prices.

Table 6

**Driving factors of price increases and decreases**

| Price increases | Mean scores (1) | p-value (2) | % Relevant factor (3) |
|---|---|---|---|
| A change in the cost of raw materials | 3.12 | 0.00 | 72.6% |
| A change in labour costs | 2.72 | 0.00 | 56.8% |
| A change in competitors' prices | 2.54 | 0.00 | 52.1% |
| A change in demand | 2.36 | 0.00 | 43.5% |
| **A change in energy and fuel prices** | **2.20** | **0.00** | **35.3%** |
| A change in other production costs | 2.10 | 0.89 | 32.0% |
| An improvement in design, quality or the product range | 2.09 | 0.00 | 34.0% |
| A change in productivity | 1.91 | 0.00 | 27.3% |
| A change in financial costs | 1.77 | -- | 19.4% |

| Price decreases | Mean scores (1) | p-value (2) | % Relevant factor (3) |
|---|---|---|---|
| A change in competitors' prices | 2.66 | 0.08 | 57.2% |
| A change in the cost of raw materials | 2.54 | 0.00 | 51.7% |
| A change in demand | 2.43 | 0.00 | 48.1% |
| The intention of gaining market share | 2.20 | 0.00 | 40.1% |
| A change in labour costs | 1.96 | 0.00 | 29.3% |
| A change in productivity | 1.85 | 0.01 | 25.9% |
| **A change in energy and fuel prices** | **1.83** | **1.00** | **23.1%** |
| A change in other production costs | 1.83 | 0.00 | 23.5% |
| A change in financial costs | 1.55 | -- | 13.4% |

(1) Respondents are asked in question C1 to indicate the importance of each factor, the alternative scores being: (1) unimportant, (2) of minor importance,(3) important, (4) very important.
(2) The p-value in columns 2 refers to the null hypothesis that the factor's mean scores (reported in colum 1) is
(3) % important denotes the fraction of firms rating the factor as important or very important.

Table 6 presents the ranking of driving factors behind price changes using mean scores (in a scale from 1 (unimportant) to 4 (very important)) and of the share of firms that state that a given factor is important or very important. Both measures show that energy costs are not considered by firm managers to be a major driver of price changes. In fact, only 35% of firms state that energy costs are important or very important to explain price increases. This reason is even less important for determining price cuts, since only 23% of firms report that energy costs are a relevant factor in explaining price decreases. The minor role of energy costs is also apparent in terms of the ranking of possible explanations. This reason is ranked fourth out of 9 explanatory factors in terms of price increases and fifth in terms of price decreases. Cost of other material inputs and labour costs are the main determinants of price increases. By contrast, the most relevant factors leading to price decreases are changes in competitors' prices, the cost of other raw materials, and in demand.

As expected, the survey also shows considerable sectoral heterogeneity in the role of energy as a driver of price changes. Energy prices are particularly important to explain prices in the production of energy, energy trade and also in the transport sector. In contrast, they are hardly relevant in communications and non-energy trade, so the impact on non-energy consumer prices can be expected to be quite limited.

The qualitative information from the survey on pricing behaviour is supported by quantitative national accounts data. Input-output tables provide information on the cost structure of the different industries. Indeed, it offers detailed information on the material inputs used in the different production processes, which can be used to determine the share of oil and fuels, other energy items and non-energy material inputs. Further, it provides information on labour costs, in terms of compensation per employee. As can be seen in Table 7, the share of oil and fuels costs in total costs is fairly small (3.4% in Spain, and 2.9% in EMU), except for the production of energy. These small shares suggest that indirect impacts of oil price shocks are likely to be quite limited.

Table 7

COST STRUCTURE OF DIFFERENT INDUSTRIES. INPUT OUTPUT TABLE, BASIC PRICES. YEAR 2005

| | | COST STRUCTURE (%) | | | | |
|---|---|---|---|---|---|---|
| | | OIL AND FUELS COSTS | OTHER ENERGY COSTS | OTHER INTERMEDIATE CONSUMPTION COSTS | COMPENSATION PER EMPLOYEE | TOTAL |
| SPAIN | Total economy | 3.4 | 2.0 | 61.4 | 33.2 | 100 |
| | Energy | 21.1 | 18.5 | 45.3 | 15.1 | 100 |
| | Industry | 5.7 | 1.9 | 73.8 | 18.6 | 100 |
| | Services | 1.3 | 1.3 | 54.0 | 43.4 | 100 |
| EMU (a) | Total economy | 2.9 | 1.6 | 59.3 | 36.2 | 100 |
| | Energy | 13.9 | 20.2 | 44.0 | 21.9 | 100 |
| | Industry | 5.2 | 1.6 | 71.7 | 21.5 | 100 |
| | Services | 1.2 | 0.9 | 50.9 | 47.0 | 100 |

SOURCE: Eurostat.

a. EMU: Germany, France and Spain.

The size of indirect effects of oil price changes logically depends on the efficiency and oil intensity of production processes. Oil price shocks in the early 1970s triggered the development of more energy-efficient production functions, which have reduced the use of oil per unit of output. Moreover, there have been sectoral changes in the composition of value added and production, and oil intensive industries are less important now (Martín et al. (2008)). As a result, the use of oil per unit of output was almost 20% lower than in 1973. Notwithstanding this, oil dependency in Spain is still higher than in other industrialized economies. According to data from the International Energy Agency, oil is the most relevant source of primary energy. In Spain, this share was 58% in 2005 –the last year for which there is information available, 17 pp lower than in 1973. In turn, in European OECD countries, this share was 46% in 2005, 12 pp lower than in 1973. This evidence suggests that indirect effects of oil price shocks will be smaller nowadays than they were in the past.

There is significant cross-industry heterogeneity, though. Oil intensity is very high in the transport sector, where it has hardly changed in the last decades and considerably smaller in manufacturing and the rest of the economy. A comparison of Spain with European OECD countries reveals than the oil intensity of Spanish manufacturing and transport industries is very similar, whereas it is higher for the rest of the economy.

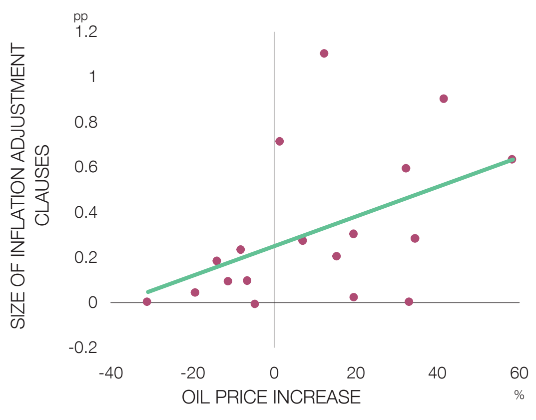
## 5 Second round effects

As mentioned above, direct and indirect effects of oil price shocks may have an impact on firms' and households' inflation expectations and on wage setting, leading to so-called second round effects. In recent decades, greater independence of central banks and price stability oriented monetary policies have contributed – against a background in which inflation has remained low- to anchor inflation expectations of private agents, although to the extent that wage setting depends on past inflation, transitory shocks on inflation lead to changes in firms' costs.

In Spain, social partners signed a collective bargaining agreement (Acuerdo Interconfederal para la Negociación Colectiva) in 2002, and this agreement has been renewed every year since then. According to the agreement, the official inflation reference target (2%) is employed in wage bargaining, and wage increases above that figure should be related to productivity increases in order to contribute to positive employment growth. In return, most settlements include indexation clauses, which come into effect whenever inflation exceeds the reference target, but not if they are below it. This has the undesirable implication that oil-related inflation increases feed through to labour costs, to the extent that indexation clauses come into effect, hindering the adjustment process of the Spanish economy (figure 3).

Figure 3

OIL PRICE INCREASES AND INFLATION
ADJUSTMENT CLAUSES (a)




SOURCE: Banco de España.

a. Annual figures: 1991-2008.

Complementary information on the likely importance of second round effects can be obtained from firms' and experts' questionnaires of the Eurosystem Wage Dynamics Network (WDN). Firm surveys on wage setting have been carried out in euro area countries (Druant et al. (2008)). Questionnaires may shed some light on the role of wage indexation, since firms were asked whether they change base wages according to inflation or not and, in that case, whether this adjustment is automatic or not, and whether it refers to past or expected inflation.

Table 8

POLICIES OF ADJUSTING BASE WAGES TO INFLATION

| | EXPERT SURVEY | FIRM SURVEY | | | | |
|---|---|---|---|---|---|---|
| | PERCENTAGE OF WORKERS COVERED BY WAGE INDEXATIONS CLAUSES | TOTAL | AUTOMATIC LINK TO PAST INFLATION | AUTOMATIC LINK TO EXPECTED INFLATION | NO FORMAL RULE. PAST INFLATION TAKEN INTO ACCOUNT | NO FORMAL RULE. EXPECTED INFLATION TAKEN INTO ACCOUNT |
| Spain | >75% | 70 | 38 | 16 | 11 | 5 |
| Euro area | | 31 | 13 | 4 | 6 | 7 |
| Germany | None | 27 | na | na | na | na |
| France | <25% | 33 | 1 | 5 | 5 | 21 |
| Italy | <25% | 6 | 1 | 1 | 3 | 2 |

SOURCES: Expert survey: Du Caju et al. (2008). Firm survey: Druant et al. (2008)

According to this firm survey, 49% of Spanish firms take into account past inflation when setting wages and 70% adjust base wages to past or expected inflation. These figures are considerably higher than in the euro area, where 19% of firms take into account past inflation and 31% past or expected inflation. Nonetheless, given that workers and firms bargain over real wages, it is surprising that a large number of firms report that past or expected inflation plays no role in wage setting, so these survey results have to be interpreted with due care. The information provided by firms in surveys on wage setting is confirmed by a questionnaire filled in by national central banks experts (Du Caju et al.(2008)). According to this survey, more than 75% of Spanish workers are covered by wage indexation clauses, whereas this share is lower than 25% in the main euro area countries. We have used these figures in the calibrations of our DSGE model. The higher role of indexation clauses in Spain suggests that second-round effects may be higher in Spain than in the main European countries.

## 6 The oil shock in a macroeconometric model

The Bank of Spain's Quarterly Model (MTBE) is a large-scale macroeconometric model used for medium term macroeconomic forecasting of the Spanish economy, as well as for performing scenario simulations. The structure of MTBE is that of a small open economy within a monetary union [See Estrada et al. (2005) and Ortega et al. (2007) for a detailed description of the model]. The model, especially in the short run, is mostly demand driven and is specified as a set of error correction equations. MTBE includes the oil price as an exogenous variable, which allows to quantify the effect on the Spanish economy of an increase in the price of oil. In this paper, we use an updated version of Ortega et al. (2007) estimates.

In MTBE[1], oil prices (pei) have a direct impact on the energy component of the harmonized index of consumer prices (hicpe) and on the deflator of imports of goods from outside the euro area (mgnd), whose estimated equations are the following:

$$hicpe^{*} = -0.19 + \underset{(-)}{0.92} pyedtrid + \underset{(0.00)}{0.08} pei$$

$$\Delta hicpe = \underset{(-)}{0.16} \Delta pyedtrid_{-1} + \underset{(0.02)}{0.64} \Delta mged + \underset{(0.00)}{0.20} \Delta pei - \underset{(0.33)}{0.08} (hicpe_{-1} - hicpe^{*}_{-1})$$

$$mgnd^{*} = 0.22 + \underset{(-)}{0.78} cmgnd + \underset{(0.00)}{0.10} pei + \underset{(0.00)}{0.12} prm - 0.20\ J932$$

$$\Delta mgnd = -0.01 + \underset{(-)}{0.23} \Delta pyed_{-2} + \underset{(0.00)}{0.31} \Delta cmgnd + \underset{(0.00)}{0.22} \Delta pei + \underset{(0.05)}{0.02} \Delta pei_{-3} + $$
$$+ \underset{(0.04)}{0.07} \Delta prm - \underset{(0.02)}{0.09} (mgnd_{-1} - mgnd^{*}_{-1})$$

According to these equations, the energy component of the HICP is an average of national (pyedtrid) and oil prices. In the long run, the estimated weight is considerably higher for domestic prices. The equation for the deflator of imports of goods from outside the euro area has a similar structure, but gives higher weights to external prices, especially in the long run.

In MTBE, it is assumed that agents consider national account deflators when taking their behavioral decisions, instead of harmonized indexes of consumer prices. As a result, changes in hicpe do not affect the rest of the economy, but those of the deflator of imports of goods from outside the euro area (mgnd) do.

The private consumption deflator (pcd) is used by households to deflate nominal income and wealth, and, more importantly in the case of an oil price shock, private sector wages. These are

[1] All variables in logs, unless stated otherwise. Δ denotes first difference. * denotes long run relationship. P-values in brackets. (-) denotes a constrained coefficient. The definition of the variables used in these equations is as follows:
cmged: prices of competitors of imports of goods from the euro area
cmgnd: prices of competitors of imports of goods from outside the euro area
hicpe: energy component of harmonized index of consumer prices
hicpne: non-energy component of harmonized index of consumer prices
mged: deflator of imports of goods from the euro area
mgnd: deflator of imports of goods from outside the euro area
mgndpei: deflator of imports of goods from outside the euro area without oil
msd: deflator of imports of services
pcd: deflator of private consumption
pei: international price of oil, in euros
pln: private sector employment
prm: international price of raw materials, in euros
pwun: private sector wages
pyed: deflator of private value added
pyedrid: deflator of private VA without housing
pyedtrid: deflator of private VA without housing with taxes
pyer: private value added
twed: tax wedge (created by taxes on labour compensation)
URX: unemployment rate (level)
J932: step dummy in 1993Q2
Drift99: drift, starting in 1999
AcDrift99: accumulated wage drift since 1999

modelled as the result of a bargaining process between firms and workers, which take real average productivity (pyer-pln) as a benchmark, but use production and consumption deflators, respectively, to deflate nominal wages (pwun). This creates a link of wages to current consumer and producer price inflation (in the short run) and also to past inflation (through its deviation from the long-run equilibrium value). The equations for the private consumption deflator and nominal wages are as follows:

$$pcd^{*} = -0.01 + \underset{(0.00)}{0.87} pyedrid + \underset{(-)}{0.08} mged + \underset{(-)}{0.05} mgnd + \underset{(-)}{0.01} msd$$
$$\Delta pcd = 0.00 + \underset{(-)}{0.85} \Delta pyedrid + \underset{(0.04)}{0.07} \Delta mged + \underset{(0.00)}{0.08} \Delta mgnd - \underset{(0.09)}{0.31} (pcd_{-1} - pcd^{*}_{-1})$$

$$pwun^{*} = -0.93 + [(\underset{(-)}{0.41} pyed + \underset{(0.00)}{0.59} pcd) + (pyer - pln)] - twed - \underset{(0.05)}{0.18} URX + \underset{(0.00)}{0.004} AcDrift99$$
$$\Delta pwun = \underset{(0.00)}{0.45} [(\underset{(0.00)}{0.43} \Delta pyed + \underset{(-)}{0.57} \Delta pcd) + (pyer - pln)] - \underset{(0.07)}{0.40} URX_{-3} +$$
$$+ \underset{(0.00)}{0.002} Drift99 - \underset{(0.00)}{0.22} (pwun_{-1} - pwun^{*}_{-1})$$

The deflator of private value added (pyed) is the main price channel in MTBE. It is assumed that the representative firm has a certain degree of market power and is thus able to price its product at a certain margin above its marginal costs, which, given the Cobb Douglas technology used, equals unit labour costs. Firms' margins are modelled as a function of the level of external competition, which means that increases in competitors' prices (cxged) reduce competition from the external sector and permit Spanish firms to increase their margins. Domestic prices are therefore a weighted average of domestic and external factors. As a consequence, both the deflator of imports of goods (mgd) and private sector wages, appear in the equation for the deflator of private value added:

$$pyed^{*} = -0.74 + \underset{(-)}{0.56} (pyer - pkr) - \underset{(-)}{0.0005} TFP + \underset{(-)}{0.92} pwun + \underset{(0.00)}{0.08} cxged + \underset{(0.00)}{0.005} T99$$
$$\Delta pyed = 0.01 + \underset{(0.07)}{0.10} \Delta mgd_{-1} + \underset{(0.04)}{0.11} \Delta mgd_{-1} + \underset{(0.01)}{0.27} \Delta pwun +$$
$$+ \underset{(0.12)}{0.16} \Delta pwun_{-1} - \underset{(0.08)}{0.22} (pyed_{-1} - pyed^{*}_{-1})$$

Changes in this private value added deflator affect most pricing decisions in the model. For instance, in the case of the non-energy component of the HICP, whose equation is, as in the case of all other prices, an aggregator of internal and external prices, we have:

$$hicpne^{*} = -0.15 + \underset{(0.00)}{0.80} pyedtrid + \underset{(-)}{0.14} mged + \underset{(-)}{0.06} mgndpei + \underset{(-)}{0.01} msd$$
$$\Delta hicpne = 0.00 + \underset{(-)}{0.80} \Delta hicpne_{-2} + \underset{(0.02)}{0.20} \Delta pyedtrid - \underset{(0.05)}{0.13} (hicpne_{-1} - hicpne^{*}_{-1})$$

Given the propagation mechanisms that have just been explained, the impact of a 10% rise in the price of oil on the Spanish economy, according to MTBE, would be as summarized in the first block of table 9 (endogenous wages).

As can be seen, the increase in the price of oil is quickly passed through to consumer prices. After one year, the energy component of HICP rises by 1.8 pp and import prices by 0.9 pp. Besides the direct impact, there are some indirect and second round effects at work. Wages react to a lesser extent than consumer or import prices, but their rise in response to higher inflation makes labour as a productive input relatively less attractive to firms, which hire less people and invest more[2]. Households' disposable income falls, due to lower employment and real wages, so households restrain their expenses, both in consumption and in housing investment. This lower demand in the medium term prompts firms to hire even less people, and also has a negative impact on investment.

Table 9

Effects from a 10% rise in the price of oil according to MTBE

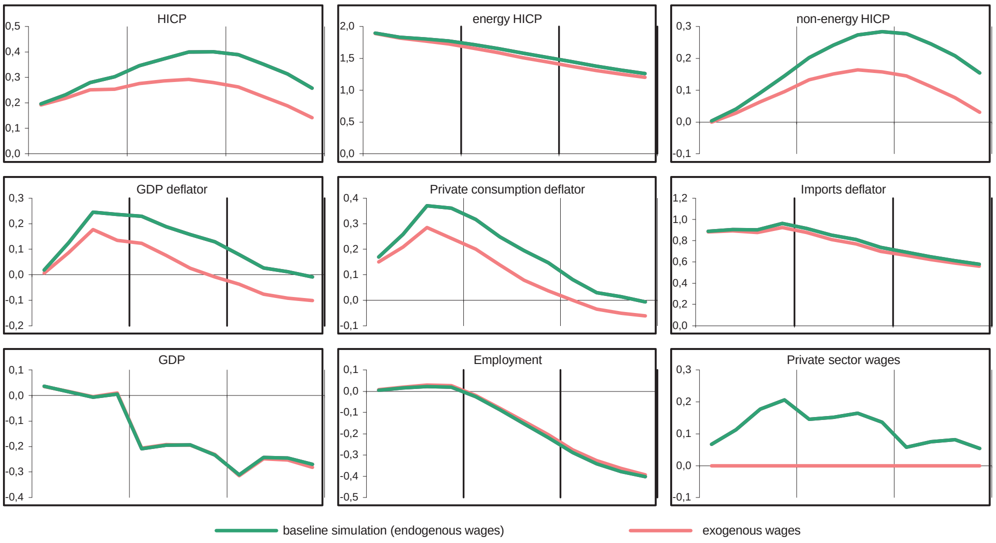
| Accumulated percentage differences from base scenario | endogenous wages | | | exogenous wages | | |
|---|---|---|---|---|---|---|
| | year 1 | year 2 | year 3 | year 1 | year 2 | year 3 |
| 1. PRICES AND COSTS | | | | | | |
| Harmonized index of consumer prices (HICP) | 0.25 | 0.38 | 0.33 | 0.23 | 0.28 | 0.20 |
| Non-energy component of HICP | 0.07 | 0.25 | 0.22 | 0.05 | 0.15 | 0.09 |
| Energy-component of HICP | 1.79 | 1.59 | 1.33 | 1.77 | 1.53 | 1.27 |
| GDP deflator | 0.16 | 0.18 | 0.03 | 0.10 | 0.05 | -0.08 |
| Private consumption deflator | 0.29 | 0.23 | 0.03 | 0.22 | 0.11 | -0.04 |
| Deflator of exports of goods and services | 0.06 | 0.12 | 0.00 | 0.04 | 0.05 | -0.04 |
| Deflator of imports of goods and services | 0.91 | 0.83 | 0.63 | 0.89 | 0.79 | 0.61 |
| Unit labour costs | 0.09 | 0.25 | 0.08 | 0.00 | 0.10 | -0.03 |
| Compensation per employee | 0.08 | 0.17 | 0.16 | 0.00 | 0.01 | 0.03 |
| 2. ACTIVITY (constant prices) | | | | | | |
| GDP | 0.01 | -0.21 | -0.27 | 0.01 | -0.21 | -0.27 |
| Private consumption | -0.04 | -0.09 | -0.18 | -0.04 | -0.09 | -0.20 |
| Public consumption | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gross fixed capital formation | 0.06 | -0.11 | -0.39 | 0.04 | -0.21 | -0.47 |
| Exports of goods and services | -0.01 | -0.09 | -0.06 | -0.01 | -0.05 | -0.01 |
| Imports of goods and services | -0.06 | 0.12 | -0.07 | -0.08 | 0.08 | -0.08 |
| Contributions to growth of real GDP | | | | | | |
| National demand (difference in levels) | 0.00 | -0.08 | -0.21 | -0.01 | -0.11 | -0.24 |
| Net exports (difference in levels) | 0.02 | -0.05 | 0.01 | 0.03 | -0.03 | 0.03 |
| 3. OTHER VARIABLES | | | | | | |
| Unemployment rate (difference in levels) | -0.01 | 0.08 | 0.20 | -0.01 | 0.07 | 0.19 |
| Employment | 0.02 | -0.12 | -0.35 | 0.02 | -0.11 | -0.34 |
| Real disposable income | -0.17 | -0.24 | -0.19 | -0.15 | -0.25 | -0.24 |

To approximate the impact of the endogeneity of wages, an additional simulation has been carried out, taking wages as exogenous, thus shutting down the second round effects that come through wage indexation and the ordinary response of wages. The results of this exercise are summarized in the second block of table 9 (exogenous wages), and compared to the results of the baseline simulation in figure 4.

[2] A shortcoming of MTBE is made clear here: the model is not forward-looking and it does not include relevant supply-side effects that would more than offset this positive effect on investment. It also does not include oil as a production input, hence underestimating the higher production costs associated with higher oil prices.

Figure 4

**Effects from a 10% rise in the price of oil with endogenous and exogenous wages**




These results help pin down the quantitative importance of the most relevant second-round effects in the model, namely the mutual feedback from prices to wages that arises in a framework in which firms set prices on the basis of their marginal cost and workers care about their real purchasing power when bargaining wages. The results from this simulation with exogenous wages show that limiting the response of wages to transitory changes in inflation would have some impact on price setting, although its magnitude is limited.

As a summary of the results from MTBE, table 10 breaks down the total effect obtained from the baseline simulation in three components: the direct impact, as estimated in the model, the additional indirect effect captured by the simulation with exogenous wages, and the second-round effects that are obtained by the difference between simulations with endogenous and exogenous wages. The last line of the table reports a range of estimates of total effects in the euro area as a whole, obtained from other large-scale macroeconomic models such as the Area Wide Model (European Central Bank), the QUEST model (European Commission), NiGEM (National Institute of Economic and Social Research), the Interlink model (OECD) and Multimod (IMF). As can be seen, the MTBE-based total effect on Spanish inflation falls within the latter range of estimates.

Table 10

Impact of a 10% rise in the international price of oil

| | Inflation | | GDP (rate of growth) | |
|---|---|---|---|---|
| | Year 1 | Year 2 | Year 1 | Year 2 |
| Total effect (1) | 0.25 | 0.13 | 0.01 | -0.22 |
| Direct effect (2) | 0.20 | 0.00 | 0.00 | 0.00 |
| Indirect effect (3) | 0.03 | 0.05 | 0.01 | -0.22 |
| Second-round effect (4) | 0.02 | 0.07 | 0.00 | 0.00 |
| Euro area total effect (5) | 0.06 to 0.32 | 0.02 to 0.22 | -0.02 to -0.16 | -0.06 to 0.04 |

(1) Results from baseline simulation with MTBE.
(2) Coefficients in equations, and weight of energy in total HICP.
(3) Results from simulation with exogenous wages, minus (2).
(4) Results from baseline simulation minus (2) minus (3).
(5) Results for the euro area from other large-scale macroeconomic models (ECB AWM, EC QUEST, NiGEM, OECD Interlink, IMF Multimod)

According to these results, the main inflationary impact on the first year in Spain corresponds to the direct one, whereas in the second year second-round effects and indirect effects become more relevant. Note, however, that the quantitative impact of indirect and second round effects is limited.

The inflationary impact for the euro area differs substantially according to the model used, but in general effects for the second year are considerably lower than for the first year, and oil shocks have a smaller real impact than the nominal one. In Spain, oil price shocks are transmitted more slowly to GDP than to inflation and the impact on the second year is higher than that of the first one, whereas in the euro area the largest impact is on the first year.

# 7 General equilibrium effects of an oil price shock

An alternative approach to analyzing the effects of an oil shock on the Spanish economy is to use a micro-founded, general equilibrium model where households consume oil related products and oil is an input in the production function of firms. This becomes especially useful when it comes to performing counter-factual simulations that allow to understand the interaction between particular structural features of the economy and the effects of the oil shock. Specifically, we use the Bank of Spain DSGE model of the Spanish economy (BEMOD). We refer the reader to Andrés et al. (2006) and Andrés et al.(2009) for the details of the model properties and estimation. Here, on the theoretical side, we limit ourselves to presenting the main features of the model, paying special attention to the role of oil in consumption and production decisions and in price and wage dynamics. On the empirical side, we carry out a careful calibration of some parameters and describe the estimation process of the rest of the parameters.

## 7.1 Overview of the model

The model considers three economies: Spain, the rest of the euro area (both of which are subject to a common monetary policy), and the rest of the world, which is treated as exogenous. The Eurosystem is assumed to set nominal interest rates according to a Taylor rule featuring euro area headline CPI inflation (which includes consumer energy prices) and output growth, along with a certain degree of interest rate smoothing. The different economies are linked by trade flows. There are two sectors of activity in each endogenous country block: tradables and non-tradables. The model displays the usual real frictions in the current vintage of DSGE models, such as habit formation in consumption, investment adjustment costs and variable capital utilization. Nominal prices and nominal wages are both subject to adjustment *à la* Calvo (1983) and backward-looking indexation.

We assume that Spain and the euro area are oil importers and that the dollar price of oil is exogenous. The consumption basket of households, $c_t$, is a CES basket of tradable goods, $c_{T,t}$, and non-tradable goods, $c_{N,t}$. Cost minimization by households implies that nominal consumption spending equals $P_t^C c_t$, where

$$P_t^C = \left[\omega_N P_{N,t}^{1-\varepsilon^C} + \omega_T P_{T,t}^{1-\varepsilon^C}\right]^{1/\left(1-\varepsilon^C\right)}$$

is the Consumer Price Index (CPI), $P_{N,t}$ is the price index of non-tradable goods, $P_{T,t}$ is the price index of tradable goods, $\{\omega_N, \omega_T\}$ are the corresponding weights and $\varepsilon^C$ is the elasticity of substitution between both types of consumption. The basket of tradable consumption goods is given in turn by a CES aggregator. The corresponding price index of tradable consumption goods is given by

$$P_{T,t} = \left[\omega_H P_{H,t}^{1-\varepsilon^T} + \omega_F P_{F,t}^{1-\varepsilon^T} + \omega_{RW} P_{RW,t}^{1-\varepsilon^T} + \omega_{oil} P_{oil,t}^{1-\varepsilon^T}\right]^{1/\left(1-\varepsilon^T\right)},$$

where $P_{H,t}$ is the price index of home tradable goods, $P_{F,t}$ and $P_{RW,t}$ are the price indexes of goods from the rest of the Euro Area and the rest of the World, respectively, $P_{oil,t}$ is the Euro price of oil, $\varepsilon^T$ is the elasticity of substitution between the different types of tradable goods and $\omega_{oil}$ measures the weight of oil consumption in the basket of tradables. The direct impact of an oil price shock on CPI inflation is largely determined by the latter parameter.

The indirect impact of the oil price shock will depend on the prices of the other components of the consumption basket. The price indexes of non-tradable consumption goods and tradables consumption goods produced at home are given by $P_{N,t} = \pi_t^N P_{N,t-1}$ and $P_{H,t} = \pi_t^T P_{H,t-1}$, respectively, where $\pi_t^S$ is producer price inflation in each sector $S = \{N, T\}$. Firms in sector $S$ reset prices optimally with probability $\theta^S$ each period, regardless of the time elapsed since the last adjustment. The fraction of firms that cannot reset prices optimally adjust them according to an indexation rule to catch up with lagged sectoral inflation. In the log-linear approximation of the model, producer price inflation in sector $S$ is given by

$$\pi_t^S - \psi^S \pi_{t-1}^S = \frac{\left(1-\theta^S\right)\left(1-\beta\theta^S\right)}{\theta^S} mc_t^S + \beta E_t\left(\pi_{t+1}^S - \psi^S \pi_t^S\right), \quad (1)$$

where $\beta$ is a discount factor, $\psi^S$ is the degree of backward-looking indexation and $mc_t^S$ is the sector-specific real marginal cost. The parameter $\psi^S$ allows to consider no price indexation ($\psi^S = 0$), as in the standard Calvo model, or full price indexation ($\psi^S = 1$), as in Christiano et al. (2005). Real marginal costs are determined by the cost-minimization problem of firms. Output in sector

$S = \{N, T\}$ is given by the following CES production function,

$$y_{S,t} = \left\{ \chi_S^{1/\varphi^S} o_{S,t}^{\left(\varphi^S-1\right)/\varphi^S} + \left(1-\chi_S\right)^{1/\varphi^S} \left[ \left(cu_{S,t}k_{S,t}\right)^{\alpha^S} n_{S,t}^{1-\alpha^S} \right]^{\left(\varphi^S-1\right)/\varphi^S} \right\}^{\varphi^S/\left(\varphi^S-1\right)},$$

where $o_{S,t}$, $k_{S,t}$ and $n_{S,t}$ are oil, capital and labor inputs, respectively, $cu_{S,t}$ is capital utilization (equal to 1 in the steady state), $\alpha^S$ is the capital share of value added, $\varphi^S$ is the elasticity of substitution between oil and the other inputs in the production function and $\chi_S$ is a weight parameter that measures the importance of oil in the production process. Subject to the production function, cost minimization by firms implies the following expression for real marginal cost,

$$mc_t^S = \frac{p_t^{oil}}{\partial y_{S,t}/\partial o_{S,t}},$$

where $p_t^{oil}$ is the real price of oil and $\partial y_{S,t}/\partial o_{S,t}$ is the marginal productivity of the oil input. Ceteris paribus, an increase in the real price of oil will push up real marginal costs and, from equation (1), producer price inflation. In the rest of the Euro Area, producer price inflation of tradable goods is given by an equation analogous to (1), for $S = T$, which in turn determines the evolution of $P_{F,t}$.

On the other hand, labor demand in Spain depends critically on the evolution of nominal wages, $W_t$. The latter evolve according to $W_t = \pi_t^W W_{t-1}$, where $\pi_t^W$ is nominal wage inflation. Following Erceg et al. (2000), we assume that nominal wages are set by the workers (who act as monopolistic suppliers of labor), and that each period only a fraction $\theta^W$ of workers reset optimally their nominal wage. Those workers that do not optimally adjust wages adapt them automatically in line with a multiple $\psi^W$ of CPI inflation, $\pi_{t-1}^{CPI} \equiv P_t^C/P_{t-1}^C$. Up to a first order approximation, wage inflation is given by

$$\pi_t^W - \psi^W \pi_{t-1}^{CPI} = \frac{\left(1-\theta^W\right)\left(1-\beta\theta^W\right)}{\theta^W\left(1+\varepsilon^W \iota\right)} mrs_t + \beta E_t\left(\pi_{t+1}^W - \psi^W \pi_t^{CPI}\right),$$

where $\varepsilon^W$ is the elasticity of substitution between different types of labour services, $\iota$ is the inverse of the Frisch elasticity of labour supply and $mrs_t$ is the marginal rate of substitution between consumption and labour. The parameter $\psi^W$ allows to consider no wage indexation ($\psi^W$ =0) as in the standard Calvo model or full wage indexation ($\psi^W = 1$).

Finally, monetary policy is conducted by means of a Taylor rule,

$$R_t = \rho_R R_{t-1} + \left(1-\rho_R\right)\left[\bar{R} + \rho_\pi EA\pi_t^{CPI} + \rho_y \log\left(EAy_t/EAy_{t-1}\right)\right],$$

where $R_t$ is the nominal interest rate set by the ECB, $\bar{R}$ is its steady-state level, $EA\pi_t^{CPI}$ is Euro-Area-wide CPI inflation and $EAy_t$ is Area-wide GDP. The weight of Spain's CPI inflation ($\pi_{t-1}^{CPI}$) on Euro-Area CPI inflation equals 10%, which corresponds roughly to Spain's share of the Euro Area economy.

## 7.2 Parameterization

### 7.2.1 Calibration

Regarding the calibration used, oil shares in production for each sector are set using information from input-output tables, as in Andrés et al. (2006), for Spain, France, Germany and Italy, where the latter 3 countries are used as a proxy for EMU (excluding Spain). As can be seen in Table 11, sectoral oil shares in production are similar in both economies, although they are somewhat higher in Spain. The elasticity of substitution between oil and value-added is set to 0.2, in order to capture the relatively low substitutability between oil and other inputs at business cycle frequencies. This value is also used in Medina and Soto (2005) and Hunt (2006). The share of oil in the consumption basket in Spain and the euro area is set to the 2008 weight in the Harmonized Index of Consumer Prices of oil refined products (transport fuels and heating oil), as reported in section 3.

Table 11. Calibrated parameters

| Parameter | Spain | Rest of EMU | Description |
|---|---|---|---|
| $\chi_T$ | 0.137 | 0.113 | oil share in tradables production |
| $\chi_N$ | 0.006 | 0.003 | oil share in non-tradables production |
| $\varphi^T, \varphi^N$ | 0.2 | 0.2 | elasticity of substitution in the production fct. |
| $\omega_{oil}$ | 0.062 | 0.055 | oil share in the consumption basket |
| $\iota$ | 2 | 2 | inverse of labour supply elasticity |
| $\varepsilon^W$ | 4 | 4 | elasticity of subst. across labour varieties |

## 7.3 Estimation

The parameters which are not calibrated (shock parameters, Calvo and indexation parameters, habit formation, investment adjustment costs and Taylor rule coefficients) are estimated using Bayesian methods. Formally, Bayesian estimation consists of finding the parameter vector that maximizes the product of the likelihood function (which gauges the model's ability to match the observables series for given parameter values) and the density of the joint prior distribution of the estimated parameters (thereby giving more weight to those parameter values that are more plausible according to the researcher's priors). By introducing priors in the estimation procedure, we can exploit non-sample information regarding the values of the estimated parameters, such as micro-level data on the duration of nominal prices and nominal wages.

Table 12 contains the means of the prior distributions assumed in the estimation.[3] The prior means of the Calvo price parameters are based on studies that employ individual price data to compute frequencies of price adjustment [Álvarez and Hernando (2006) and Dhyne et al. (2006)]. Specifically, we consider that price stickiness in the tradable sector in Spain is similar to that in the

[3] All parameters are assumed to be independently distributed, such that the joint density is simply the product of individual densities. Parameters are assumed to be normally distributed, except for bounded ones, which are assumed to be beta distributed.

euro area and consider a mean duration of 4 quarters, which implies $\theta^T = 0.75$.[4] For non-tradables, the evidence points to higher durations. We consider durations of 5 quarters for the euro area and 6 quarters for Spain, to allow for higher price stickiness in Spain. Studies using survey data on wage setting provide a basis for the prior means of the Calvo wage parameters and the degrees of indexation to CPI inflation [du Caju et al. (2008), Druant et al.(2008)]. In particular, we consider that the average duration of a wage contract is 4 quarters in both areas and, as discussed in section 5, Spain has a considerably higher degree of wage indexation. For wage indexation, we choose values of 0.75 and 0.25 for Spain and EMU, respectively, reflecting the more widespread use of indexation clauses in collective wage agreements in Spain.

Table 12. Prior means for the estimated parameters

| Parameter | Spain | Rest of EMU | Distribution | Description |
|---|---|---|---|---|
| $\theta^T$ | 0.75 | 0.75 | Beta | Calvo parameter, tradables |
| $\theta^N$ | 0.83 | 0.80 | Beta | Calvo parameter, non-tradables |
| $\theta^W$ | 0.75 | 0.75 | Beta | Calvo parameter, wages |
| $\psi^T$ | 0.30 | 0.30 | Beta | indexation, tradables |
| $\psi^N$ | 0.40 | 0.40 | Beta | indexation, non-tradables |
| $\psi^W$ | 0.75 | 0.25 | Beta | indexation, wages |
| $\gamma$ | 0.70 | 0.70 | Beta | habit formation parameter |
| $\Phi$ | 4.00 | 4.00 | Normal | convexity investment adjustment costs |
| $\rho_\pi$ | 1.50 | | Normal | Taylor rule, inflation |
| $\rho_y$ | 0.50 | | Normal | Taylor rule, output growth |
| $\rho_R$ | 0.90 | | Normal | Taylor rule, lagged interest rate |

The model is estimated using quarterly data for Spain and EMU on year-on-year CPI inflation, growth rates of real GDP, real private consumption, real private investment, employment in the tradable and non-tradable sectors, real wages and total real exports, as well as euro nominal interest rates and dollar nominal interest rates (as a proxy for world nominal interest rates). Our sample period is 1997:Q1-2007:Q4. Table 13 contains the posterior estimates of those parameters that are relevant for our subsequent analysis. The estimates are fairly precise, with a few exceptions (such as investment adjustment costs). By comparing the parameter estimates with their priors in Table 12, we can see that the sample information seems to confirm the prior insight from micro studies that tradable prices are more flexible than non-tradable prices ($\theta^T < \theta^N$). On the other hand, aggregate data suggests that price indexation in both production sectors is somewhat lower than what micro studies indicate. The posterior estimate of the wage indexation parameter coincides with its prior mean, indicating a strong influence of the prior distribution on the posterior one.[5] Investment adjustment costs are estimated to be higher in EMU, suggesting that investment is less

[4] In the Calvo model, the mean duration of price/wage contracts ($d$) is given by $d = 1/(1-\theta)$, where $\theta$ is the constant probability of price/wage adjustment. This implies $\theta = 1 - 1/d$.

[5] When comparing the prior and posterior distributions of the wage indexation parameter (not shown here), we find that the latter is virtually on top of the former, which suggests that our aggregate data set does not contain much information about this parameter.

volatile in EMU, but this probably reflects an aggregation effect. Finally, estimates of the Taylor rule coefficients turn out to be quite close to their prior means.

Table 13. Posterior parameter estimates

| Parameter | Spain | Rest of EMU | Description |
|---|---|---|---|
| $\theta^T$ | 0.69 | 0.83 | Calvo parameter, tradables |
| | (0.05) | (0.03) | |
| $\theta^N$ | 0.91 | 0.94 | Calvo parameter, non-tradables |
| | (0.03) | (0.01) | |
| $\theta^W$ | 0.64 | 0.69 | Calvo parameter, wages |
| | (0.07) | (0.05) | |
| $\psi^T$ | 0.10 | 0.19 | indexation, tradables |
| | (0.08) | (0.13) | |
| $\psi^N$ | 0.31 | 0.32 | indexation, non-tradables |
| | (0.16) | (0.16) | |
| $\psi^W$ | 0.75 | 0.15 | indexation, wages |
| | (0.18) | (0.13) | |
| $\gamma$ | 0.45 | 0.45 | habit formation parameter |
| | (0.07) | (0.07) | |
| $\Phi$ | 0.98 | 2.79 | convexity investment adjustment costs |
| | (0.40) | (1.15) | |
| $\rho_\pi$ | 1.38 (0.14) | | Taylor rule, inflation |
| $\rho_y$ | 0.43 (0.12) | | Taylor rule, output growth |
| $\rho_R$ | 0.79 (0.03) | | Taylor rule, lagged interest rate |

Note: standard errors of parameter estimates in parenthesis

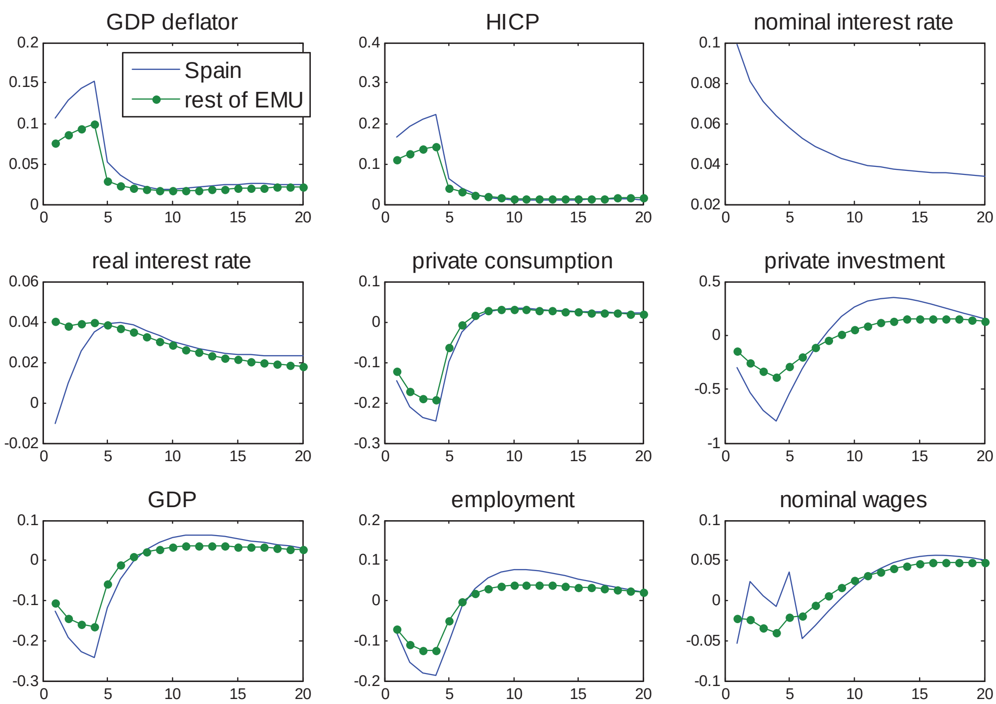
### 7.4 The effects of an oil price shock

We now simulate how the Spanish economy and the rest of EMU respond to an oil price shock in the estimated model. The size of the shock is chosen as follows. Our intention in this exercise is to simulate the effects of a rise in the dollar price of crude oil of 10%. In its current version, BEMOD abstracts from imperfect pass-through of crude oil prices to the consumer prices for refined oil products paid by households. As discussed in section 3, a rise in crude oil prices of 10% has an impact of 2.1% on the energy component of Spanish CPI inflation, so we now simulate the response of the Spanish and EMU economies to a shock of this size. We assume that this particular shock is very persistent, by setting its autocorrelation coefficient to 0.95, which implies a half-life of 13.5 quarters for the shock.[6]

[6] The half-life of a shock to an AR(1) process is defined as the number of periods that must elapse until the process returns to one half of its impact value. Letting $\rho$ denote the autocorrelation coefficient of the AR(1) process, the half-life of the shock is given by $\log(0.5)/\log(\rho)$.

Figure 5 plots the impulse responses in Spain and the rest of EMU. The fall in oil prices brings about a rise in inflation, as measured by the Harmonized Index of Consumer Prices (HICP). This takes place both through a direct effect, via refined oil products in the consumption basket, and an indirect effect, via the increase in the price of the oil input, which is used in the production of tradables and non-tradables. Notice that producer prices, as measured by the GDP deflator, rise faster in Spain than in EMU, due to a greater weight of oil both in tradables and non-tradables. This, together with a greater weight of oil expenditures in the consumption basket, produces a larger rise in Spanish inflation.[7] The increase in HICP inflation in the euro area leads the Eurosystem to raise nominal interest rates. This depresses consumption and investment growth in EMU. In Spain, consumption drops by a similar amount, whereas private investment experiences a somewhat larger drop. Overall, Spanish GDP growth falls by more than in EMU, an effect which is reinforced by the fact that Spanish exports are more dependent on domestic demand in the rest of EMU than viceversa. In both regions, employment falls as a result of weaker demand. Notice however that the effects on GDP and employment growth are rather small.

Figure 5. Impulse responses to an oil price shock, baseline model




All variables in year-on-year growth rates (%), except nominal interest rate in annual terms.

Table 14 compares the effects of the shock on Spanish year-on-year CPI inflation and GDP growth in MTBE (the quarterly macroeconomic model presented in section 6) and in BEMOD.

[7] When decomposing the response of HICP inflation into a direct effect and an indirect effect, we find that the direct effect dominates in the first year after the shock (0.13% vs. 0.07% on average), but the indirect effect dominates afterwards, due to its greater persistence.

As can be seen, the effects on CPI inflation are broadly similar in both models, although they are somewhat smaller in BEMOD (especially in the second year after the shock). Regarding GDP growth, both models predict a different adjustment pattern, with a delayed response in MTBE and a more immediate response in BEMOD. This difference is largely due to the forward-looking nature of expenditure decisions in BEMOD, as opposed to the purely backward-looking structure in MTBE.

Table 14. Effects of a 10% rise in oil prices in MTBE and BEMOD[8]

| | yoy CPI inflation | | yoy GDP growth | |
|---|---|---|---|---|
| | Year 1 | Year 2 | Year 1 | Year 2 |
| MTBE | 0.25 | 0.13 | 0.01 | -0.22 |
| BEMOD | 0.20 | 0.04 | -0.20 | -0.04 |

Note: annual averages of quarterly values, in %

These baseline results have to be interpreted with care. First, our analysis assumes that the increase in government tax revenue due to the oil price increase has no effect on equilibrium dynamics. To the extent that tax windfalls affects the government's fiscal policy and households are non-Ricardian, our quantitative results may be affected somewhat. Second, our exogenous treatment of the rest of the world implies, inter alia, that we do not consider the contractionary impact in real activity in the rest of the world non-oil producing countries and also ignore the effects of the oil windfall on spending decisions of oil-producing countries.

### 7.4.1 Second-round effects from wage indexation

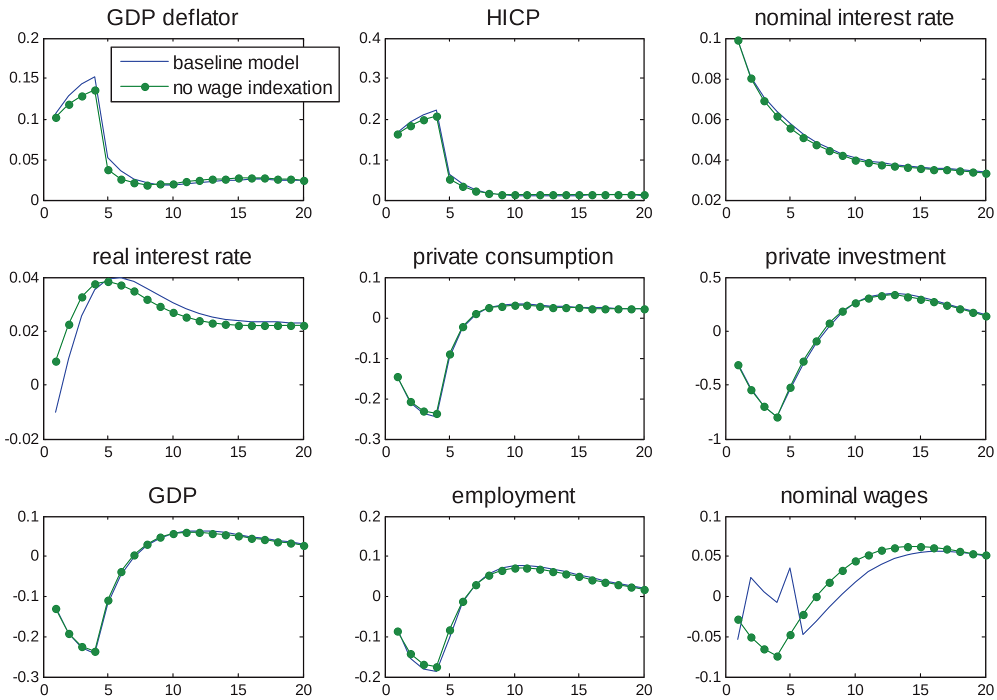
Spain's relatively high degree of wage indexation may hinder the necessary adjustment of wages in response to shocks and thus have damaging consequences for output and employment. Furthermore, to the extent that wages are linked to CPI inflation, the rise in the latter produced for instance by an oil shock is bound to raise labour and non-labour production costs for firms, with the resulting second-round effects on CPI inflation.

In order to isolate the effect of wage indexation on the Spanish economy, we now perform a second exercise in which we simulate the same oil price shock under the assumption that wage indexation is zero both in Spain and the rest of EMU. The baseline calibration remains unchanged otherwise. Figure 6 compares the responses of Spanish variables in this counter-factual scenario with those in the baseline model. As expected, both GDP deflator inflation and CPI inflation increase to a lesser extent in the counter-factual scenario, thanks to the absence of second-round effects. The same can be said about the response of GDP growth. The main difference between both scenarios is in the response of nominal wage inflation. In the absence of wage indexation, nominal wage growth falls due to weaker labor demand. Notice that employment growth is nearly identical

[8] Note that these simulations are not completely homogenous, as the MTBE shock is permanent, while such a shock cannot be implemented in BEMOD. If we modify the MTBE shock to follow the path of the one applied to BEMOD, the effect on CPI inflation is 0.24 percentage points in the first year and 0.09 in the second year, while the effect on GDP growth in the second year becomes -0.20 percentage points.

in both scenarios, due to the fact that employment is largely demand-determined in BEMOD and the fact that the GDP response is virtually the same. However, these quantitative results have to be interpreted with care, among other reasons because indexation and wage setting are modelled in BEMOD using standard specifications which could be improved along the following lines: first, wages in the model are indexed to the quarter on quarter inflation rate of the previous quarter, whereas in Spain wage contracts are indexed to the year-on-year inflation rate of December of the previous year, which would imply longer inertia; second, wages are assumed to be set *à la* Calvo, instead of having a predetermined duration established in the wage contract, as is typically the case. We leave these modifications for future research.

Figure 6. Impulse responses to an oil price shock, baseline model vs. no wage indexation



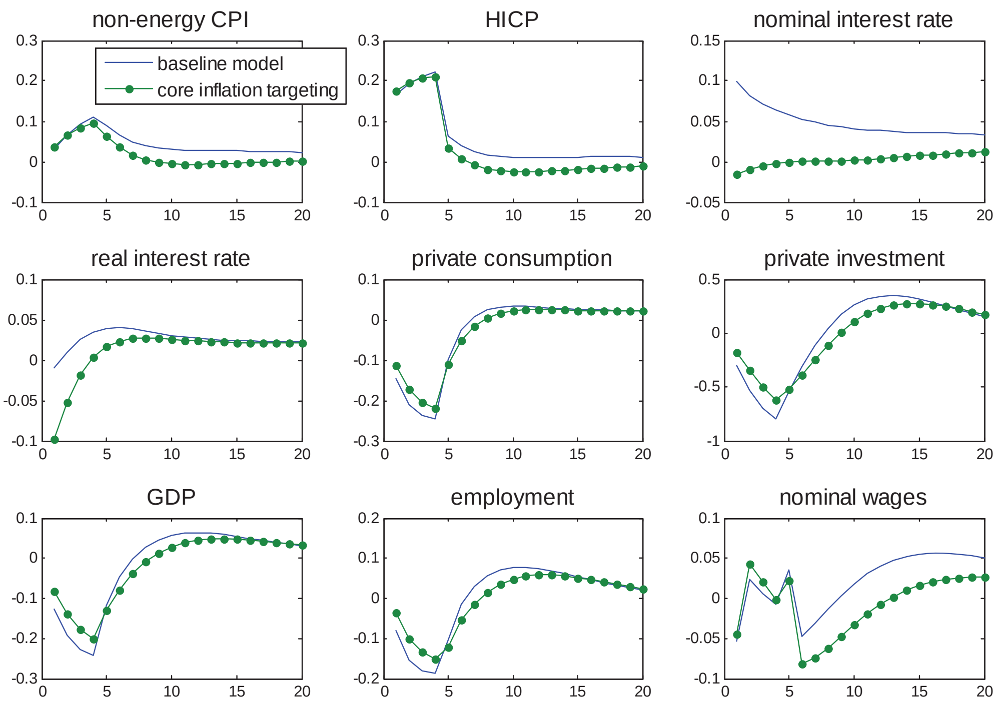

All variables in year-on-year growth rates (%), except nominal interest rate in annual terms.

### 7.4.2 Core inflation targeting

A maintained assumption in our previous two exercises is that the Eurosystem targets headline consumer price inflation, consistently with its mandate of keeping this measure of price stability below but close to 2%. As emphasized by a number of authors [e.g. Aoki (2001)], there are good reasons why central banks should target core inflation, which excludes increases in the price of oil. In particular, to the extent that oil prices are not subject to nominal rigidities, but the other components of the consumption basket are (which seems to be the empirically relevant case), then the central bank should focus on the stabilization of the core price index, rather than the overall index. By not reacting to changes in such a volatile variable as the oil price, the central bank can also avoid unnecessary fluctuations in its policy instrument and the resulting instability in economic activity.

In order to isolate the importance of this effect, we now perform a third exercise, which consists of simulating the oil price shock under the assumption that it is core inflation that enters the Taylor rule for the nominal interest rate[9]. Figure 7 compares the impulse responses in this counterfactual scenario with those in the baseline model. As expected, non-energy (or core) inflation reacts less than headline CPI inflation in both scenarios. Under core inflation targeting, the effect of the deterioration in GDP growth on monetary policy counteracts the effect of the increase in core inflation, such that nominal interest rates actually remain nearly constant. As a result, real interest rates drop in the counterfactual scenario. This has beneficial effects on private consumption and private investment in both regions during the first year after the shock. As a result, the fall in GDP and employment in the first year is also smaller. However, the quantitative differences between both scenarios are again small.

Figure 7. Impulse responses to an oil price shock, baseline model vs. core inflation targeting




All variables in year-on-year growth rates (%), except nominal interest rate in annual terms.

[9] In this counterfactual exercise, the coefficients of the Taylor rule are kept at their estimated values, as there is no obsevable world in which the ECB targets core inflation, on which we could estimate this new Taylor rule. If we ignore the misspecification and estimate a core-inflation-targetting Taylor rule with the available observed data in the context of BEMOD, we obtain very similar parameter values, with a just slightly lower response to (core) inflation and a slightly bigger response to output.

## 8 Conclusions

Oil price shocks of the 1970s had a marked inflationary impact, when inflation reached two digits in industrialized economies and close to 25% in Spain, and also a sizable contractionary effect on output and employment. Inflation and output developments in the 21st century, though, seem to call into question the relevance attached to oil price changes as a significant source of macroeconomic fluctuations.

In fact, there is a growing body of evidence documenting the loss of relevance of oil as a source of macroeconomic fluctuations both in industrialized and emerging economies. The evidence we present for Spain shows that the inflationary impact of oil price changes is limited. A 10% increase in the price of oil increases consumer price inflation in Spain by 0.20 pp to 0.25 pp the year of the shock and an additional 0.04 pp to 0.13 pp the year after.

The direct contribution of changes in the prices of refined oil products on headline consumer price inflation averages 0.2 pp both in Spain and in the euro area. However, in the last decade household expenditure in Spain and in the euro area is switching to oil refined products, such as transport fuels, so that the direct inflationary impact of oil price increases is rising over time. Sizable fluctuations in the oil price suggests that they are an important driver of inflation variability. In fact, oil price changes account for more than 50% of the variance of Spanish inflation, a figure which is somewhat lower in the euro area, reflecting the lower share of indirect taxes in Spanish retail prices.

Indirect effects on inflation in Spain and the euro area are quite limited for the economy as a whole, as is expected from the low oil intensity of most industries, as shown by input-output tables, and the fact that energy costs are not considered by firm managers to be a major driver of price changes, as shown by survey data. Recent years have seen advances in oil efficiency of production processes, so these indirect effects are losing importance.

There is also evidence that transitory inflationary shocks have a stronger impact on Spanish wages than in those of the euro area, reflecting both the natural endogenous response and the fact that indexation clauses are widespread in Spain, in contrast with the euro area. The estimated magnitude of this effect is limited, though.

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