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Tesis Doctoral

Three Essays on Applied Time Series Econometrics

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Departamento de Economía e Historia Económica
Salamanca, Mayo de 2016

FACULTAD DE ECONOMÍA Y EMPRESA
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A mi Familia

Agradecimientos

Esta tesis no hubiera sido posible sin la ayuda de Rebeca, mi directora. Gracias Rebeca por tu interés, tu energía, tu ánimo, y tus valiosos consejos.

También quiero agradecer a Andrés Barge-Gil y a Miguel Jerez por la oportunidad que me brindaron de realizar con ellos un extraordinario trabajo lleno de resultados y experiencias positivas.

Gracias a Pilar Poncela y Eva Senra por ayudarme en la realización de parte de esta investigación.

A Luisa, gracias por tu compañía, tu cariño, tu amistad, tu apoyo, por todo. Por luchar conmigo en las buenas y las malas.

Gracias a mis padres Julita y Álvaro, por haber apoyado siempre mis deseos. Y a Ernesto y Adriana por el invaluable e incondicional respaldo a mis padres y a nosotros mismos; por su inmensa generosidad.

Gracias a los amigos, en especial al zoológico; Richi, Anita, Sonso y Neil, por los buenos momentos y por el cariño de siempre.

A todos, muchas gracias.

Introducción

Esta tesis consta de tres capítulos en los que se profundiza sobre los efectos que tiene un cambio en el precio del petróleo sobre los precios de la zona euro. El primer capítulo analiza el efecto a nivel desagregado de las fluctuaciones del precio del petróleo sobre la inflación de la zona euro y sus principales economías. El segundo capítulo estudia la transmisión del precio del petróleo a lo largo de la cadena de precios de la zona euro usando datos desagregados a nivel industrial. Y finalmente, el tercer capítulo propone una metodología para predecir el precio del petróleo y los riesgos de deflación en la zona euro.

El primer capítulo, "*A new look at oil price pass-through into inflation: Evidence from disaggregated European data*", analiza el efecto de un cambio en el precio del petróleo sobre la inflación de los bienes y servicios al mayor nivel de desagregación posible en la zona euro y sus cuatro principales economías: Alemania, Francia, Italia y España. Para el análisis de estos efectos se excluyen todos los bienes y servicios administrados, en cuanto que se considera que responden a fuerzas alejadas de la lógica del mercado. Este análisis permite establecer que los bienes energéticos administrados (electricidad y gas) han ayudado a mitigar la mayor inflación de los bienes energéticos no administrados (combustibles). Sin bienes administrados, España presenta la mayor inflación energética, lo cual se puede explicar por un mayor consumo energético y por menores impuestos en combustibles. Con la base de datos depurada, identificamos las funciones de transferencia para 58 bienes y servicios en las 5 regiones de estudio (290 funciones en total), controlando los efectos en cada función por elementos de oferta (precios de materias primas no energéticas) y de demanda (indicador de sentimiento económico y comercio exterior). Las ganancias de las funciones de transferencia se estiman para 12 meses. Aunque los mayores efectos son los directos sobre los combustibles, se identifican efectos adicionales, aunque de menor magnitud, en muchos bienes y servicios. Estos pequeños efectos de signo opuesto se ocultan en el agregado, de forma que en este capítulo se propone una aproximación del efecto agregado utilizando la suma ponderada de los efectos individuales. Con la metodología propuesta, Italia resulta ser el país con menores efectos directos en los combustibles, lo que a su vez podría explicar que tenga el menor número de bienes y servicios no energéticos con efectos derivados de cambios en el precio del petróleo.

El segundo capítulo, "*Oil price pass-through along the price chain in the euro area*", investiga cómo las fluctuaciones en el precio del petróleo son transmitidas a los precios del productor y del consumidor en la zona euro al máximo nivel de desagregación por industria posible. Para ello, en primer lugar construimos una base de datos apropiada que identifica cada sector de producción industrial con sus correspondientes precios de bienes y servicios en la zona euro. A continuación, se estima un modelo autorregresivo restringido, mostrando que un aumento en el precio del petróleo tiene un efecto estadísticamente significativo para industrias con altos niveles de consumo de petróleo, aunque esta transmisión de precios más altos es únicamente parcial. Sin embargo, no hay evidencia de una transmisión significativa de los precios del petróleo a los precios del consumidor para la mayoría de industrias, lo cual sugiere que los productores europeos de la mayoría de industrias tienen una alta capacidad de adaptación a la presión impuesta por los altos precios del petróleo sin necesidad de transmitir dicha presión a los consumidores (excepciones: *minería*, *química* y *metal*).

El tercer capítulo, "*The deflationary effect of oil prices in the euro area*", estudia el efecto de un cambio en el precio del petróleo sobre la inflación a nivel agregado en la zona euro. En primer lugar, se argumenta que es natural que la literatura existente considere endógeno el precio del petróleo a la economía de Estados Unidos porque: 1) su precio se establece en dólares; 2) en consecuencia se ve afectado por la política monetaria de la Reserva Federal; 3) se usa como activo financiero internacional y 4) Estados Unidos es el mayor consumidor mundial de petróleo. Como estas características no se presentan en una economía importadora neta de petróleo como es la zona euro, se considera razonable considerar el precio del petróleo como una variable exógena en el modelo de predicción. Adicionalmente, el test de causalidad de Granger muestra evidencia de que el precio del petróleo ayuda en la predicción de la inflación de Estados Unidos y de la zona euro, pero la inflación de la zona euro no ayuda a la predicción del precio del petróleo. Partiendo de este supuesto, se identifican modelos ARIMA y funciones de transferencia y se analiza el papel del tipo de cambio en el efecto del cambio del precio del petróleo sobre la inflación. A pesar de que los resultados son indiferentes frente a la denominación del precio del petróleo en euros o en dólares, se elige trabajar en dólares siguiendo criterios de información estadística (AIC). El tratamiento del modelo ARIMA del precio del petróleo como un modelo de espacio estado permite encontrar los valores desconocidos de la serie, partiendo de tres supuestos sobre el precio futuro del petróleo en un horizonte de un año. Esta estrategia puede resultar útil frente a la dificultad de la predicción del precio del petróleo. Estas predicciones se utilizan para analizar los riesgos de deflación en la zona euro.

Los resultados de esta tesis contribuyen al entendimiento del efecto de los cambios del precio del petróleo sobre los precios de la zona euro y sus principales economías. En primer lugar, muestra la pertinencia de asumir el precio del petróleo como una variable exógena en economías distintas a la de Estados Unidos. Este supuesto sustenta el uso de modelos ARIMA, funciones de transferencia y modelos de vectores autorregresivos restringidos, en donde el precio del petróleo es tratado como una variable exógena. Esta metodología nos permite: 1) hacer predicciones del precio del petróleo sujetas a varios escenarios y analizar riesgos de deflación; 2) probar que los efectos del precio del petróleo sobre la inflación no provienen de los mayores costos asumidos por los productores y 3) establecer que los efectos derivados del cambio en los precios del petróleo se concentran en la reacción de los consumidores y que los efectos en la inflación de los bienes y servicios no energéticos dependen a su vez de la magnitud del efecto directo e inmediato observado en los precios de los combustibles.

Introduction

This thesis consists of three chapters which contribute to understanding the effects of oil price changes in the prices of the euro area. The first chapter studies the effect of oil price fluctuations on inflation at disaggregate level in the euro area and its major economies. The second chapter analyzes the transmission of oil price in the chain of prices of the euro area using disaggregated industrial prices. Finally, the third chapter proposes a methodology to predict both the oil price and the risks of deflation in the euro area.

The first chapter, "*A new look at oil price pass-through into inflation: Evidence from disaggregated European data*, focuses on the effect of oil price changes on consumer price indices at the highest level of disaggregation in the euro area and its four main economies: Germany, France, Italy and Spain. The administered goods and services are excluded due to they do not respond to the logic of market forces. This analysis allows us to establish that administered energy goods (electricity and gas) have helped to mitigate higher non-administered inflation (fuel). Excluding administered goods and services, Spain shows the highest energy inflation, which can be explained by its higher energy consumption and lower taxes on fuels. With the refined database, we identify the transfer functions for 58 goods and services in the 5 regions of study (290 series), controlling by supply (prices of non-energy commodities) and demand (economic sentiment indicator and foreign trade) variables. We estimate transfer functions gains up to 12 months. Although the greatest effects are directly on fuels, we also identify smaller effects on many goods and services across countries. In many cases, these small effects with opposite signs are hidden in the aggregate effect, thus we propose an approximation to the aggregate effect using the weighted sum of the individual effects. With the proposed methodology, Italy seems to be the country in which the direct effects on fuel are lower, which in turn could explain the low number of goods and services with effects from oil price changes.

The second chapter, "*Oil price pass-through along the price chain in the euro area*", analyzes how oil price shocks are transmitted downstream to producer and consumer prices in the euro area at the highest disaggregate level. In doing so, we first generate an appropriate database that identifies each industrial production sector with its corresponding price of consumer goods for the euro area. We next estimate a constrained vector autoregressive model. Our findings show a statistically significant increase in producer prices after an oil price shock for industrial branches with high oil consumptions, although this statistical pass-through is only partial. However, there is no evidence of a significant oil price pass-through to consumer prices for most branches, which suggests the adaptability of European producers from the most branches to higher oil price pressures without transmitting them to consumers (exceptions: *mining*, *chemical* and *metal*).

The third chapter, "*The deflationary effect of oil prices in the euro area*", examines the effect of oil price changes on inflation at the aggregate level in the euro area. First, we argue that the natural assumption in the empirical literature about the oil price endogeneity is supported by: 1) its U.S. dollar-denomination; 2) therefore it depends on the monetary policy of the Federal Reserve; 3) the role as an international financial asset and 4) the importance of the U.S. as the largest oil global consumer. However, these features are not present on a net oil-importer economy as the euro area, and therefore, in this case, it is reasonable to consider oil price as an exogenous variable in the forecast model. Additionally, the Granger-causality test confirms that oil price helps predict U.S. and euro area inflation, although euro area inflation does not help predict oil price. Based on this assumption, we identify ARIMA models and transfer functions and we analyze the role of the exchange rate in the effects of oil price on inflation. Despite the fact that the results do not change independently of the currency used for the denomination of oil prices (euro/U.S. dollar), we work in U.S. dollars following statistical information criteria (AIC). The treatment of the ARIMA model for oil prices as a state space model allows us to find missing values based on three assumptions about the future oil price at the 12-month horizon. This strategy is a different approach to forecast oil price changes, which allows us to analyze the risk of deflation in the euro area.

The results of this thesis contribute to better understand the effects of oil price changes on prices in the euro area and its main economies. First, it shows the relevance of assuming oil prices as an exogenous variable in economies different from the U.S. This assumption supports the use of ARIMA models, transfer functions and restricted vector autoregressive models, where oil price is treated as an exogenous variable. This methodology allows us: 1) to forecast oil price under different scenarios and to assess the risk of deflation; 2) to prove that the effect of oil price changes on inflation does not come from higher industrial costs; and 3) to show that the effects on inflation depend on the reaction of consumers and that the effect on the inflation of non-energy goods and services depends on the magnitude of the direct and instantaneous effect on fuel prices.

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Chapter 1

A new look at oil price pass-through into inflation: Evidence from disaggregated European data

1.1. Introduction

There are several studies that analyze how non anticipated fluctuations in international crude oil prices affect the developed economies, especially the U.S. (see, e.g., Barsky and Kilian [2004]; Kilian [2008c]; Hamilton [2009a]). The origins of crude oil shocks and their mechanisms of transmission into the economy are crucial to understand the effects of crude oil price shocks on variables such as inflation. The recent literature has pointed out the relative importance of global crude oil supply and demand as determinants of rising and falling of crude oil prices (see Kilian [2009]). Crude oil price shocks in the 1970s were mainly originated by oil supply disruptions and other exogenous events related with political reasons in the Middle East, while the most recent crude oil shocks have been mainly originated by changes in domestic and global demand, especially in developing countries. The recent literature has also shown that the actual exogenous political turmoil (especially in oil producing countries) and the likely oil supply disruptions do not cause significant effects on either inflation or economic growth because the magnitude of the oil disruptions and their effects on crude oil prices depend on the reactions of other oil suppliers as well as both domestic and global demand (see Kilian [2008c]).

In relation with the mechanisms of transmission from crude oil prices into inflation, we can distinguish between direct first-round effects on consumers (higher energy bills, especially in fuels and heating oil), indirect on producers (higher production costs on goods and services that use petroleum products as input), and second-round effects related with consumer and producers expectations that cause negative effects on investment and consumption plans (see, e.g., ECB [2010]). The recent empirical literature has found that the most important transmission channel of crude oil price shocks to the economy is through a disruption in consumer expenditures due to lower levels of current and expected income (see, e.g., Edelstein and Kilian [2007]; Kilian [2008c]).

Most of the empirical literature about the effects of crude oil prices on inflation use aggregate measures of inflation or very simple disaggregations (energy/non-energy),[1] and conclude that there is mainly a direct effect through the energy component, while indirect and second-round effects are commonly less important (see, e.g., ECB [2010]; Álvarez et al. [2011]).

This chapter analyzes the effects of crude oil price shocks on inflation at disaggregate level for the euro area and its four main economies (France, Germany, Italy and Spain), with the objective of comparing the magnitude and timing of such effects across countries and assessing the impact on competitiveness among them.[2] To do so, we consider the harmonized indices of consumer prices (HICPs)[3] at aggregate and disaggregate level from January 1996[4] to December 2014 and multivariate transfer function models, which include - apart from crude oil - other inputs such as the price of other commodities and measures of the demand pressures that may affect the HICP.[5] In contrast to the previous studies, this chapter excludes from the

[1] The main exception is Edelstein and Kilian [2009], who assess the effects of crude oil price shocks on consumers based on disaggregated data for personal consumption expenditures in the U.S.

[2] Euro area HICPs are calculated as weighted averages of HICPs of its members. Country weights are computed every year reflecting the country's share of private final consumption expenditure (see http://ec.europa.eu/eurostat). Thus, the four countries considered here represent 78% of total weights.

[3] It is worth noting that HICPs are monthly price indices designed for international comparison of consumer price inflation.

[4] The first date available in Eurostat is 1996. That is why our sample starts in such a year.

[5] The recent literature states that oil price should be considered endogenous with respect to macroeconomic variables (see, e.g., Kilian [2008c]; Hamilton [2009a]; Kilian [2014]). However, our multivariate transfer function models consider oil price as an input and, consequently, as an exogenous variable. This consideration may be explained by the fact that the economies considered here do not have enough size to influence the oil price, but we have formally tested for it.

HICP the group of administered prices that are ruled out of market fluctuations and might distort the results, and studies the transmission mechanism from crude oil to inflation by using a disaggregated approach.

The rest of the chapter is structured as follows. Section 2.2 describes data. Section 1.3 describes the methodology. Section 2.4 presents the main results. Section 1.5 concludes.

1.2. Data

1.2.1. Previous considerations

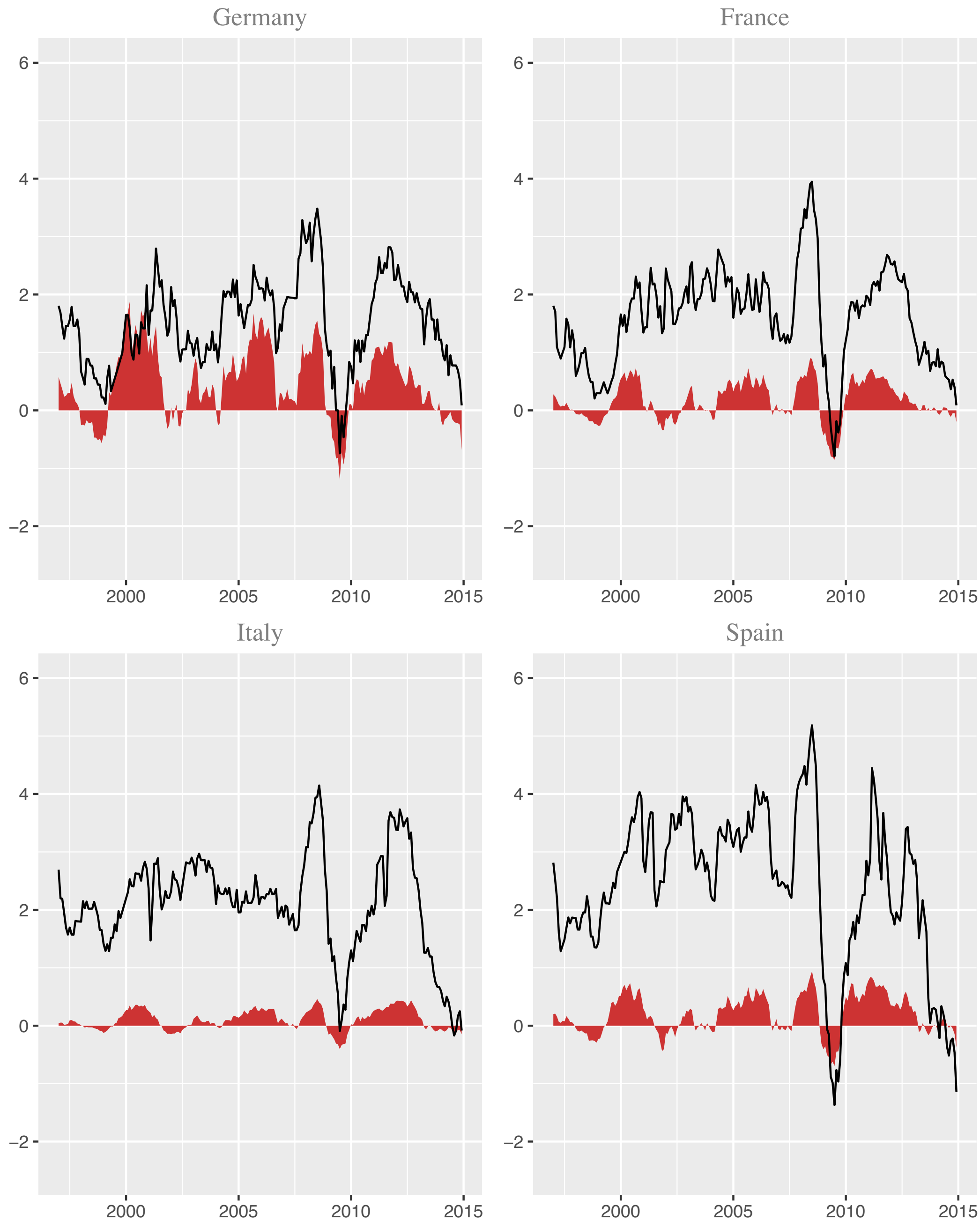
In this subsection, we describe the evolution of prices referred to the monthly HICP for the euro area and its main economies (France, Germany, Italy and Spain) during the sample period running from January 1996 to December 2014. These data come from Eurostat (http://ec.europa.eu/eurostat).

Table 1.1 shows a simple descriptive analysis of the accumulated energy and non-energy inflation and their contributions in percentage points to total inflation for the euro area and its main economies.[6] We observe that the accumulated energy inflation has been larger than the non-energy component for all economies although there are some differences across economies. Whereas the accumulated energy inflation has been about 4 times larger in Germany, it has been less than 2 times in Italy and Spain and a bit more than the double in the euro area. Moreover, the non-energy group presents the greatest contributions to the total inflation in all economies, with contributions being around 30 percentage points in Germany and France and larger in the rest of economies.

Figure 1.1 illustrates the contribution of the energy group to the total annual inflation shown in Table 1.1. As expected, the energy group has contributed notably to inflation fluctuations in all countries, especially in Germany.

In an attempt to better understand these differences among European countries, we

[6] Energy HICP group includes electricity, gas, liquid fuels, and fuels and lubricants for personal transport equipment. Contributions are referred to accumulated inflation multiplied by its corresponding weights in total HICP. Mean weights of energy for the period 1996-2014 are: 9.4% for the euro area, 8.9% for France, 10.8% for Germany, 7.5% for Italy, and 9.4% for Spain.



Note: The red shaded areas correspond to energy contributions. Source: Eurostat.

Figure 1.1: Contributions of energy and non-energy groups to annual inflation, 1997:1-2014:12.

Table 1.1: Accumulated inflation (%), and contributions of Energy and Non-energy inflation to total (percentage points), 1996:01-2014:12.

	Accumulated inflation			Contributions, percentage points	
	Total	Energy	Non-energy	Energy	Non-energy
Euro area	40.66	92.83	37.35	8.69	33.86
Germany	32.31	101.83	28.06	10.95	25.04
France	34.74	73.57	32.34	6.57	29.45
Italy	48.88	74.9	47.23	5.62	43.69
Spain	56.7	98.66	52.87	9.29	47.89

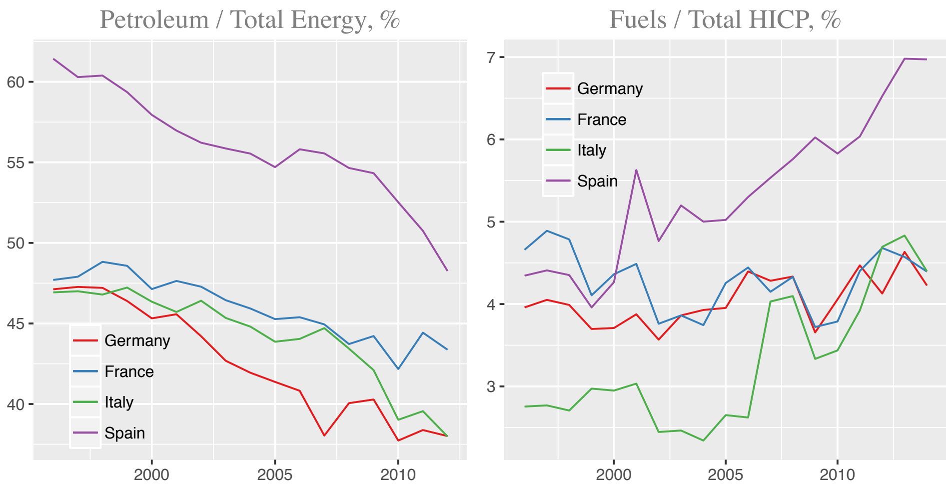
Note: Contributions are referred to accumulated inflation multiplied by its corresponding weights in total HICP. There are some differences in total inflation when adding up energy and non-energy contributions due to changes in weights.

consider the energy consumption structure,[7] taxes and regulatory rules in domestic energy markets, as well as the role of administrative inflation. On the one hand, the left panel of Figure 1.2 shows that Germany has the smallest share of petroleum products with respect to the total final national energy consumption between 1996 and 2012 and Spain has the largest one, while France and Italy show relative similar behavior to Germany. The right panel of Figure 1.2 shows that the percent of consumption of fuels for personal transport (the item probably with more direct effects from an oil price shock) accounted for 6-7% for Spain and about 4% for the other countries in the 2010s.

On the other hand, Figure 1.3 also shows the different taxation structure in two of the most important petroleum products for consumption (euro-super 95 and diesel oil) among countries, with Germany and France showing the highest imposition, as opposed to Spain, with the lowest one. These key facts suggest that variations in the price of petroleum products may have greater effects in Spain than in Germany.

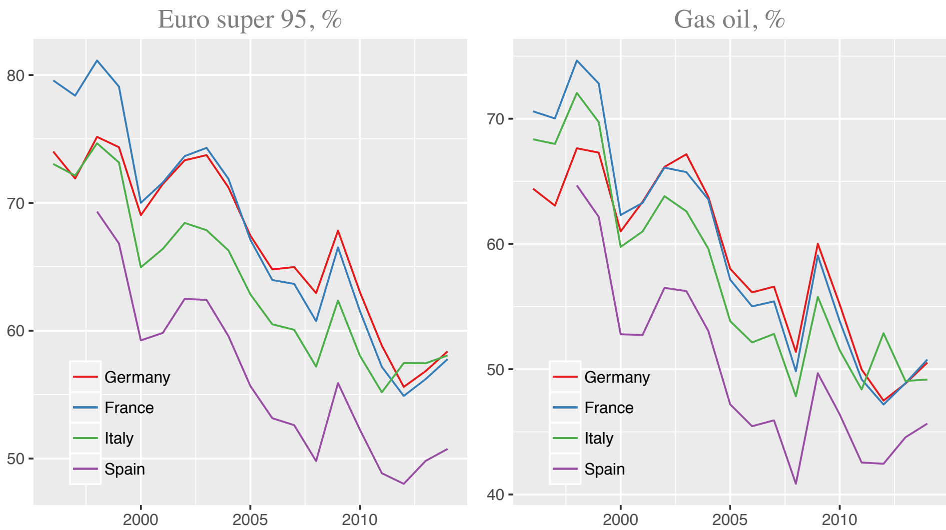
Additionally, there are different regulations in the four countries considered for the price of the remaining energy consumption products and services (mainly, gas and electricity). These regulations can be affected by political considerations, among others. In order to do more homogeneous comparison, we have decided to exclude from our analysis all goods and services classified as administered (therefore, not directly open to market fluctuations) by Eurostat.

[7] According to Eurostat, the weights for the HICP sub-indices are "the aggregate expenditure by households on any set of goods and services covered by the HICP, expressed as a proportion of the total expenditure on all goods and services within the coverage of the HICP." For more details see Eurostat (http://ec.europa.eu/eurostat).



Note: Petroleum refers to LPG, gasoline, kerosen and gas/diesel oil consumption. Fuels refers to expenditure in fuels and lubricants for personal transport equipment. Source: European Commission and Eurostat.

Figure 1.2: Share of consumption for petroleum (1996-2012) and fuels (1996-2014).



Note: Source: European Commission.

Figure 1.3: Total taxation share in the final consumer price (%); 1996-2014.

1.2.2. Data description

We work with a set of 58 subclasses of non-administered price indices (aggregate in five groups: processed food, non-energy industrial goods, services, unprocessed food and energy) for the euro area and its main economies (France, Germany, Italy and Spain), using Eurostat data from January 1996 to December 2014.[8]

Table 1.2 presents the weights, in percentage, of administered goods and services excluded from total HICP. We observe that the total weight excluded from HICP ranges from 23.4% in Italy to 30.7% in Germany, and is mainly concentrated in services.[9] The most important services excluded are telephone, waste collection, cultural services, combined passenger transport and education. In the energy sector, we exclude solid fuels and heat energy, which are administered prices only in Germany and France, but we exclude them in the remaining regions for homogeneous aggregation. We also exclude electricity and gas, which are fully or mainly administered in all economies.

Table 1.2: Weigths (%) of administered goods and services excluded from total HICP.

	Euro area	Germany	France	Italy	Spain
Processed-food	2.4	2.5	2.3	2.3	2.0
Non-energy industrial goods	3.5	4.3	3.3	2.9	3.5
Services	15.6	17.4	14.8	13.6	13.6
Energy	5.2	6.5	4.6	4.5	4.8
TOTAL	26.7	30.7	25.0	23.4	23.9

Table 1.3 shows the behavior of non-administered inflation. There are some differences with respect to inflation shown in Table 1.1. First, non-administered accumulated inflation is smaller in the euro area and Germany, which indicates that administered prices have been positive and have helped to increase inflation pressures. These differences are mainly attributable to the excluded administered prices of gas and electricity. Second, energy contributions to total non-administered inflation are much smaller in all economies. Finally, non-energy inflation is highly similar to inflation including administered prices.

Therefore, we consider non-administered disaggregate inflation to analyze the effects

[8]Eurostat reports 93 subclasses of price indices, but we have excluded the goods and services with totally or partially administered prices according to the Eurostat criterion. When some of them are administered in one region but not in another, we exclude the corresponding prices in both in order to obtain the highest level of comparison.

[9]There are not administered prices in the group of unprocessed food.

of oil price shocks. Henceforth, non-administered inflation will be referred simply to as inflation.

Table 1.3: Accumulated non-administered inflation (%), and contributions of Energy and Non-energy inflation to total (percentage points), 1996:01-2014:12.

	Accumulated inflation, %			Contributions, percentage points	
	Total	Energy	Non-energy	Energy	Non-energy
Euro area	37.26	95.12	33.85	6.13	31.67
Germany	26.07	88.06	22.38	5.98	22.04
France	32.51	83.66	29.44	5.34	27.26
Italy	48.94	82.51	46.99	5.13	42.37
Spain	53.68	106.98	49.78	6.57	44.39

Note: Contributions are accumulated non-administered inflation multiplied by its corresponding weigths in total HICP. There are some differences in total inflation when adding up energy and non-energy contributions due to changes in weights.

While the contribution of energy component to inflation seems to be, on average, slightly smaller when non-administered prices are considered (see Table 1.3), energy inflation seems to be an important determinant for total inflation, especially in Germany and France (see Figure 1.4). The energy component seems to be less important in Spain and Italy, where global inflation seems to be dominated by other factors, although it has played a relevant role during some periods.

As determinants of non-administered inflation, we include oil prices, non-energy commodity prices, consumer confidence indicator and a measure of global demand. We consider the nominal price of Brent in € per barrel (henceforth, Brent, downloaded from the U.S. Energy Information Administration web page http://www.eia.gov) as a measure of international price of oil. We use the nominal non-fuel price index in terms of €, which includes food and beverages and industrial inputs price indices, as non-energy commodity prices. These data come from the International Monetary Fund (http://www.imf.org). The consumer confidence indicator for each economy comes from the European Commission (http://www.ec.europa.eu). This indicator measures the level of optimism that consumers have about the economy and is the result of a monthly consumer survey about their financial and general economic situation, unemployment expectations and savings over next 12 months. Finally, we consider the index of worldwide monthly data on international trade and industrial production provided by the CPB Netherlands Bureau for Economic Policy Analysis (http://www.cpb.nl).

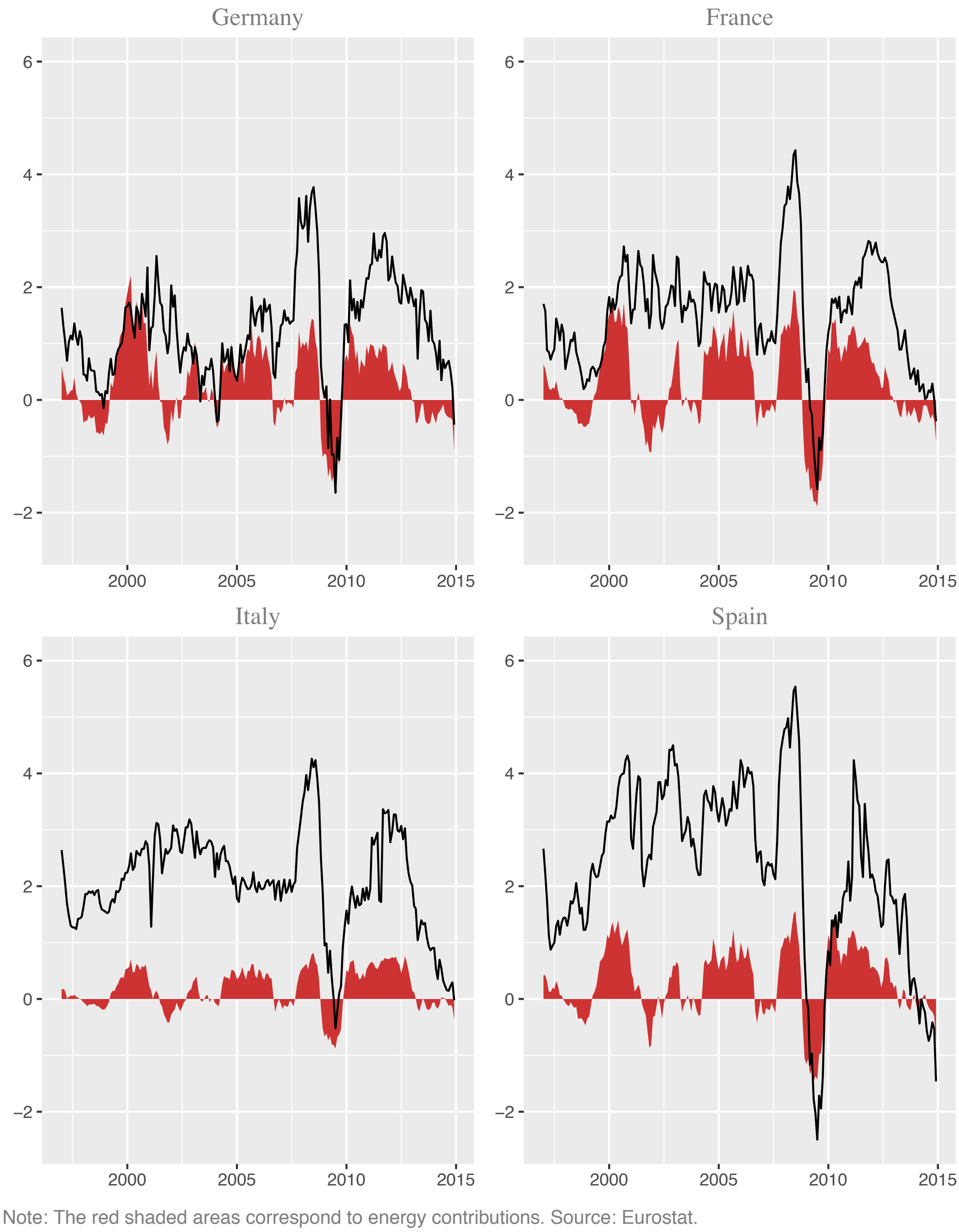


Figure 1.4: Contributions of energy and non-energy groups to annual inflation, excluding administered prices (%), 1997:1-2014:12.

1.2.3. Other considerations

There is a widespread agreement in the recent literature that oil price should be considered endogenous with respect to macroeconomic aggregates, especially with respect to the U.S. output growth and inflation (see, e.g., Kilian [2008c]; Hamilton [2009b]; Kilian [2014]). Thus, it is standard in the related literature to estimate a vector autoregressive (VAR) model to study the relationship between oil prices and macroeconomic variables (see, e.g., Hamilton [1983]; Jiménez-Rodríguez and Sánchez [2005]; Kilian [2009]; Blanchard and Galí [2010]; Mandal et al. [2012]). Due to the predeterminedness of oil prices with respect to the U.S. macroeconomic variables in monthly data (Kilian and Vega [2011]), bivariate VAR has been widespread used in the literature with oil price ordered first. However, large structures of VAR can be problematic because they need additional identification assumptions for impulse response analysis.

It is seems reasonable to think that global oil prices may depend on the U.S. macroeconomic variables such as GDP growth and inflation. However, it seems less reasonable to consider that each component of aggregate inflation may have an influence in the evolution of global oil prices and less in countries like those considered in this chapter.

To investigate the latter assertion, we perform a test for linear Granger (G)-causality in bivariate stationary series evaluating whether the past values of inflation, P_t^i, help predicting the value of oil price changes, O_t, at aggregate and disaggregate level for the corresponding i economy (the euro area, Germany, France, Italy and Spain). Additionally, we also test for linear G-causality from oil price changes to inflation at aggregate and disaggregate level.

We first study the seasonal and non-stationary behavior in the log transformed variables. As expected, all of the consumer price indexes in these economies display seasonality, originated especially in the behavior of non-energy industrial goods. On the contrary, oil price changes do not have seasonal fluctuations. Therefore, we perform a seasonal adjustment procedure to consumer price indexes using the TRAMO-SEATS.[10]

Once the consumer price indexes have been seasonally adjusted, we analyze the stationarity of the log levels of oil prices and consumer prices by using the augmented

[10]We implement the multi processing seasonal adjustment with JDemetra+, available at European Statistical System http://ec.europa.eu/eurostat/.

Dickey-Fuller test (ADF, Ho: unit root exists). We obtain that we cannot reject the null hypothesis for any variable. Thus, we analyze the first differences of the variable in order to establish the order of integration and we obtain that all variables (in first log differences) are stationary. Table 1.4 shows that $p-$values of the ADF test for the log levels and 1st difference of the variables.

Table 1.4: $p-$values of ADF test for log levels and 1st differences (∇).

	Levels	∇	
O_t	0.29	0.01	***
$P_t^{E.A.}$	0.97	0.01	***
$P_t^{Germany}$	0.54	0.01	***
P_t^{France}	0.76	0.01	***
P_t^{Italy}	1.00	0.01	***
P_t^{Spain}	1.00	0.01	***

Note: One/two/three asterisks denote significance at the 10%, 5% and 1% levels, respectively.

Once we have determined how each variable has to be considered, we implement the G-causality test. We perform a bivariate test for each inflation against oil price changes:[11]

$$P_t^i = c^{i,1} + \sum_{j=1}^{p} \alpha_j^1 P_{t-j}^i + \sum_{j=1}^{p} \beta_j^1 O_{t-j} + \mu_t^{i,1} \tag{1.1}$$

$$O_t = c^2 + \sum_{j=1}^{p} \alpha_j^2 O_{t-j} + \sum_{j=1}^{p} \beta_j^2 P_{t-j}^i + \mu_t^2 \tag{1.2}$$

for $p = 1, 2, \ldots 24$ and $i \in$ {euro area, Germany, France, Italy, Spain}. The null hypothesis for equation 2.1 is that p lags of O_{t-j} do not help in predicting value of P_t^i, and for equation 1.2 is that p lags of P_{t-j}^i do not help in predicting value of O_t. In particular, we use an $F-$test to determine whether jointly β_j^k are zero:

$$Ho: \quad \beta_1^k = \beta_2^k = \cdots \beta_p^k = 0 \quad \text{with} \quad k = 1, 2$$

Instead of evaluating the G-causality test for a convenient p lag, we consider the warning of Hamilton and Herrera [2004] about the convenience of including a rich

[11] As expected, we obtain similar results with the block exogeneity Granger test for a fitted VAR.

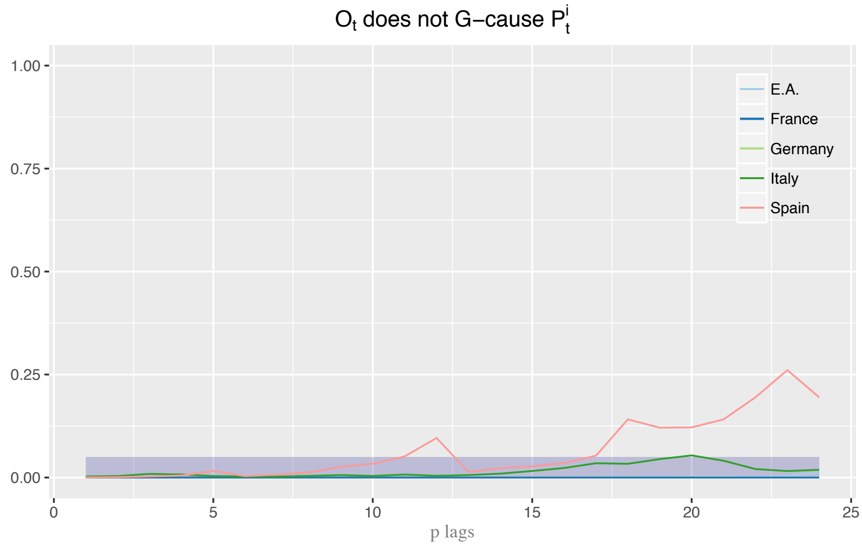


Figure 1.5: p-values for G-causality test with lags $p = 1, 2, \cdots 24$. $p-$value < 0.05 (shaded area) rejects $Ho : O_t$ does not G-cause P_t^i.

lag structure in studying the effects of oil prices on macroeconomic variables. Then, we investigate the sensitive of the G-causality test to the choice of lag length $p = 1, 2, \ldots 24$, estimating their corresponding $p-$values.

Figure 1.5 shows that O_t G-causes P_t^i in all economies for most lags. However, Figure 1.6 indicates that inflation does not G-cause oil price changes for the euro area and most of the individual countries. In fact, we do not find evidence of G-causality from inflation to oil price changes in the euro area, France, Italy and Spain, although there is some evidence for Italy (p=1) and Germany (at different lags). We examine in more detail the latter result by using the nonparametric G-causality test (see Diks and Panchenko [2006]), and we observe that there is no evidence that German inflation G-causes oil price changes (see Figure 1.7).[12]

We extend the previous analysis to 58 non-administered goods and services of HICP for Germany, France, Italy, Spain and the euro area. We find that all inflation series in the five economies (except milk, cheese and eggs in Italy and non-durable household goods in the euro area) have a seasonal component and therefore they were seasonally adjusted by using TRAMO-SEATS. Regarding the presence of unit roots in these series, we cannot reject the null hypothesis of the existence of a unit root for most of the logarithms of variables (see Table 1.5), but the first difference

[12]We have also applied the nonparametric G-causality test for Italy when p=1. The Diks-Panchenko test equals 1.369 ($p-$value: 0.91451). Thus, there is no evidence that inflation G-causes oil price changes.

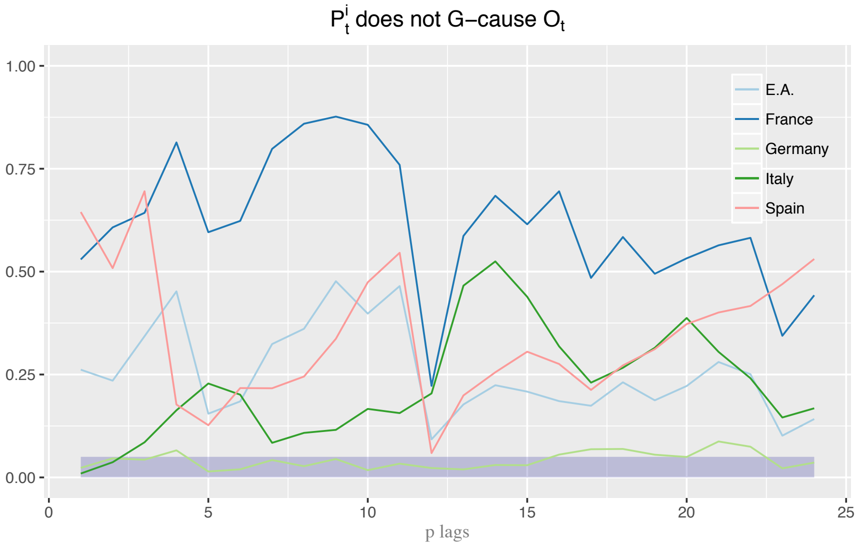


Figure 1.6: p-values for G-causality test with lags $p = 1, 2, \cdots 24$. $p-$value < 0.05 (shaded area) rejects $Ho : P_t^i$ does not G-cause O_t

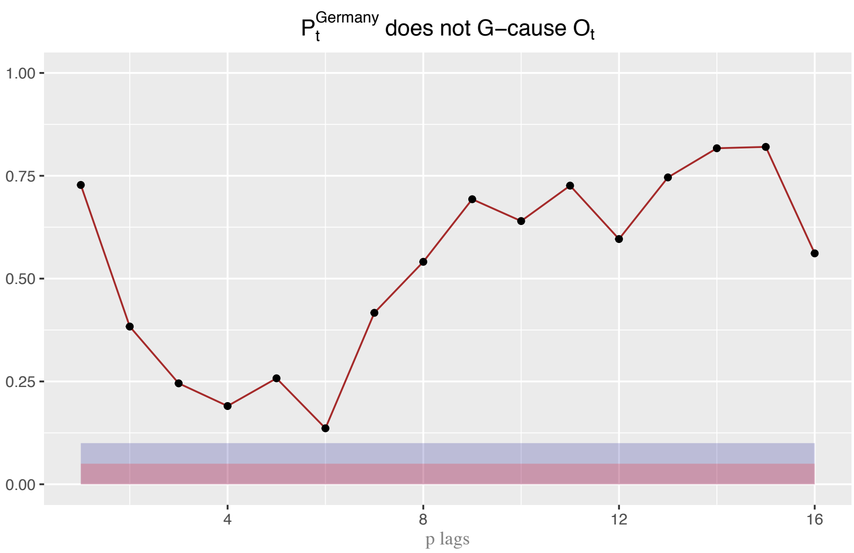


Figure 1.7: p-values for non-parametric G-causality test with lags $p = 1, 2, \cdots 16$. $p-$value < 0.05 (red shaded area) and $p-$value < 0.1 (blue shaded area) rejects $Ho : P_t^{Germany}$ does not G-cause O_t.

of the logarithms of the variables are clearly stationary (see Table 1.6).[13] Finally, we perform the G-causality test for the stationary variables. Table 1.7 presents the $p-$values for the null hypothesis that inflation of corresponding good/service j, in economy i, $P_t^{i,j}$ does not G-cause O_t at p =12. In general, we do not reject the null hypothesis and so, inflation at disaggregate level does not seem to help in predicting oil price changes.[14]

Therefore, it seems reasonable not to consider oil price as an endogenous variable in the context of a disaggregated analysis of macroeconomic variables for the euro area and its main economies. Given that this chapter tries to study the effects of oil price shocks on inflation at disaggregate level for the euro area and its four main economies, we do not consider oil price as an endogenous variable. Thus, we can use transfer function (TF) models instead of VAR models, avoiding the typical problems of these models.

1.3. Methodology

To analyze how crude oil price increases are translated into inflation in the euro area and its main economies, we estimate a set of multivariate transfer function (TF) models for 58 subclasses of inflation. In order to control for internal and external market pressures that can affect the price formation, the TF model also includes the consumer confidence indicator, the price of non-energy commodities and an index of international trade.

The TF model for the inflation of good/service j, in economy i, $P_t^{i,j}$ with $i = 1, \ldots, 5$, and $j = 1, \ldots, 58$, is written

$$P_t^{i,j} = c^{i,j} + v(L)x_t^i + N_t^{i,j} \tag{1.3}$$

$$v(L) = (v^1(L), v^2(L), v^3(L), v^4(L))$$

[13] Although some variables are stationary in log levels, we also use them in first-differences to facilitate the interpretation of the results.

[14] Although there are very few rejections at the greatest disaggregate level, we will assume that oil price is also exogenous for these cases.

$$v^k(L) = v_0^k + v_1^k L + v_2^k L^2 + \cdots + v_{12}^k L^{12}$$

$$x_t^i = (O_t, NC_t, S_t^i, T_t)'$$

where L is the lag operator, $c^{i,j}$ is the constant, O_t is oil price changes, NC_t is non-energy commodity price changes, S_t^i is the change in the consumer confidence indicator, T_t is the growth of the international trade index, and $N_t^{i,j}$ is the disturbance term.

Table 1.5: ADF $p - value$ for log levels of HICP of goods and services.

	Euro area		Germany		France		Italy		Spain	
Bread and cereals	0.38		0.69		0.98		0.56		0.98	
Milk, cheese and eggs	0.04	**	0.31		0.33		0.52		0.54	
Oils and fats	0.02	**	0.39		0.10	*	0.36		0.04	**
Sugar, jam, honey, chocolate and confectionery	0.52		0.46		0.98		0.56		0.98	
Food products n.e.c.	0.96		0.70		1.00		0.92		0.36	
Coffee, tea and cocoa	0.84		0.95		0.19		0.82		0.65	
Mineral waters, soft drinks, fruit and vegetable juices	0.47		0.62		0.89		0.95		0.93	
Spirits	0.98		0.80		0.96		0.87		0.42	
Wine	0.90		0.98		0.86		0.02	**	0.77	
Beer	0.55		0.40		0.29		1.00		0.03	**
Furniture and furnishings	1.00		0.57		0.46		1.00		1.00	
Carpets and other floor coverings	0.90		0.01	***	0.46		0.16		0.96	
Major, small household appliances	1.00		0.95		0.48		0.27		1.00	
Motor cars	0.99		0.93		0.10	*	0.01	***	0.86	
Motor cycles, bicycles and animal drawn vehicles	0.87		0.82		0.71		0.03	**	0.56	
Equip. reception, recording and rep. sound and pictures	0.46		0.59		0.58		0.88		0.36	
Phot. and cinematographic equipment and optical inst.	0.19		0.40		0.81		0.74		0.36	
Information processing equipment	1.00		1.00		1.00		0.45		0.60	
Jewellery, clocks and watches	0.48		0.81		0.31		0.42		0.70	
Garments	0.01	***	1.00		0.01	***	0.12		0.03	**
Other articles of clothing and clothing accessories	0.09	*	0.85		0.01	***	0.82		0.94	
Footwear including repair	0.46		0.99		0.09	*	0.35		0.90	
Household textiles	0.84		1.00		0.80		0.64		1.00	
Glassware, tableware and household utensils	0.99		0.99		1.00		1.00		1.00	
Tools and equipment for house and garden	0.10	*	0.97		0.39		1.00		1.00	
Spares parts, accessories for personal transport equip.	0.05	**	0.69		0.01	***	0.77		0.30	
Recording media	0.52		0.06	*	0.41		0.23		1.00	
Games, toys and hobbies	0.23		0.46		0.11		0.01	***	0.95	
Equipment for sport, camping and open-air recreation	0.96		1.00		0.25		0.77		1.00	
Other personal effects	0.94		0.36		0.73		0.10	*	0.85	
Materials for the maintenance and repair of the dwelling	0.77		0.66		0.71		0.95		1.00	
Non-durable household goods	0.86		0.98		0.90		0.45		0.40	
Gardens, plants and flowers	0.01	***	0.66		0.01	***	0.93		0.99	
Pets and related products; veterinary and other services	0.40		0.81		0.49		0.01	***	0.01	***
Newspapers and periodicals	0.83		0.99		0.45		0.68		0.78	
Miscellaneous printed matter; stationery, drawing mat.	0.86		0.95		0.99		0.93		0.37	
Electrical appliances, articles and products personal care	1.00		1.00		1.00		0.87		1.00	
Actual rentals for housing	0.88		0.01	***	0.98		0.01	***	1.00	
Services for the maintenance and repair of the dwelling	0.92		0.74		0.53		1.00		1.00	
Repair of household appliances	0.81		0.24		0.57		0.01	***	0.92	
Domestic services and household services	1.00		0.01	***	0.65		0.66		1.00	
Recreational and sporting services	1.00		0.01	***	0.07	*	0.99		1.00	
Restaurants, cafes and the like	1.00		0.78		0.93		1.00		1.00	
Canteens	0.55		0.14		0.87		0.12		1.00	
Hairdressing salons, personal grooming establishments	1.00		0.81		0.99		1.00		1.00	
Package holidays	0.23		0.76		0.01	***	0.38		0.21	
Accommodation services	0.95		0.64		0.17		0.94		0.97	
Maintenance and repair of personal transport equip.	0.99		0.70		0.97		1.00		1.00	
Other services in respect of personal transport equip.	0.99		0.86		0.83		0.37		1.00	
Passenger transport by air	0.21		0.48		0.08	*	0.17		0.59	
Insurance connected with transport	0.97		0.70		0.68		0.78		1.00	
Financial services n.e.c.	1.00		1.00		0.60		0.94		0.56	
Meat	0.18		0.81		0.38		0.61		0.93	
Fish and seafood	0.90		0.49		0.52		0.93		0.88	
Fruit	0.15		0.27		0.01	***	0.72		0.77	
Vegetables	0.01	***	0.01	***	0.01	***	0.48		0.54	
Liquid fuels	0.27		0.37		0.16		0.08	*	0.12	
Fuels and lubricants for personal transport equipment	0.11		0.32		0.12		0.06	*	0.01	***

Note: Ho : Unit root exists. One/two/three asterisks denote significance at the 10%, 5% and 1% levels, respectively. All test results are based on p=12 lags.

Table 1.6: ADF $p-$values for $1st$ difference of log HICP of goods and services.

	Euro area		Germany		France		Italy		Spain	
Bread and cereals	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Milk, cheese and eggs	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Oils and fats	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Sugar, jam, honey, chocolate and confectionery	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Food products n.e.c.	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Coffee, tea and cocoa	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Mineral waters, soft drinks, fruit and vegetable juices	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Spirits	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Wine	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Beer	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Furniture and furnishings	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Carpets and other floor coverings	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Major, small household appliances	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Motor cars	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Motor cycles, bicycles and animal drawn vehicles	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Equip. reception, recording and rep. sound and pictures	0.04	**	0.01	***	0.01	***	0.01	***	0.01	***
Phot. and cinematographic equipment and optical inst.	0.01	***	0.01	***	0.01	***	0.01	***	0.02	**
Information processing equipment	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Jewellery, clocks and watches	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Garments	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Other articles of clothing and clothing accessories	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Footwear including repair	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Household textiles	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Glassware, tableware and household utensils	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Tools and equipment for house and garden	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Spares parts, accessories for personal transport equip.	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Recording media	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Games, toys and hobbies	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Equipment for sport, camping and open-air recreation	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Other personal effects	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Materials for the maintenance and repair of the dwelling	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Non-durable household goods	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Gardens, plants and flowers	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Pets and related products; veterinary and other services	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Newspapers and periodicals	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Miscellaneous printed matter; stationery, drawing mat.	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Electrical appliances, articles and products personal care	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Actual rentals for housing	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Services for the maintenance and repair of the dwelling	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Repair of household appliances	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Domestic services and household services	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Recreational and sporting services	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Restaurants, cafes and the like	0.01	***	0.01	***	0.01	***	0.01	***	0.05	**
Canteens	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Hairdressing salons, personal grooming establishments	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Package holidays	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Accommodation services	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Maintenance and repair of personal transport equip.	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Other services in respect of personal transport equip.	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Passenger transport by air	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Insurance connected with transport	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Financial services n.e.c.	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Meat	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Fish and seafood	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Fruit	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Vegetables	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Liquid fuels	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***
Fuels and lubricants for personal transport equipment	0.01	***	0.01	***	0.01	***	0.01	***	0.01	***

Note: Ho : Unit root exists. One/two/three asterisks denote significance at the 10%, 5% and 1% levels, respectively. All test results are based on p=12 lags.

Table 1.7: $p-$values for linear G-Causality test for 58 HICP of goods and services.

	Euro area		Germany		France		Italy		Spain	
Bread and cereals	0.27		0.16		0.18		0.18		0.14	
Milk, cheese and eggs	0.00	***	0.02	**	0.01	**	0.31		0.06	*
Oils and fats	0.78		0.75		0.03	**	0.73		0.36	
Sugar, jam, honey, chocolate and confectionery	0.50		0.13		0.25		0.15		0.42	
Food products n.e.c.	0.03	**	0.63		0.18		0.29		0.51	
Coffee, tea and cocoa	0.83		0.84		0.54		0.79		0.64	
Mineral waters, soft drinks, fruit and vegetable juices	0.28		0.39		0.68		0.30		0.92	
Spirits	0.18		0.53		0.71		0.04	**	0.40	
Wine	0.85		0.52		0.34		0.47		0.23	
Beer	0.09	*	0.42		0.84		0.32		0.36	
Furniture and furnishings	0.98		0.52		0.91		0.99		1.00	
Carpets and other floor coverings	0.89		0.79		0.24		0.35		0.68	
Major, small household appliances	0.64		0.30		0.84		0.80		0.97	
Motor cars	0.13		0.43		0.44		0.03	**	0.66	
Motor cycles, bicycles and animal drawn vehicles	0.41		0.81		0.41		0.70		0.23	
Equip. reception, recording and rep. sound and pictures	0.43		0.34		0.50		0.72		0.99	
Phot. and cinematographic equipment and optical inst.	1.00		0.72		0.99		0.98		0.87	
Information processing equipment	0.02	**	0.35		0.05	*	0.82		0.47	
Jewellery, clocks and watches	0.70		0.98		0.74		0.50		0.72	
Garments	0.86		0.95		0.85		0.93		0.64	
Other articles of clothing and clothing accessories	0.81		0.84		0.89		0.82		0.76	
Footwear including repair	0.85		0.98		0.92		0.76		0.81	
Household textiles	0.79		0.33		0.99		0.99		0.22	
Glassware, tableware and household utensils	0.97		0.23		0.43		0.79		0.92	
Tools and equipment for house and garden	0.82		0.94		0.93		0.84		0.49	
Spares parts, accessories for personal transport equip.	0.89		0.96		0.99		0.55		0.72	
Recording media	0.92		0.96		0.30		1.00		0.73	
Games, toys and hobbies	0.80		0.53		0.65		0.95		0.72	
Equipment for sport, camping and open-air recreation	0.84		0.45		0.69		0.74		0.93	
Other personal effects	0.86		0.47		0.95		0.90		0.40	
Materials for the maintenance and repair of the dwelling	0.59		0.30		0.73		0.71		1.00	
Non-durable household goods	0.52		0.23		0.83		0.83		0.48	
Gardens, plants and flowers	0.86		0.95		0.71		0.93		0.81	
Pets and related products; veterinary and other services	0.04	**	0.00	***	0.29		0.91		0.02	**
Newspapers and periodicals	0.68		0.09	*	0.98		0.92		0.63	
Miscellaneous printed matter; stationery, drawing mat.	0.73		0.59		0.52		0.98		0.01	***
Electrical appliances, articles and products personal care	0.47		1.00		0.23		0.85		0.58	
Actual rentals for housing	0.96		0.43		0.01	**	0.09	*	0.90	
Services for the maintenance and repair of the dwelling	0.67		0.97		0.06	*	0.10	*	0.65	
Repair of household appliances	0.52		0.14		0.08	*	0.17		0.45	
Domestic services and household services	0.09	*	0.96		0.76		0.07	*	0.47	
Recreational and sporting services	0.14		0.03	**	0.04	**	0.57		0.51	
Restaurants, cafes and the like	0.26		0.38		0.91		0.69		0.61	
Canteens	0.38		0.53		0.32		0.50		0.33	
Hairdressing salons, personal grooming establishments	0.80		0.74		0.85		0.44		1.00	
Package holidays	0.55		0.03	**	0.73		0.46		0.36	
Accommodation services	0.99		0.89		1.00		0.98		0.74	
Maintenance and repair of personal transport equip.	0.88		0.89		0.23		0.98		1.00	
Other services in respect of personal transport equip.	0.52		0.91		0.21		0.95		0.33	
Passenger transport by air	0.15		0.73		0.11		0.45		0.22	
Insurance connected with transport	0.26		0.30		0.70		0.38		0.27	
Financial services n.e.c.	0.14		0.52		0.71		0.82		0.64	
Meat	0.44		0.18		0.10		0.30		0.15	
Fish and seafood	0.07	*	0.36		0.01	**	0.06	*	0.23	
Fruit	0.57		0.98		0.07	*	0.93		0.99	
Vegetables	0.10	*	0.04	**	0.06	*	0.78		0.30	
Liquid fuels	0.00	***	0.00	***	0.00	***	0.17		0.25	
Fuels and lubricants for personal transport equipment	0.00	***	0.02	**	0.09	*	0.05	*	0.10	*

Note: $Ho : P_t^{i,j}$ does not G-cause O_t. One/two/three asterisks denote significance at the 10%, 5% and 1% levels, respectively. All test results are based on p=12 lags.

We include non-energy commodity price to control for other costs in the domestic production that could be transmitted to inflation. The consumer confidence indicator is included since its influence is important for price formation on the demand side, especially since the 2008-09 crisis. The international trade index is used to capture global demand shocks and to measure global competition.[15] Note that the input and output variables are stationary.[16]

The effects of each input $k \in \{1, \ldots, 4\}$ are represented with the linear TF operator $v^k(L)$, where the values $v_0^k, v_1^k, \ldots, v_{12}^k$ are referred to the impulse response TF weights and represent the delay of response in the process within a year. These weights provide a measure of how the input variables affect the inflation at each time lag. The sum of all weights $g_k = v_0^k + v_1^k + \cdots + v_{12}^k$ is called the steady state gain (see Liu et al. [1992]). As our objective is to check how O_t is transmitted dynamically into the HICP inflation, we are interested in calculating from equation 2.2 the steady state gain for k =1, g_1.

Finally, the disturbance term $N_t^{i,j}$ is normally considered to be a stationary ARMA process defined as

$$N_t^{i,j} = \frac{\theta(L)}{\phi(L)} a_t^{i,j}$$

where $\phi(L)$ is the autoregresive operator of order p and $\theta(L)$ the moving average process of order q. $a_t^{i,j}$ is a sequence of random errors that are independently and identically distributed with a normal distribution $N(0, \sigma^2_{a^{i,j}})$.

The TF has been specified by the Linear Transfer Function (LTF) identification method, proposed by Liu and Hanssens [1982]. All the calculations have been implemented in SCA statistical system software (Liu et al. [1992]).

[15] There are other variables used to measure global demand growth as the Industrial Production or the Kilian [2009] monthly global real activity index, but the results are similar.

[16] We estimate the ADF test ($p-$values in parenthesis) for log levels of NC_t (0.41), S_t^i (Germany: 0.113, France: 0.073, Italy: 0.436, Spain: 0.315) and T_t (0.018), and conclude that we should employ the 1st-difference to achieve stationary.

1.4. Results

We first obtain the steady state gain in percentage points derived from a 10% oil price increase for total inflation (see Table 1.8, first column).[17] This gain is around 0.16 percentage points for all economies except for Italy where no gain is observed. To gain further insights about the inflation gain derived from the change in oil prices, we calculate the steady state gain for each of the five special groups in inflation (see Table 1.8): processed food (PF), non-energy industrial goods (NEIG), services (SER), non-processed food (NPF) and energy (ENE). The results indicate that an oil price increase only has a relevant impact on one of the five special groups in inflation, specifically on energy inflation. The gain in energy inflation is around 3.5 percentage points for the euro area and Germany, around 3 percentage points for France and Spain, and 2.4 for Italy. Finally, we also compute the steady state gain from a 10% oil price increase for each of the 58 components of the five special groups (see Figures 1.8 and 1.9): 10 processed foods (PF), 27 non-energy industrial goods (NEIG), 15 services (SER), 4 for non-processed foods (NPF) and 2 energy goods (ENE).

Table 1.8: TF gains in percentage points derived from a 10% oil price increase for total, processed food (PF), non-energy industrial good (NEIG), services (SER), non-processed food (NPF), and energy (ENE) inflation.

	Total	PF	NEIG	SER	NPF	ENE
Euro area	0.16	0.00	0.00	-0.01	-0.05	3.56
Germany	0.17	0.00	-0.00	-0.03	0.05	3.45
France	0.18	0.00	0.00	0.00	0.18	3.18
Italy	0.00	0.00	0.02	0.00	0.00	2.38
Spain	0.16	0.00	0.00	0.00	0.00	2.99

We analyze the effects of the oil price changes on the two components (liquid fuels, and fuels and lubricants for personal transport equipment) of energy inflation.[18] Figure 1.8 shows the accumulated TF one-year gains in energy inflation and its components derived from a 10% increase in the oil prices. The impact on the liquid fuels inflation ranges from 2 percentage points in Italy to 6 percentage points in Germany, but this component has a small weight in the total inflation basket (with

[17] It is common in the related literature to consider a 10% increase in oil prices, which corresponds in this case with 16 times its standard deviation.

[18] Liquid fuels refer to domestic heating and lighting oils. Fuels and lubricants for personal transport equipment include diesel, petrol and other fuels for personal transport equipment and lubricants.

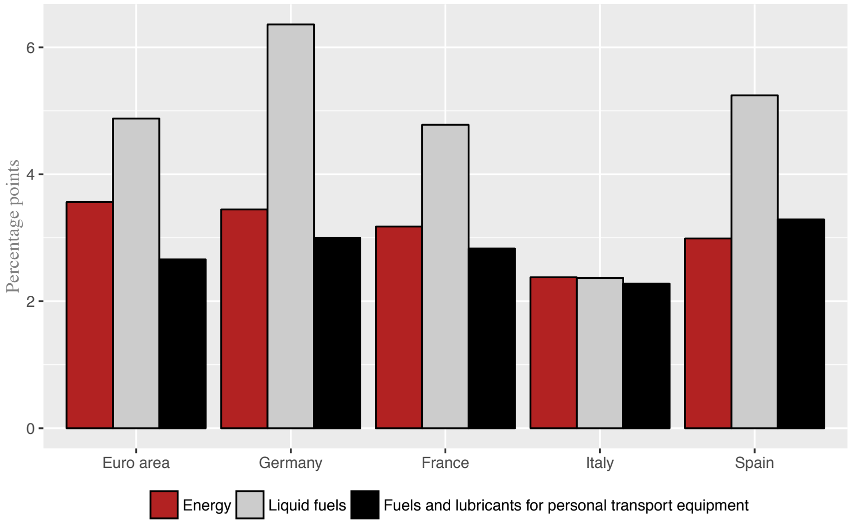


Figure 1.8: Effects from a 10% oil price increase on energy inflation and its components (excluding administered prices) in percentage points.

a range from 0.4% in Spain to 0.9% in Germany).[19] The impact on inflation of fuels and lubricants for personal transport equipment is smaller than that in the other energy component, although its weight in total inflation is higher and, consequently, it has a larger effect on the aggregated energy and total inflation. In sum, an increase in oil prices leads to an increase mainly in liquid fuels inflation (component with small weight in total inflation) and to a lesser extent in inflation of fuels and lubricants for personal transport equipment (component with a greater weight in total inflation). The euro area (with 3.6 percentage points) and Germany (with 3.5 percentage points) suffer the greatest impact on energy inflation and Italy (with 2.4 percentage points) the lowest effect. The difference effects across countries may be due to either the competitiveness of the energy sector or the taxation system.

We now analyze the impact of an oil price increase on inflation for the 56 goods and services of PF, NEIG, SER and NPF. We find no effect on the inflation of 13 goods and services for all countries.[20] Thus, Figure 1.9 only shows the results for the remaining 43 goods and services. We observe that the TF effects are highly

[19]Note that the consumption structure of households determines the HICP weights (see Footnote 7).

[20]The goods and services with no effect are the following: (1) bread and cereals, (2) milk, cheese and eggs, (3) mineral waters, soft drinks, fruit and vegetable juices, (4) major and small household appliances, (5) equipment reception, recording and reproduction of sound and pictures, (6) photographic and cinematographic equipment and optical instruments, (7) jewellery, clocks and watches, (8) garments, (9) footwear, (10) tools and equipment for house and garden (11) newspapers and periodicals, (12) miscellaneous printed matter; stationery, drawing material, and (13) other services in respect of personal transport equipment.

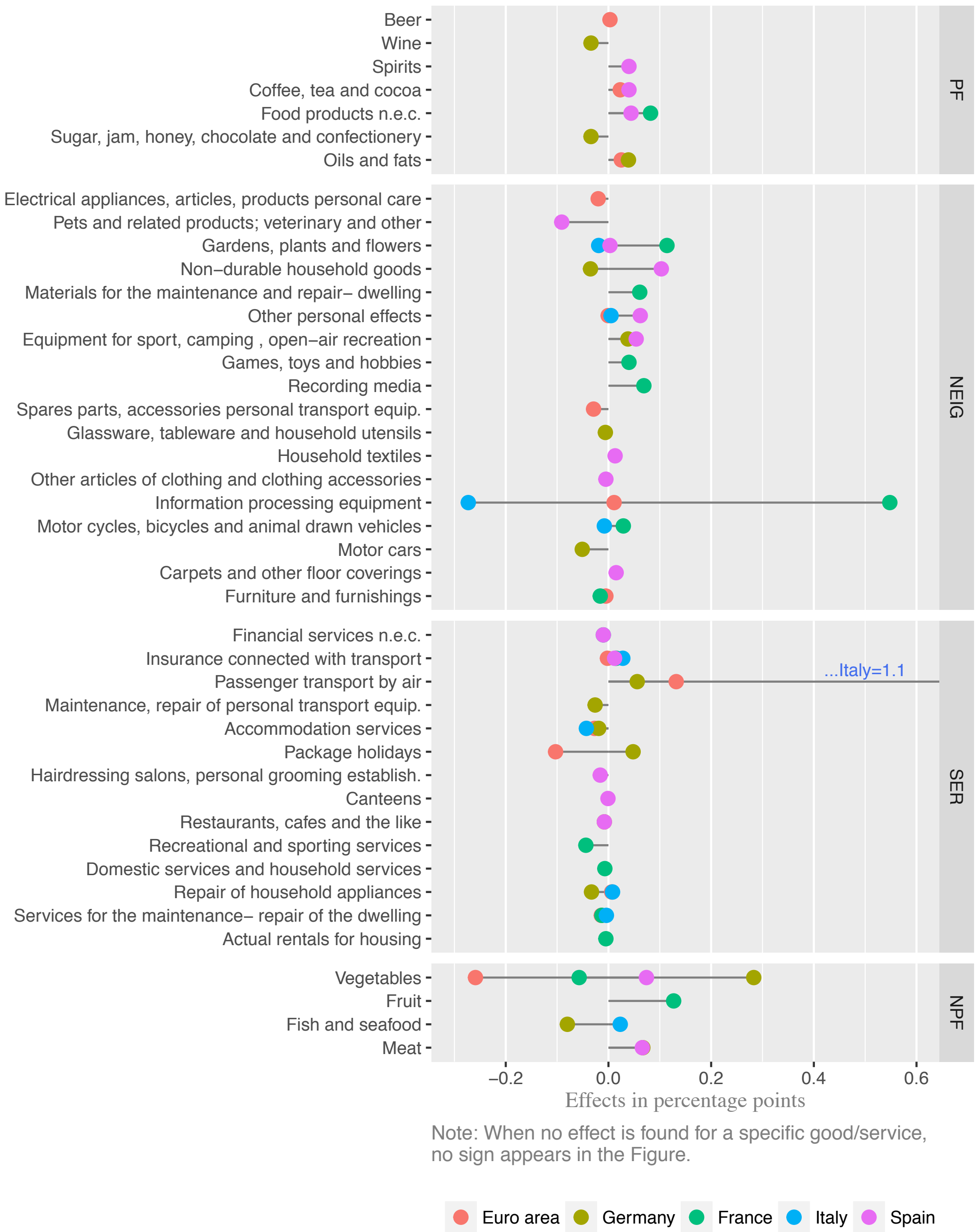


Figure 1.9: Effects in percentage points on inflation of processed foods (PF), non-energy industrial goods (NEIG), services (SER) and non-processed foods (NPF) derived from a growth of 10% in oil prices within a year, 1996:1-2014:12.

heterogeneous and without any clear pattern. For many goods and services, the effects only occur for one economy. Indeed, we do not find any good or service with effects in the five economies. The largest number of effects occurs in insurance connected with transport (negative for the euro area and positive for Germany, Italy and Spain) and vegetables (positive for Spain and Germany, and negative for France and the euro area). In other cases like passenger transport by air, the effects on inflation are (as expected) positive for Germany, Italy and the euro area, although there is no effect for Spain and France.

There is no consensus in the literature regarding the nature of the positive/negative effects of an increase in oil price. On the one hand, inflation movements are related to the falling in the consumer demand for goods and services due to an increase in oil price. These demand side changes may occur through four direct transmission channels: (a) changes in the discretionary income (i.e., the available money to spend after paying energy bills); (b) uncertainty about future energy prices; (c) precautionary savings; and (d) operating costs effects (see, e.g., Edelstein and Kilian [2009]; Kilian [2008c]). On the other hand, there are indirect effects of oil price changes due to an increase in the production costs of goods and services that use energy in its own production process, although this issue has not been still solved in the empirical literature (see Kilian [2008c]). Moreover, Hamilton [2009b] points out that magnitude and timing of disruption in consumer's and firm's spending on goods and services, other than energy costs, determine the supply reaction and thus is a main way toward explaining how energy price shocks affect the economy.

In short, the positive gain in inflation due to oil price increases for some goods and services may be partially explained by the reduction in the supply, while the negative gain may be associated with the slowdown in the demand. The final sign of the gain depends on the balance between the particular structure in the production and the idiosyncratic factor of consumption and, consequently, we can find opposite signs for the same good or service in two different economies. This finding might indicate a further loss of competitiveness due to indirect or second round effects of oil price increases.

Figure 1.10 plots the number of goods and services with positive, negative and zero gains 12 months after a 10% oil price shock. We first observe that inflation corresponding to most goods and services remain unchanged when oil price changes. Second, Spain is the economy where oil price changes are disseminated through the inflation of largest number of goods and services (20), while Italy has the lowest

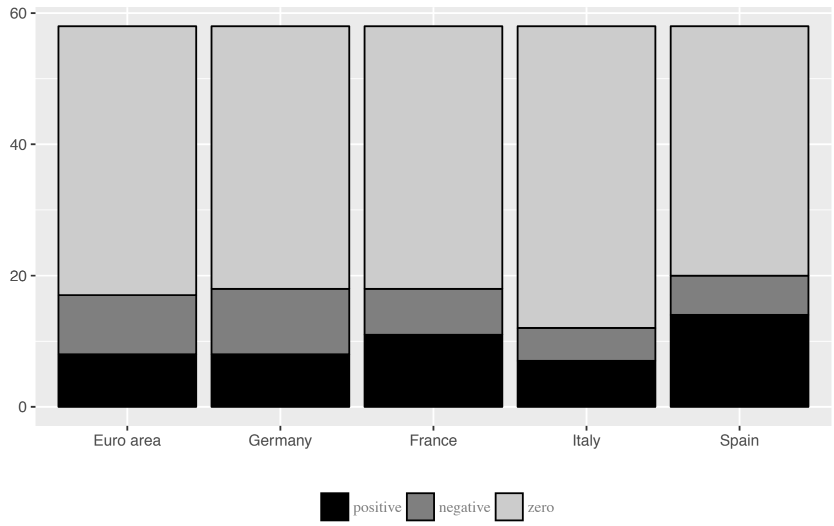


Figure 1.10: Number of goods and services according to the sign of their effects within a year, as a consecuence of an increase of 10% in oil prices, 1996:1-2014:12.

number (12). Finally, Germany shows the highest number of goods and services with negative gains (10), likely due to a lower demand, while the largest number of positive effects is found in Spain (14), likely due to a reduction in the supply.

The results shown in Figure 1.9 can also be seen as changes in competitiveness of goods and services among economies. When an increase in oil price leads to a rise in inflation for a good/service of one specific economy and a fall in the corresponding inflation for other economy, this may mean a competitiveness improvement for the latter economy. This is, for example, the case of the inflation in nondurable household goods, whose inflation increases in Spain and decreases in Germany due to a positive oil price shock. This can be interpreted as a loss of Spanish competitiveness and a gain of the German one.

An important concern is to analyze the reason why the effects on total inflation are very similar across most countries (Table 1.8, first column) despite the fact that there are different impacts at disaggregate level (Figures 1.9 and 1.8). A possible explanation could be that positive and negative indirect and second round effects (those affecting especially non-energy goods and services) offset the positive effects found on energy inflation, dissipating the effects on total inflation. In this sense, Figure 1.8 suggests that the calculation of effects in the aggregate variables (i.e., total inflation) could hide a wide range of effects on their disaggregated components, to the extent that we could not find any effect on aggregate variables. That is the case of Italy, where an important effect on energy inflation is found and no effect appears in the direct TF gain of total inflation (see Table 1.8). Thus, an alternative approach is to calculate indirectly the effects on total inflation (or the groups of inflation) aggregating the impact on its components with their corresponding weights. The results are shown in Table 1.9. In the case of energy inflation, the aggregate effects are similar to the direct calculation shown in Table 1.8. In other groups, the results using the indirect method are similar to those considering the direct one, with the exception of the effects on inflation of processed food (PF). Furthermore, the effect on total inflation obtained by the indirect method is higher than that found using the direct method in all economies. In particular, the impact on total inflation by aggregation of effects (indirect method) is 0.13 percentage points in Italy.

Table 1.9: Indirect calculations of TF gains in percentage points derived from a 10% oil price increase for total, processed food (PF), non-energy industrial good (NEIG), services (SER), non-processed food (NPF), and energy (ENE) inflation.

	Total	PF	NEIG	SER	NPF	ENE
Euro area	0.19	0.06	-0.00	-0.04	-0.05	3.01
Germany	0.26	0.04	-0.01	0.03	0.09	3.65
France	0.24	0.05	0.01	0.06	0.01	3.13
Italy	0.13	0.08	-0.00	0.02	0.00	2.29
Spain	0.27	0.09	0.01	0.02	0.04	3.44

1.5. Conclusions

This chapter provides an exhaustive examination of the effects of oil price changes in inflation for the euro area and its main economies (France, Germany, Italy and Spain) by using a disaggregated approach.

In a first disaggregation of inflation in energy and non-energy components, we find that changes in oil price have a large and clear direct impact on energy inflation, although the effect on total inflation seems to be weak. There is a strong contribution of energy inflation due to an oil price increase to total inflation in Germany, but the reaction of non-energy inflation helps to contain notably total inflation. However, both energy and non-energy inflation contribute notably to total inflation in Spain. These differences across countries might be explained by the indirect or second round effects, the differences in consumption and production structure, and the specific taxes and regulatory rules of each domestic market.

To better understand the oil price pass-through into inflation, we consider a deeper disaggregation of inflation (excluding goods and services with administered prices to avoid the distortionary influence of price movements outside of the market forces). On looking at the disaggregation of inflation for the special group “energy”, we observe that the largest effect to an oil price increase corresponds to the inflation of fuels and lubricants for personal transport equipment in Spain, which is consistent with (1) its more direct transmission due to lower taxes, (2) its larger dependence on energy, and (3) its largest consumer’s spend in this product.

Regarding the other special groups (processed and non-processed food, non-energy industrial goods and services), we observe a small significant gain in the corresponding special group inflation after an oil price increase. Looking at the disaggregate level, we obtain that the prices of the goods and services considered remain unchanged after an oil price shock, which is consistent with a low price elasticity of demand for energy, typical of advanced economies, which causes marginal variations in the demand for non-energy goods and services. Moreover, when a reaction is obtained we observe different responses across countries and across items, which may be associated with indirect and second round effects. These differences are partly the consequence of specific domestic structure in the production and the idiosyncratic factor of consumption.

We found that Spain shows the largest number of goods and services with positive effects on inflation derived from oil price changes, maybe due to a slowdown in domestic supply. This means a loss of competitiveness for these goods and services in Spain. By contrast, Germany shows the largest number of negative effects on inflation, maybe due to a slowdown in domestic demand, which means a competitiveness gain.

Finally, our findings suggest that aggregation of effects at disaggregate level could be more accurate than their direct calculation given that indirect and second round effects (those affecting especially non-energy goods and services) may offset the positive effects found in energy inflation and dissipate the effect on total inflation.

Chapter 2

Oil price pass-through along the price chain in the euro area

2.1. Introduction

There is a large body of research on analyzing production reactions to oil price changes (see, Fukunaga et al. [2010]; Lee and Ni [2002]; Ramcharran [2002]; among others). The theoretical literature states that crude oil is a basic raw material at many production levels and a rise in its price increases production costs, which give rise to a drop in productivity due to the use of a more costly input. Higher costs seem to be insufficient to explain the observed effects of oil price fluctuations on production (see, e.g., Rotemberg and Woodford [1996]; Atkeson and Kehoe [1999]) and the related literature has tried to find complementary explanations. Some of these explanations are based on the gradual decline in the share of oil in total gross value added and consumption (see Blanchard and Galí [2010]),[1] the existence of different manufacturing structures or the rigidities in product and labor markets (see, e.g., Blanchard and Galí [2010]; Jiménez-Rodríguez [2008]). Nevertheless, the main effect of an increase in oil price on the industrial production seems to be the fall in domestic demand caused by the cutbacks in consumer expenditures due to lower real and expected incomes. The latter is in line with Davis and Haltiwanger [2001] and Keane and Prasad [1996], who find a fall in wages and employment (at

[1]For example, Álvarez et al. [2011] show that the share of oil and fuels costs in total economy is only 3.4% in Spain and 2.9% in the euro area. Edelstein and Kilian [2007] indicate that energy share in value added (the sum of nominal value added in oil and gas extraction and imports of petroleum and petroleum products divided by nominal GDP) is 3.3% for the U.S. in 2005.

least, in the short run) after an oil price shock. The fall in wages and employment exacerbates the fall in consumer income and thus generates additional reductions in domestic demand. Therefore, the main concern for producers would come from the uncertainty about the depth and duration of an oil price shock and its impact on the future consumer demand, as well as the subsequent reaction of monetary policy. The reactions of consumers and monetary policy are precisely those that most affect the producers and those on which the empirical literature has put more emphasis (see, e.g., Lee and Ni [2002]; Hamilton [2009b]; Kilian [2008c]; Blanchard and Galí [2010]).

The literature has also analyzed the main mechanisms through which producers make adjustments to deal with an increase in oil prices: (i) producers may transfer higher costs to consumers, which causes an increase in non-energy inflation and a subsequent fall in the demand;[2] (ii) producers may reduce production[3] since they expect that consumers decrease demand for their products and thus reduce their production level in order to prevent the fall in prices; (iii) producers may reduce investment, although the degree of adjustment will depend on the intensity of use of energy in production and the elasticity of substitution by other less energy intensive technologies (see ECB [2010]; Lee and Ni [2002]);[4] (iv) producer may support technological upgrading to maintain the production level, treating thus an energy shock as a productivity shock;[5] (v) producers may reallocate resources given that changes in consumption patterns induced by an oil price shock can give rise to a

[2]Lescaroux and Mignon [2008] highlight that such a producers' reaction clearly explains the effects of oil price shocks in the early 1970s, but it is not considered relevant in the shocks of the 2000s for three reasons: the increased credibility of monetary policy, lower indexation wages and higher international competition between companies.

[3]Rotemberg and Woodford [1996] estimate that the reduction in production originated by higher costs is small and can be amplified if companies cannot offset higher production costs by reducing wages. In this line, Keane and Prasad [1996] find that real wages (and employment at the short run) are reduced as a result of an oil price shock. Lee and Ni [2002] suggest that an oil price shock reduces production, planned investment or employment only in oil intensive sectors like oil refining and the chemical industry. Davis and Haltiwanger [2001] also study the effects of oil price shocks on the U.S. industries, especially during the shock of 1973 and the fall in employment on the U.S. automotive sector. In the European countries, Jiménez-Rodríguez [2008] finds that oil price increases have a negative impact on industrial production at the sectoral level.

[4]Bernanke [1983] shows that companies reduce their irreversible investment in durable goods until they are sure of the duration and intensity of the oil price change. More recently, some authors do not find arguments to support the reduction in investment as a result of an oil price shock (see Edelstein and Kilian [2007]).

[5]Atkeson and Kehoe [1999] argue that the product falls in the long term even when the producers adopt less intensive capital and energy technologies. Hamilton [1988] marks, from a flexible pricing model, the appearance of frictional unemployment as workers seek to work in other sectors. The adoption of energy-saving technologies in production is also one of the reasons why Blanchard and Galí [2010] and Bachmeier and Cha [2011] explain the progressive reduction of the effects of the oil price shocks on the non-energy inflation.

sectoral reallocation;[6] and (vi) producers may increase inventories in order to reduce temporarily the supply, assuming that the oil price shock will not be long lasting (see Herrera [2006]).

Despite the fact the large literature on production reactions and producers' adjustments after an oil price shock, there is no study that analyzes the patterns of oil pass-through along the price chain at a disaggregate level. However, this analysis is crucial to forecast consumer prices and so to determine the appropriate monetary policy.

This chapter extends the empirical work on oil price impacts by analyzing the oil pass-through along the price chain in the euro area (EA) by using disaggregate data at the industry level.[7] To do so, we have first to generate an appropriate database due to there is no available database that identify industrial production sectors with their corresponding consumer goods at a disaggregate price level. Once we match the industrial production sectors with their corresponding consumer goods at the highest level of disaggregation, we investigate the oil price pass-through in the euro area by considering a pricing chain approach and by analyzing how shocks in oil prices are transmitted downstream to producer and consumer prices.[8]

The chapter is organized as follows. Section 2.2 discusses the data. Section 2.3 describes the model. Section 2.4 shows the results.

2.2. Data

We use monthly disaggregate EA[9] data at the industry level on producer price index (ppi_t)[10] and the Harmonised index of consumer price ($hicp_t$), as well as the nominal

[6]Davis and Haltiwanger [2001] argue that technological rigidities or markets do not allow rapid conversion of production and may lead to reduction of an entire industrial sector. This was the case of the automobile industry in the U.S. during the shocks of the 1970s (see Edelstein and Kilian [2009]; Lee and Ni [2002]). Davis and Haltiwanger [2001] study the effects on sectoral employment and show that an oil price shock increases job losses and reduces its creation after four months of the shock, with a negligible effect after 2 years, but with the reallocation of employment.

[7]Authors such as Herrera et al. [2011] and Jiménez-Rodríguez [2008] have highlighted the relevance of a disaggregated analysis of the industrial production.

[8]The pricing chain approach has been previously used by authors such as Ferrucci et al. [2012]

[9]Euro area refers to EA-18, which consists of Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Greece, Slovenia, Cyprus, Malta, Slovakia, Estonia and Latvia.

[10]Eurostat indicates that "producer price index shows the development of transaction prices for the monthly industrial output of economic activities. Overall, it measures the average price

Brent price in € ($poil_t$). The longest available sample period for disaggregate data runs from January 2000 to August 2015. The producer and consumer price data are downloaded from the Eurostat database (http://ec.europa.eu/eurostat). The nominal oil price data in U.S. dollars and the U.S. dollar to euro exchange rate data come from U.S. Energy Information Administration (http://www.eia.gov) and European Central Bank (http://www.ecb.europa.eu), respectively.

As pointed out previously, there is no available database that identify industrial production sectors with their corresponding consumer goods at a disaggregate price level. Thus, we make a correspondence between the industrial production sectors and consumer prices. We first identify 31 industrial branches (from the NACE, Revision 2 classification)[11] that use oil in support of its primary activities according to the international methodology for oil statistics.[12] Among these industrial branches, there are only nineteen related to the supplies or direct production of 49 consumer goods which are identified according to COICOP/HICP classification.[13] Thus, we obtain for each producer price index an equivalent group of Harmonised index of consumer price by aggregating all the related consumer price indices with their corresponding weights (see Appendix).[14] For clarification purposes, we next show how we have made the match between the industrial production sectors and consumer prices for one particular industrial branch. The industrial branch named *Manufacture of wearing apparel* (NACE rev. 2 code 14) is dedicated to the production of two consumer goods: *Garments* and *Other articles of clothing and clothing accessories* (COICOP/HICP codes 03.1.2 and 03.1.3, respectively). Therefore, the producer price index for *Manufacture of wearing apparel* is matching with the consumer price index obtained from the weighted aggregation of the corresponding two consumer

development of all goods and related services on both the domestic and the non-domestic markets, at all processing stages".

[11]The statistical classification of economic activities in the European Community, abbreviated as NACE, is the classification of economic activities in the European Union.

[12]In oil statistics, oil is used in transformation sector (quantities of oil transformed into another energy form, i.e. generation of electricity and heat), energy sector (oil consumed by the energy sector to support the extraction or plant operation of transformation activities) and total final consumption (transport, industry and other sectors). Consequently, we use total final consumption in industry, excluding the use of oil in other sectors, and therefore we do not take into account costs generated for providing consumer goods and services, as transport. See, for example, the methodology in http://www.iea.org.

[13]The COICOP/HICP is the United Nations Classification of individual consumption by purpose (COICOP), which was adapted to the compilation of the Harmonised index of consumer prices (HICP) of the European Union and the euro area.

[14]We use the annual weights for each COICOP/HICP item from 2000 to 2014 published by Eurostat. The information used by Eurostat to calculate the weight of each product group is collected mainly by means of household budget surveys and therefore is representative for the average household consumption expenditure. See methodology in https://www.ecb.europa.eu.

price indices (*Garments* and *Other articles of clothing and clothing accessories*).[15]

Once we match the industrial production sectors with their corresponding consumer goods, we analyze the seasonal and non-stationary behaviour of the log transformed indices. Table 2.1 shows the main results for producer and consumer prices. We observe that most of the producer and consumer price indices display seasonality and, consequently, we have performed a seasonal adjustment procedure using the TRAMO-SEATS.[16] On the contrary, $poil_t$ does not show seasonal fluctuations.

Once the producer and consumer price indices have been seasonally adjusted, we investigate the stationarity of the log levels by using the augmented Dickey-Fuller (ADF) test, whose the null hypothesis is the existence of a unit root. We cannot reject the null hypothesis for oil prices (not shown in the table)[17], eighteen producer price indices and seventeen consumer price indices (see Table 2.1). Despite the fact there is one producer price and two consumer prices in which stationary in the log-levels is found, we have decided to do the first log-differences for all indices for interpretation purposes.

Table 2.1: Seasonal adjustment and unit root test.

		Producer price index, ppi_t^b					Consumer price index, $hicp_t^b$				
b	branch		log-level		Δ			log-level		Δ	
1	mining	SA	0.30		-7.41	***	SA	1.06		-7.38	***
2	food		-2.45		-4.11	***	SA	-1.95		-6.86	***
3	beverages	SA	-1.51		-7.47	***	SA	-1.25		-4.90	***
4	tobacco	SA	-1.64		-10.67	***		-0.71		-9.31	***
5	textile	SA	-1.03		-5.07	***	SA	-1.64		-12.04	***
6	apparel	SA	-1.76		-8.01	***	SA	-5.13	***	-13.56	***
7	leather	SA	-0.68		-7.95	***	SA	0.05		-8.26	***
8	wood		-1.79		-4.80	***	SA	1.36		-6.18	***
9	paper		-2.74		-4.53	***	SA	-0.52		-5.78	***
10	recorded		-4.20	***	-8.66	***	SA	-1.66		-5.43	***
11	chemical	SA	-2.36		-6.54	***	SA	-2.04		-8.84	***
12	non-metallic	SA	0.16		-4.49	***	SA	1.08		-3.36	***
13	basic metals		-1.50		-4.67	***		-0.86		-4.71	***
14	metal	SA	-0.06		-4.84	***	SA	-0.36		-5.02	***
15	electronic		1.43		-8.10	***	SA	-1.17		-6.08	***
16	electrical	SA	-1.09		-4.79	***	SA	-0.77		-5.90	***
17	machinery	SA	-0.88		-7.49	***	SA	-3.64	**	-6.24	***
18	motor		-3.09		-9.62	***	SA	-1.28		-7.70	***
19	transport		-2.75		-13.64	***	SA	0.41		-5.77	***

Note: Seasonal adjustment (SA) series and ADF test statistics for log-levels and 1st log-differences (Δ) of each branch b. The null hypothesis is that a unit root exists. One/two/three asterisks denote significance at the 10%, 5% and 1% levels, respectively.

We now investigate whether the past values of oil price changes help predict the

[15] See details in the Appendix.

[16] We implement the multi processing seasonal adjustment with JDemetra+, available at European Statistical System (http://ec.europa.eu/eurostat/).

[17] The p-values of ADF test for oil prices are 0.59 and 0.01 for the log-levels and the first log-differences of oil prices, respectively.

value of the changes in the producer price index of branch b:

$$\Delta ppi_t^b = c^{b,1} + \sum_{j=1}^{p} \alpha_j^1 \Delta ppi_{t-j}^b + \sum_{j=1}^{p} \beta_j^1 \Delta poil_{t-j} + \mu_t^{b,1} \tag{2.1}$$

We also test whether changes in the producer price index of branch b help predict changes in the consumer price index of branch b:

$$\Delta hicp_t^b = c^{b,2} + \sum_{j=1}^{p} \alpha_j^2 \Delta hicp_{t-j}^b + \sum_{j=1}^{p} \beta_j^2 \Delta ppi_{t-j}^b + \mu_t^{b,2} \tag{2.2}$$

where $p = 1, 2, \ldots 24$ and $b = 1, 2, \ldots 19$ branches. We use an F-statistics to test for the null hypothesis that $\beta_1^k = \beta_2^k = \cdots \beta_p^k = 0$ with $k = 1, 2$.

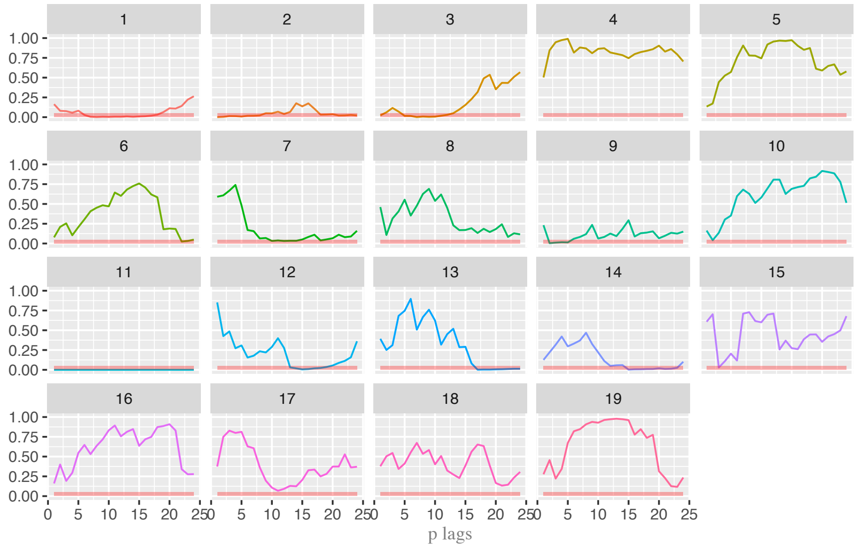
Instead of evaluating the Granger-causality (G-causality) test for a convenient p lag, we take into account the Hamilton and Herrera [2004]'s warning about the convenience of including a rich lag structure in studying the effects of oil prices on macroeconomic variables. Then, we investigate the sensitive of the G-causality test to the choice of lag length $p = 1, 2, \ldots 24$, obtaining their corresponding $p-$values.

Figure 2.1 indicates that oil price changes G-cause industrial price changes (at least, for some lag) in ten out of nineteen branches. As expected, G-causality is found for the industrial sectors with the highest oil consumption (see Figure 2.2).[18] We find that evidence of G-causality when more than 12 lags are included for the branch 12, the *non-metallic* branch (the branch with the highest relative consumption of oil). We also obtain that oil price changes help predict the branch 11 (the *chemical* branch) for any lag. In contrast, we do not find G-causality at any lag for branches with the lowest consumption of oil (*wood* branch, b=8).

Figure 2.3 shows that industrial price changes G-cause consumer price changes in most of branches (12 out of 19) for, at least, some lag.

Therefore, G-causality test provides evidence of causality running from oil prices

[18] There are no data of final consumption in total petroleum products that perfectly coincide with the branches used in this chapter. Thus, we have done a correspondence between the branches of this chapter and the industrial sectors for which there are data of final consumption in total petroleum products. Specifically, we have used the following identification: *Non-Metallic Minerals*=branch 12; *Chemical and Petrochemical Products*=branch 11; *Food and Tobacco*=branches 2, 3, 4; *Machinery*=branches 15, 16, 17; *Iron and Steel* and *Non-Ferrous Metals*=branch 13; *Mining*=branch 1; *Paper, Pulp and Print*=branches 9, 10; *Textile and Leather*=branches 13, 14, 15; *Transport Equipment*=branches 18, 19; and *Wood and Wood Products*=branch 8.



Note: This Figure presents the p–values for G–causality test for b=1,2,...,19 branches and p=1,2,..,24 lags.
p–values < 0.05 (bottom shaded area in red) rejects the null hypothesis that $poil_t$ does not G–cause ppi_t^b

Figure 2.1: G-causality test $(Ho : poil_t$ does not G-cause $ppi_t^b)$

to producer prices and from producer to consumer prices, thereby supporting the chosen modeling strategy (the pricing chain approach).

2.3. The Model

It is our aim to analyze the oil pass-through along the price chain in the EA at disaggregate level. To do so, we consider a pth-order VAR for each branch b with oil price changes $(\Delta poil_t)$, changes in the producer price index (Δppi_t^b) and changes in the consumer price index $(\Delta hicp_t^b)$ as variables. Thus, the reduced form of VAR(p) is written as

$$Y_t = a + \sum_{j=1}^{p} \Phi(j) Y_{t-j} + \varepsilon_t \tag{2.3}$$

for each branch, with $Y_t = (\Delta poil_t, \Delta ppi_t^b, \Delta hicp_t^b)$ and with ε_t being a generalization of a white noise process with variance-covariance matrix Ω.

Although it is common in the literature on the effects of oil prices to consider oil prices as endogenous variable (see, e.g., Kilian [2008c]), the use of disaggregated data in a region like the euro area previously required test for whether domestic disaggregated prices cause oil prices. Thus, we apply a block-exogeneity test with the null hypothesis that oil price changes are not Granger-caused by changes in the producer price index and the harmonized index of consumer price of the branch b.

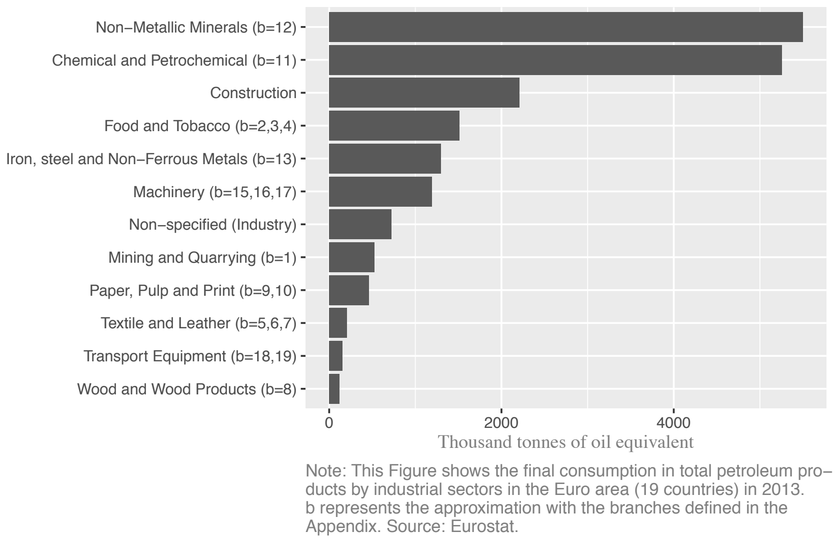


Figure 2.2: Final consumption in total petroleum products by industrial sectors.

Figure 2.3: G-causality test $(Ho : ppi_t^b$ does not G-cause $hicp_t^b)$.

Table 2.2[19] shows that the null hypothesis cannot be rejected for all branches but for *food* ($b = 2$) and *basic metals* ($b = 13$). Consequently, we consider a VAR(p) in which we do not allow that domestic price variables affect oil price changes for all branches but *food* and *basic metals* (given the results of the block-exogeneity test), but we allow the latter variable affects the former variables.

Thus, we estimate the following VAR(p) model:

$$\begin{pmatrix} \Delta poil_t \\ \Delta ppi_t^b \\ \Delta hicp_t^b \end{pmatrix} = \begin{pmatrix} a_1 \\ a_2 \\ a_3 \end{pmatrix} + \sum_{j=1}^{p} \begin{pmatrix} \phi_{11}^{(j)} & \phi_{12}^{(j)} & \phi_{13}^{(j)} \\ \phi_{21}^{(j)} & \phi_{22}^{(j)} & \phi_{23}^{(j)} \\ \phi_{31}^{(j)} & \phi_{32}^{(j)} & \phi_{33}^{(j)} \end{pmatrix} \begin{pmatrix} \Delta poil_{t-j} \\ \Delta ppi_{t-j}^b \\ \Delta hicp_{t-j}^b \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{pmatrix} \quad (2.4)$$

with $\phi_{12}^{(j)}$ and $\phi_{13}^{(j)}$ being zero for all j and for all branches but *food* and *basic metals*.

We estimate by maximum likelihood, with the optimal lag length chosen on the basis of the Akaike Information Criterion with an upper bound of 12 lags and a lower bound of 1 lag. Moreover, shocks are identified by means of a standard Cholesky decomposition with the variables ordered as follows: $\Delta poil_t$, Δppi_t^b and $\Delta hicp_t^b$. We obtain the impulse responses to an oil price shock and their corresponding 90%, 95% and 99% confidence bands calculate by means of a bootstrapping procedure.[20]

2.4. Results

This section presents the accumulated impulse responses to a 1% oil price shock, which come from a constrained VAR(p) for all branches except *food* and *basic metals*,

[19]The VAR(p) can be written as follows:

$$\Delta poil_t = a_1 + B_1' x_{1t} + B_2' x_{2t}^{(b)} + \varepsilon_{1t}$$

$$x_{2t}^{(b)} = a_2 + D_1' x_{1t} + D_2' x_{2t}^{(b)} + \varepsilon_{2t}$$

where x_{1t} contains lags of $\Delta poil_t$ and $x_{2t}^{(b)}$ is a vector $(2 \cdot p \times 1)$ vector containing lags of changes in the producer price index (Δppi_t^b) and the harmonized index of consumer price of branch b ($\Delta hicp_t^b$). We use the following test statistic to test for whether Δppi_t^b and $\Delta hicp_t^b$ Granger-cause $\Delta poil_t$ (i.e., $B_2 = 0$):

$$T \times \{\log |\sigma^2(0)| - \log |\sigma^2|\} \overset{a}{\sim} \chi^2(2p)$$

where σ^2 is the variance of the residuals from OLS estimation of (2.3) and $\sigma^2(0)$ that of the residuals from OLS estimation of model (2.3) when $B_2 = 0$.

[20]We apply the Efron bootstrap percentile confidence interval with 2500 draws.

Table 2.2: Block exogeneity test.

	branch	lags	statistic		p-value
1	mining	3	1.1917		0.3091
2	food	2	2.7595	**	0.0272
3	beverages	2	0.7856		0.5348
4	tobacco	1	1.3354		0.2639
5	textile	8	1.1145		0.3380
6	apparel	4	0.4044		0.9181
7	leather	6	0.8512		0.5974
8	wood	4	0.3738		0.9344
9	paper	4	1.0621		0.3884
10	recorded	3	0.1533		0.9884
11	chemical	1	2.2281		0.1087
12	non-metallic	12	0.4536		0.9888
13	basic metals	3	2.5346	**	0.0199
14	metal	6	1.3386		0.1927
15	electronic	6	1.5454		0.1044
16	electrical	5	0.9199		0.5144
17	machinery	2	1.3261		0.2590
18	motor	1	0.052		0.9494
19	transport	7	1.1817		0.2857

Note: One/two/three asterisks mean a *p*-value less than 10%, 5% and 1%, respectively.

in which an unrestricted VAR(p) model is used. Table 2.3 shows the accumulated responses of producer price index of branch b (in percentages) to a 1% oil price shock. For the sake of conciseness, we show the accumulated responses in quarters rather than months. We observe that an increase in oil prices leads to higher industrial production prices for most of branch, which is consistent with a natural subsequent increase in industrial costs given that crude oil has been a basic input to production, and that oil price pass-through to producer prices is not complete. However, the patterns of pass-through from oil prices to producer prices differ across branches. The branches with higher oil consumption (see Figure 2.2) are those in which the impact of an oil shock is statistically significant (*mining, food, paper, chemical, non-metallic metals, basic metals, metal* and *electrical*). In particular, the *basic metals* and *chemical* branches (which show very high oil consumption) have the largest significant accumulated effects, with an impact of 0.18% and 0.13% after one year, respectively. Therefore, it seems that there is a link between oil consumption and accumulated responses shown in Table 2.3. The branches with the highest oil consumption (*non-metallic, chemical* and *basic metals*) show significantly high responses to oil price shocks and those with the lowest oil consumption (*wood, motor* and *transport*) do not response significantly to oil shocks. Therefore, an oil price shock seems to increase industrial costs according to the intensity of final consumption of oil.

Table 2.3: Accumulated impulse responses of producer price index (in percentages) attributed to a 1% oil price shock.

	branch	lags	quarter 1		quarter 2		quarter 3		quarter 4	
1	mining	3	0.0051		0.0107	*	0.0143	*	0.0162	*
2	food	2	0.0179	**	0.0289	**	0.0348	**	0.0381	**
3	beverages	2	0.004		0.0049		0.0054		0.0057	
4	tobacco	1	-0.0027		-0.0028		-0.0028		-0.0028	
5	textile	8	0.0043		0.0084		0.0115		0.014	
6	apparel	4	0.0022		-0.0009		-0.0022		-0.0026	
7	leather	6	0.0037		0.0049		0.0134		0.0148	
8	wood	4	0.0039		0.0123		0.0175		0.0208	
9	paper	4	0.0124	*	0.0317	**	0.0395	**	0.0435	**
10	recorded	3	0.002		0.0026		0.003		0.0033	
11	chemical	1	0.0979	***	0.1279	***	0.1312	***	0.1315	***
12	non-metallic	12	0.0066	***	0.0122	***	0.0182	***	0.0256	***
13	basic metals	3	0.1047	***	0.1684	***	0.1816	***	0.1767	***
14	metal	6	0.008		0.0189	**	0.0277	**	0.0295	**
15	electronic	6	-0.0078		-0.017		-0.0316		-0.0328	
16	electrical	5	0.003	**	0.0048	*	0.0065	*	0.0079	*
17	machinery	2	0.0002		0.0002		0.0002		0.0002	
18	motor	1	0.0035		0.0036		0.0036		0.0036	
19	transport	7	0.0023		0.0009		-0.0014		-0.0035	

Note: Responses come from a constrained VAR(p) for all branches except *food* and *basic metals*, in which an unrestricted VAR(p) model is used. The optimal lag length chosen on the basis of the Akaike Information Criterion. For conciseness, only the quarterly aggregations of impulse responses are reported in the table. One/two/three asterisks mean a *p*-value (calculated by bootstrapping procedure) less than 10%, 5% and 1% respectively.

We are also interested to assess the transmission of higher oil prices to consumer prices. Table 2.4 shows the accumulated responses of consumer prices of branch b to a 1% increase in oil prices. We observe that an unanticipated oil price increase leads to a statistically significant increase in consumer prices for only three branches (*mining, chemical* and *metal*). These three branches also have significant responses of producer prices to an oil price shock, but there are five branches with a significant impact of oil prices on producer prices (*food, paper, non-metallic, basic metals* and *electrical*) that not show a significant response of consumer prices to an oil shock. The impact of an oil price shock on producer prices is quantitatively similar to the one on consumer prices for *mining* and *chemical*, which seems to indicate that the pass-through from producer prices to consumer prices is complete. This is not the case for *metals*, where the pass-through is partial. Therefore, it seems that most of the increase in the production costs driven by an oil price shock does not transfer into inflation (with the exceptions previously highlighted).

Table 2.4: Accumulated impulse responses of consumer price index (in percentages) attributed to a 1% oil price shock

	branch	lags	quarter 1		quarter 2		quarter 3		quarter 4	
1	mining	3	0.0053		0.0106	*	0.0132	*	0.0146	*
2	food	2	-0.0063		-0.002		0.001		0.0027	
3	beverages	2	0.0011		0.0022		0.0027		0.003	
4	tobacco	1	0.0032		0.003		0.003		0.003	
5	textile	8	-0.0013		-0.0015		-0.001		-0.0005	
6	apparel	4	-0.0034		-0.0009		-0.003		-0.0026	
7	leather	6	0.0007		0.0024		0.0044		0.006	
8	wood	4	-0.0021		-0.0032		-0.0036		-0.0037	
9	paper	4	-0.0025		-0.0041		-0.0038		-0.0031	
10	recorded	3	-0.0025		-0.0043		-0.005		-0.0053	
11	chemical	1	0.1421	***	0.1407	***	0.1404	***	0.1403	***
12	non-metallic	12	-0.0004		-0.0003		0.0006		0.0029	
13	basic metals	3	0.0011		0.0035		0.0061		0.008	
14	metal	6	0.0032	*	0.0177	***	0.0339	***	0.0435	***
15	electronic	6	-0.0018		-0.006		-0.0052		-0.0059	
16	electrical	5	0.0008		-0.0001		0.0003		0.0008	
17	machinery	2	-0.0013		-0.0014		-0.0014		-0.0014	
18	motor	1	0.0014		0.0015		0.0015		0.0015	
19	transport	7	0.0004		-0.0004		0.0005		0.0007	

Note: Responses come from a constrained VAR(p) for all branches except *food* and *basic metals*, in which an unrestricted VAR(p) model is used. The optimal lag length chosen on the basis of the Akaike Information Criterion. For conciseness, only the quarterly aggregations of impulse responses are reported in the table. One/two/three asterisks mean a *p*-value (calculated by bootstrapping procedure) less than 10%, 5% and 1% respectively.

In short, we have found evidence that an increase in oil prices leads to higher producer prices for branches with high levels of oil consumption, in line with other studies (see e.g., Fukunaga et al. [2010]; Lee and Ni [2002]).[21] Nevertheless, even in the highest oil-intensive branch (*basic metals*), industrial prices only increase 0.17% after one year of an unanticipated oil price increase. This relatively low pass-through can be explained by the fact that main energy source for industries seems not to be nowadays crude oil, but electricity and the gas.[22]

[21] Fukunaga et al. [2010] suggest shifts in the oil price driven by either of the two oil demand shocks (global or oil-specific demand) cause an increase in most industrial prices in the U.S. and Japan. Lee and Ni [2002] show in a VAR model that oil price shocks reduce the supply of oil-intensive industries in the U.S. (*petroleum refinery* and *industrial chemical*).

[22] In the euro area (19 countries), gas makes up for 35.1% of final energy consumption, electrical energy 31%, solid fuels 11.5% and total petroleum products only 9.5%. In the U.S., electricity makes up 40.3% of energy use, natural gas 14.5%, unleaded gasoline 14%, diesel fuel 11.4% and

In contrast, there is no clear evidence about the transmission of such highest industrial prices to inflation at disaggregate level. The only exceptions to this are the *mining*, *chemical* and *metal* branches, in which there is a significant transmission of prices in the channel oil-industry-consumption. These findings seem to confirm the results of other studies such as Álvarez et al. [2011], who show that this indirect transmission channel is limited. This lack of transmission would depend on the capacity of the producers to offset the higher costs through changes in production, investments, inventories, or through sectoral reallocation or technological upgrading.

2.5. Conclusions

The study of the transmission channels through which oil price changes affect macroeconomic variables is, in general, an interesting issue to better understand the consequences of oil price shocks and to design the optimal monetary policy for counteracting such effects. In particular, the analysis of how oil price shocks are transmitted downstream to producer and consumer prices at industrial level may be determinant for the design of such a policy.

This chapter finds evidence of a partial oil price pass-through to producer prices for the branches with higher oil consumption and a negligible pass-through for the other branches. This result may be explained by the fact that crude oil has reduced its importance as a main energy source for the industries over the last two decades. Moreover, oil price pass-through to consumer prices is very low in general and is only relevant for three branches (*mining*, *chemical* and *metal*). Therefore, we show evidence of some capacity of producers to adjust their production plans to changes in costs for most of the analyzed industrial branches, avoiding pass-through to consumer inflation. This is not the case for mining and chemical, where the pass-through from producer to consumer prices after an oil price shock seems to be complete. Also, there is a partial transmission for metals.

The literature has found that oil price shocks reduce industrial production (see, e.g., Jiménez-Rodríguez [2008]), although the effects for each industry depend on the origin of the oil price changes (see, e.g., Fukunaga et al. [2010]). This chapter sheds light on the possible explanations for the fall in the industrial production observed after an oil price shock in the related literature. This industrial production fall may

jet fuel 9.7% (Kilian [2008c]).

be explained by the increase in producer prices (mainly for branches with higher oil consumption) after the oil shock and also by the adjustment in the production level for avoiding the transmission of higher costs to consumer prices.[23] Consequently, the design of the monetary policy reaction in the euro area should consider the fact that inflation risks do not seem to arise from supply shocks, but from the demand shocks.

[23]There are many factors that have been an important role in this adjustment. Some of these factors are the lower use of petroleum products in industrial production, technological innovations reducing industrial costs and the direct decision of producers in order to prevent the fall in the prices originated from the likely drop in future consumer demand.

2.A. Appendix

	branch	NACE rev.2		COICOP/HICP		weights*
1	mining	8	Other mining and quarrying	0454	Solid fuels	0.151
2	food	10	Manufacture of food products	0111	Bread and cereals	2.603
				0112	Meat	3.606
				0113	Fish and seafood	1.076
				0114	Milk, cheese and eggs	2.223
				0115	Oils and fats	0.436
				0116	Fruit	1.185
				0117	Vegetables	1.575
				0118	Sugar, jam, honey, chocolate and confectionery	0.940
				0119	Food products n.e.c.	0.517
				0121	Coffee, tea and cocoa	0.458
3	beverages	11	Manufacture of beverages	0122	Mineral waters, soft drinks, fruit and vegetable juices	0.920
				0211	Spirits	0.327
				0212	Wine	0.781
				0213	Beer	0.592
4	tobacco	12	Manufacture tobacco products	022	Tobacco	2.374
5	textiles	13	Manufacture of textiles	0311	Clothing materials	0.035
				0312	Garments	4.518
				0313	Other articles of clothing and clothing accessories	0.213
				0511	Furniture and furnishings	1.921
				0512	Carpets and other floor coverings	0.125
				052	Household textiles	0.457
				0561	Non-durable household goods	1.021
				0932	Equipment for sport, camping and open-air recreation	0.261
6	apparel	14	Manufacture of wearing apparel	0312	Garments	4.518
				0313	Other articles of clothing and clothing accessories	0.213
7	leather	15	Manufacture of leather and related products	032	Footwear	1.222
				0431	Materials for the maintenance and repair of the dwelling	0.419
				052	Household textiles	0.457
				054	Glassware, tableware, household utensils	0.528
				0561	Non-durable household goods	1.021
				0712 _0714	Motor cycles, bicycles and animal drawn vehicles	0.282
				0932	Equipment for sport, camping and open-air recreation	0.261
				1231	Jewellery, clocks and watches	0.463

Note: *We use the annual weights for each COICOP/HICP item from 2000 to 2014 published by Eurostat. To save space, we only report here the last available weights (2014 HICP basket).

	branch	NACE rev.2		COICOP/HICP		weights*
8	wood	16	Manufacture of wood and of products of	0431	Materials for the maintenance and repair of the dwelling	0.419
			wood and cork, except	0511	Furniture and furnishings	1.921
			furniture; manufacture	052	Household textiles	0.457
			of articles of straw	054	Glassware, tableware, household utensils	0.528
			and plaiting materials	055	Tools and equipment, house and garden	0.468
9	paper	17	Manufacture of paper and paper products	0431	Materials for the maintenance and repair of the dwelling	0.419
				0561	Non-durable household goods	1.021
				0931	Games, toys and hobbies	0.536
				0953 _0954	Miscellaneous printed matter; stationery and drawing materials	0.325
10	recorded	8	Printing and reproduction recorded media	0953 _0954	Miscellaneous printed matter; stationery and drawing materials	0.325
11	chemical	20	Manufacture of chemicals and	0431	Materials for the maintenance and repair of the dwelling	0.419
			chemical products	0561	Non-durable household goods	1.021
				0722	Fuels and lubricants for personal transport equipment	4.444
				0914	Recording media	0.204
				0931	Games, toys and hobbies	0.536
				0933	Gardens, plants and flowers	0.604
				0953 _0954	Miscellaneous printed matter; stationery and drawing materials	0.325
				1212 _1213	Electrical appliances for personal care; other appliances, articles and products for personal care	1.704
12	non-metallic	23	Manufacture of other non-metallic mineral	0431	Materials for the maintenance and repair of the dwelling	0.419
			products	0511	Furniture and furnishings	1.921
				0531 _0532	Major household appliances whether electric or not and small electric household appliances	0.891
				054	Glassware, tableware, household utensils	0.528
				1232	Other personal effects	0.425
13	basic metals	24	Manufacture of basic metals	0561	Non-durable household goods	1.021

Note: *We use the annual weights for each COICOP/HICP item from 2000 to 2014 published by Eurostat. To save space, we only report here the last available weights (2014 HICP basket).

	branch	NACE rev.2		COICOP/HICP		weights*
14	metal	25	Manufacture of fabricated metal products, except machinery and equipment	0313	Other articles of clothing and clothing accessories	0.213
				0431	Materials for the maintenance and repair of the dwelling	0.419
				0452	Gas	2.100
				0511	Furniture and furnishings	1.921
				0531 _0532	Major household appliances whether electric or not and small electric household appliances	0.891
				054	Glassware, tableware, household utensils	0.528
				055	Tools and equipment, house and garden	0.468
				0561	Non-durable household goods	1.021
				0931	Games, toys and hobbies	0.536
				0932	Equipment for sport, camping and open-air recreation	0.261
				0953 _0954	Miscellaneous printed matter; stationery and drawing materials	0.325
				1212 _1213	Electrical appliances for personal care; other appliances, articles and products for personal care	1.704
15	electronic	26	Manufacture of computer, electronic and optical products	055	Tools and equipment, house and garden	0.468
				0721	Spare parts and accessories for personal transport equipment	0.554
				0820	Telephone and telefax equipment	0.208
				0911	Equipment for the reception, recording and reproduction of sound and picture	0.439
				0912	Photographic and cinematographic equipment and optical instruments	0.122
				0913	Information processing equipment	0.494
				0914	Recording media	0.204
				0931	Games, toys and hobbies	0.536
				0953 _0954	Miscellaneous printed matter; stationery and drawing materials	0.325
				1231	Jewellery, clocks and watches	0.463
				1232	Other personal effects	0.425
16	electrical	27	Manufacture of electrical equipment	0511	Furniture and furnishings	1.921
				0531 _0532	Major household appliances whether electric or not and small electric household appliances	0.891
				055	Tools and equipment, use and garden	0.468
				0721	Spare parts and accessories for personal transport equipment	0.554
				0911	Equipment for the reception, recording and reproduction of sound and picture	0.439
				0931	Games, toys and hobbies	0.536

Note: *We use the annual weights for each COICOP/HICP item from 2000 to 2014 published by Eurostat. To save space, we only report here the last available weights (2014 HICP basket).

	branch	NACE rev.2		COICOP/HICP		weights*
17	machinery	28	Manufacture of machinery and equipment n.e.c.	0531_0532	Major household appliances whether electric or not and small electric household appliances	0.891
				054	Glassware, tableware, household utensils	0.528
				055	Tools and equipment, use and garden	0.468
				0721	Spare parts and accessories for personal transport equipment	0.554
				0913	Information processing equipment	0.494
				0921_0922	Major durables for indoor and outdoor recreation including musical instruments	0.293
18	motor	29	Manufacture of motor vehicles, trailers and semi-trailers	0511	Furniture and furnishings	1.921
				0711	Motor cars	3.162
				0712_0714	Motor cycles, bicycles and animal drawn vehicles	0.282
				0721	Spare parts and accessories for personal transport equipment	0.554
				0921_0922	Major durables for indoor and outdoor recreation including musical instruments	0.293
19	transport	30	Manufacture of other transport equipment	0712_0714	Motor cycles, bicycles and animal drawn vehicles	0.282
				0721	Spare parts and accessories for personal transport equipment	0.554
				0921_0922	Major durables for indoor and outdoor recreation including musical instruments	0.293
				0932	Equipment for sport, camping and open-air recreation	0.261
				0934_0935	Pets and related products; veterinary and other services for pets	0.654
				1232	Other personal effects	0.425

Note: *We use the annual weights for each COICOP/HICP item from 2000 to 2014 published by Eurostat. To save space, we only report here the last available weights (2014 HICP basket).

Chapter 3

The deflationary effect of oil prices in the euro area

3.1. Introduction

The relevance of oil prices as a source of variations in prices is established since the 1970s. However, in the last two decades several works have documented that this relevance has decreased. Hooker [2002] finds no significant impact of oil price changes on U.S. inflation, excluding energy products. DeGregorio et al. [2007] document an important reduction in the contribution of oil price changes on consumer prices, providing evidence for a sample of 34 countries. Blanchard and Galí [2010] find that the inflationary impact of crude costs decreased since mid 1980s. Kilian [2008a,b] states that the effect of exogenous oil prices shocks on inflation in G7 countries is quite small and highlights its heterogeneity across countries. Álvarez et al. [2011] find that the contribution of oil price changes is limited, but still constitutes a major driver of inflation variability in Spain and the euro area, mainly through direct effects.

Several reasons have been proposed to explain this loss of relevance (e.g., DeGregorio et al. [2007], Blanchard and Galí [2010]): higher energy efficiency of production processes, relevance of globalization or changes in the conduct of monetary policy.

The emphasis of academic analyses also changed. Previous studies traditionally focused in assessing the inflationary effect of the increases in oil price. However, the main concern in the recent months is the risk of a deflation spiral unchained by oil prices reductions.

The main contributions of this chapter are: (i) a method to assess the effects of oil price changes in inflation under different oil price scenarios and (ii) a model-based indicator of inflation adjusted for the short-term effect of oil prices, being this indicator a potentially useful tool to track in real time the risk of deflation. We illustrate the practical application of these tools by means of a simulation analysis of the risk of deflation in the euro area (E.A.).[1]

To this end, we first fit a time series model relating the annual variation rates of inflation and oil price. Its dynamic structure implies that the price of crude oil in any given month affects consumer prices in the same month and the month after, with no feedback in the opposite direction of Granger causality. We provide several justifications for this assumption, as well as a Granger-causality test for the E.A.

With this model we: (a) compute twelve-months ahead forecast for inflation in the E.A., conditional to different scenarios of oil price deflation and (b) estimate which part of the recent evolution of consumer prices can be attributed to changes in oil prices. This analysis incorporates two novelties: an interpolation method to compute forecasts conditional to any predetermined terminal value using a fixed-interval smoother (see Anderson and Moore [1979]), and the procedure developed by Casals et al. [2010], which computes the contribution of each input to the output for any model in transfer function form.

The main results of this analysis are: (a) negative inflation is not expected for the twelve-months-ahead forecasts in any of the three scenarios, (b) the short-time effect of oil on consumer prices is important, as it accounts for 25% of the variance of changes in inflation so, (c) a spiral of deflation/economic contraction could finally happen if a long period of anemic inflation/deflation affects the consumer expectations and, through them, the economic activity.

The chapter is organized as follows. Section 3.2 discusses the methodological foundations, describes the data and provides a preliminary exploration of their dynamic properties. Section 3.3 describes the model-building process and Section 3.4 discusses the empirical results. Finally, Section 3.5 provides some concluding remarks.

[1]E.A. refers to the respective country compositions at a specific point in time: E.A.11-2000, E.A.12-2006, E.A.13-2007, E.A.15-2008, E.A.16-2010, E.A.17-2013, E.A.18-2014, and E.A.19-2015. Euro area is the official name for the Eurozone

3.2. Methodology

3.2.1. Methodological issues

Our analysis concentrates in the effect of oil prices over inflation in the E.A. An important issue when developing this analysis is to consider the possibility of a feedback relationship, with inflation explaining oil prices.

There is a widespread agreement in the current literature that oil price should be considered endogenous with respect to macroeconomic aggregates, in particular with respect to U.S. GDP growth (see, e.g., Barsky and Kilian [2004]; Kilian [2008c]; Hamilton [2009b]; Kilian [2014]). This idea is based in the weight of U.S. GDP growth on the global demand, including oil demand, and hence on oil prices.

On the other hand, the Granger (G- causality) test has often been used to test whether U.S. inflation help in predicting oil price changes. G-causality is usually not found after 1975 (Hooker [1996], Gillman and Nakov [2009], Alquist et al. [2013]). [2]

The E.A. shows three important differences with U.S.: its lack of internal oil production, its smaller economic size[3] and its lower influence through monetary policy. Accordingly, we will first assess whether E.A., with 13% of global oil consumption, is large enough to determine oil prices.[4] In comparison, the consumption in U.S. has been 23%. To this end, in the next Sub-section we test for linear G-causality, finding no significant influence of E.A. inflation on oil prices.

Building on this negative result, we use in our analysis a transfer function (TF) specification (Box et al. [1994]), relating oil price (cause) to E.A. inflation (effect) instead of the vector autoregressive (VAR) framework model (e.g., Hamilton [1983]; Jiménez-Rodríguez and Sánchez [2005]; Kilian [2009]; Blanchard and Galí [2010]).

The main reason for this choice is that, if no relation exists between lagged inflation and current oil price, then the bidirectional VAR representation looses its main

[2]Alquist et al. [2013] find, however, that U.S. inflation G-causes oil prices if 1973 and 1974 are included in the analysis

[3]In terms of its share of global GDP in PPP in 2014, the euro area is the world's third-largest economy (12.2%), after the United States (15.9%) and China (16.6%).

[4]This percentage has been obtained as the mean participation between 1996 and 2014 of the oil consumption of 11 European countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal and Spain) in the total world. These data come from the British Petroleum Statistical Review of World Energy 2014 http://www.bp.com.

advantage when compared to the unidirectional TF model. On the other hand, the TF model has two compelling advantages for our analysis.

First, the TF is a structural model, allowing one to attribute the contemporary correlation to a specific causal direction, while the reduced-form VAR model captures this correlation in a non-causal way. This is specially important in our analysis because the contemporaneous correlation between oil price changes and inflation: (a) has been shown to be unidirectional (Kilian and Vega [2011]), (b) is much stronger than the lagged ones, so it (c) has a strong contribution to the point forecasts and fitted values for inflation employed in our analysis.

Second, inflation displays a strong seasonal fluctuation which is easier to capture in the ARIMA model for the errors of a TF than in a VAR framework.

3.2.2. The data

In this Sub-section, we provide a exploratory analysis of the data that we will model later.

We will denote by P_t^{EA} the Harmonized Index of Consumer Price (HICP), by O_t^{EUR} the nominal price of Brent in € per barrel, by $O_t^{US\$}$ the price of Brent in US$ and by ER_t the exchange rate €/US$.[5] In all cases the observation frequency is monthly and the sampling period runs from January 1996 to December 2015.

Building on this data we computed the annual percent variation rates, defined by:

$$r^{12}(x_t) = \left(\frac{x_t}{x_{t-12}} - 1 \right) \times 100$$

Hence these basic variables often appear transformed in annual percent rates: $r^{12}(O_t^{EUR})$ for annual percent change in oil prices, and $r^{12}(P_t^{EA})$ for inflation in the E.A.

The profile of these series is shown in Figure 3.1. The second and third panels allow us to identify several oil price periods: First, the negative shock started in 1997, caused mainly by falls in oil market-specific demand following Asian crisis of

[5]The HICP data come from http://ec.europa.eu/eurostat). We consider the oil price in U.S. dollar downloaded from the U.S. Energy Information Administration (EIA) web page http://www.eia.gov and use the monthly average exchange rate published by the OECD http://www.stats.oecd.org to calculate the equivalent value in euros.

1997-1998. This effect was accompanied by positive rebounds started in late 1998 that reaches its maximum in February 2000. Second, several sustained positive rates between late 2002 and early 2008, driven by global aggregate demand, originate in a stronger economic growth, especially in Asian economies. This effect was reversed by a sharp drop in prices associated with the global crisis of 2007-2009. This effect was also accompanied by positive rebounds started in 2009 that reaches its maximum in December 2009. Finally, there has been a sustained fall in prices since late 2009, associated with a strong global supply and a weak global demand.[6] The correlation between $r^{12}(O_t^{EUR})$ and $r^{12}(O_t^{US})$ is 0.952, suggesting that the exchange rate plays a minor role in determining the oil price in Euros. This preliminary result is further confirmated by the analysis in section 3.2, models (4)-(5).

As expected, these series display changes in the mean, so their stationary transformation would be a first-order difference.[7] Accordingly, the resulting variables can then be interpreted as the monthly acceleration in the inflation rate and annual rate of growth of oil prices, respectively. Figure 3.2 shows the profile of these series.[8]

Table 3.1 displays some descriptive statistics for the stationary transform. The $p - values$ in the table show that 1st-differenced transformation of annual rates assure the stationarity. Note that the volatility of $\nabla r^{12}(O_t^{EUR})$ and $\nabla r^{12}(O_t^{US\$})$ is approximately 65 times higher than that of the $\nabla r^{12}(P_t^{EA})$.

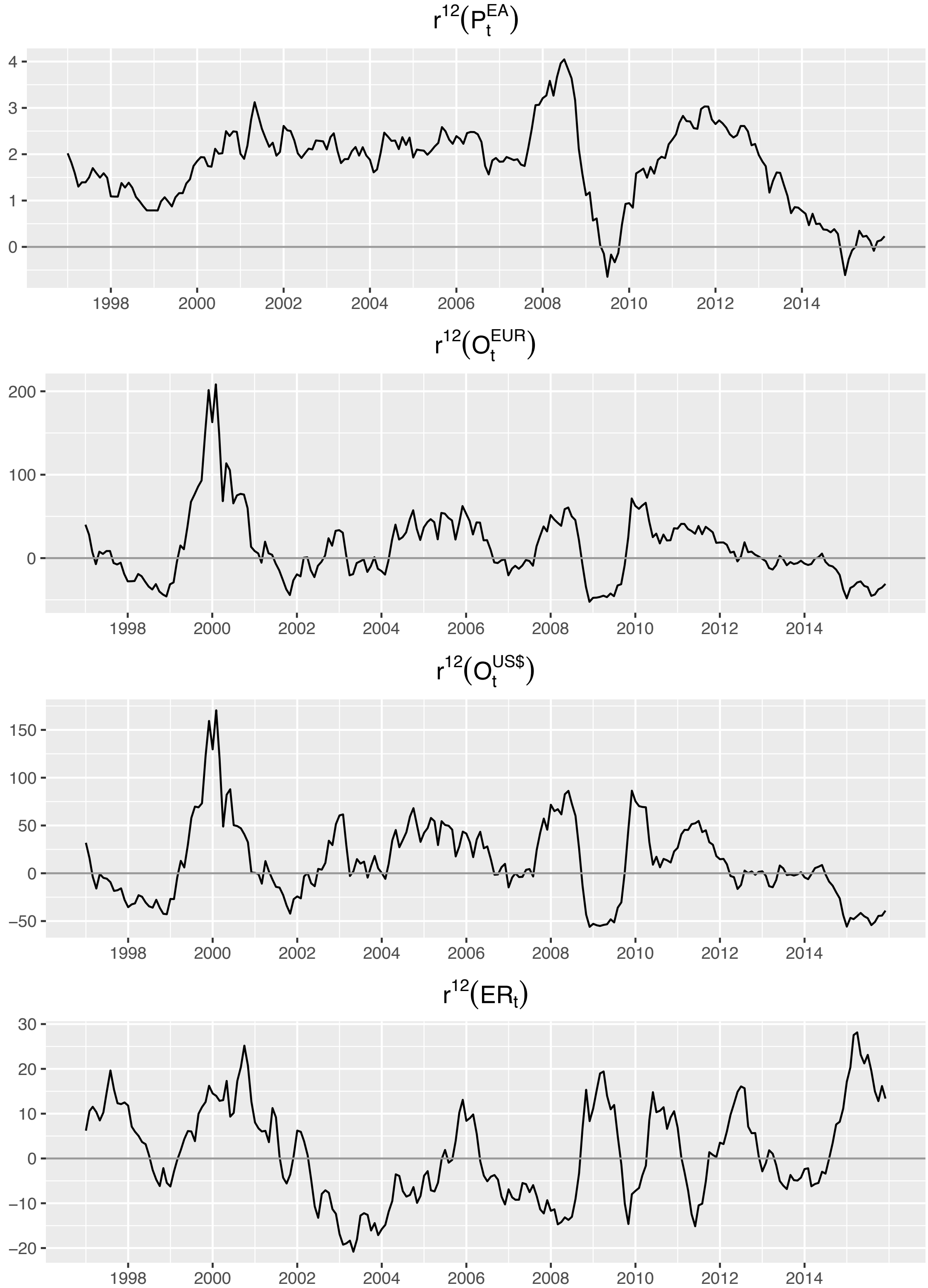
Table 3.1: Descriptive statistics for the stationary series for inflation in the euro area $\nabla r^{12}(P_t^{EA})$, Brent price per barrel in euros $\nabla r^{12}(O_t^{EUR})$ and dollars $\nabla r^{12}(O_t^{US\$})$ and exchange rates €/US\$ $\nabla r^{12}(ER_t)$.

	$\nabla r^{12}(P_t^{EA})$	$\nabla r^{12}(O_t^{EUR})$	$\nabla r^{12}(O_t^{US\$})$	$\nabla r^{12}(ER_t)$
Mean	-0.01	-0.31	-0.31	0.03
Std. Dev.	0.24	15.82	15.32	3.57
Minimum	-1.05	-79.75	-70.89	-8.78
Maximum	0.74	57.63	49.42	10.25
p-value ADF	0.01	0.01	0.01	0.01
p-value KPSS	0.10	0.10	0.10	0.10

[6] For details see e.g., Kilian [2009].

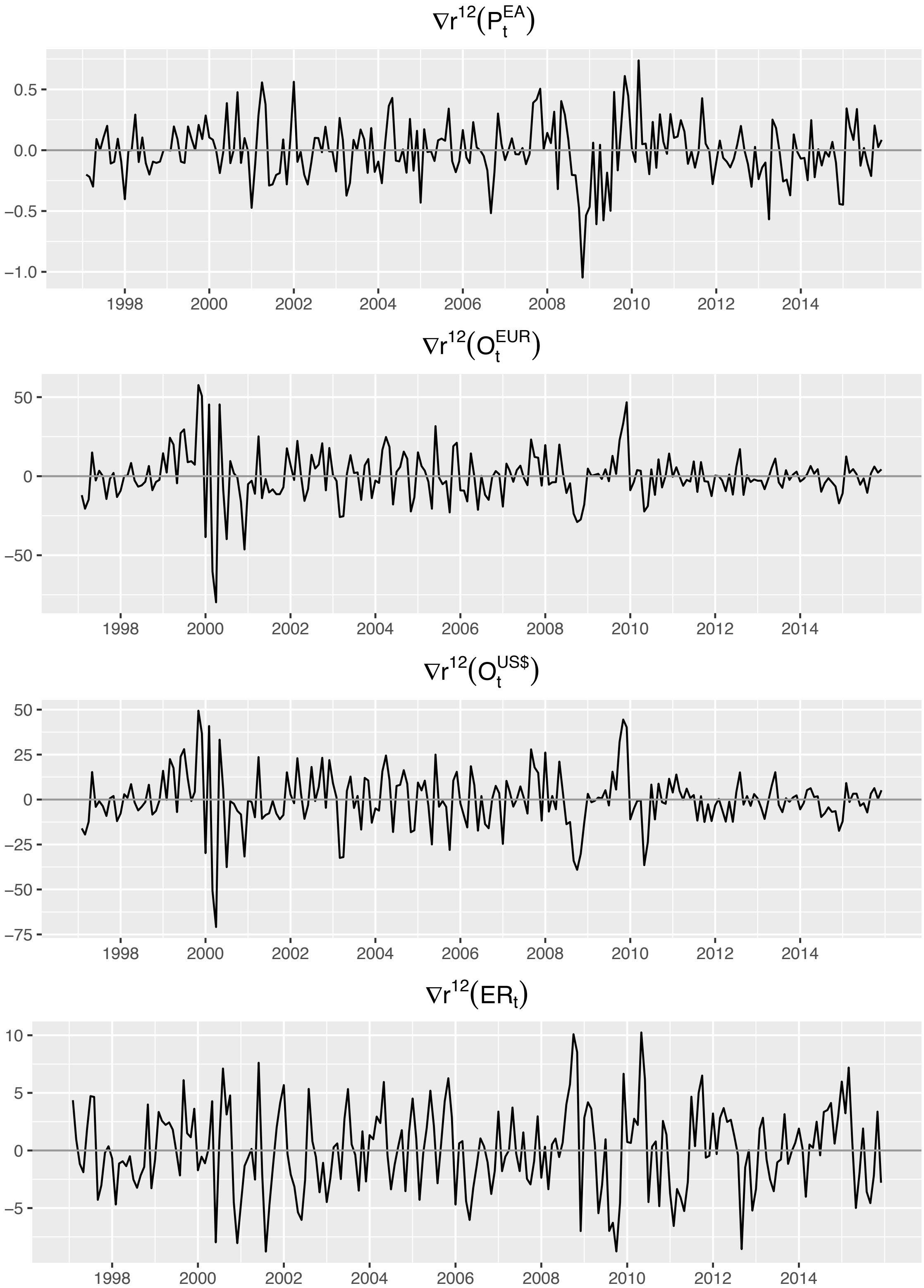
[7] In our opinion, O_t^{EUR} could either be I(1) or display a weak seasonality which is buried by its high volatility. However, we work with the same transformation in both variables because the underlying assumption is that oil prices affect consumer prices, so annual inflation must be affected by the annual growth rate of oil prices, no matter that the minimum-order stationary transform for each series can be different.

[8] $\nabla = (1 - L)$ is the difference operator, such that $\nabla \omega_t = \omega_t - \omega_{t-1}$.



Source: Eurostat, EIA and OECD.

Figure 3.1: Annual percent changes for inflation in the euro area $r^{12}(P_t^{EA})$, Brent price per barrel in euros $r^{12}(O_t^{EUR})$ and US dollars $r^{12}(O_t^{US\$})$, and exchange rate €/US\$, $r^{12}(ER_t)$.



Source: Eurostat, EIA and OECD.

Figure 3.2: Stationary series for inflation in the euro area $\nabla r^{12}(P_t^{EA})$, Brent price per barrel in euros $\nabla r^{12}(O_t^{EUR})$ and dollars $\nabla r^{12}(O_t^{US\$})$ and exchange rate €/US$. $\nabla r^{12}(ER_t)$.

3.2.3. Granger causality test

We will now perform the standard G-causality test (see Granger [1969]) for a fitted VAR model to assess whether (a) past values of oil price changes in € help in predicting current inflation changes in the E.A. and/or b) there exists the corresponding inverse G-causality effect. If causal effects in Granger sense operate in both directions, then both variables would be endogenous and a vector autoregressive (VAR) model would be needed to obtain consistent estimates for the corresponding dynamic feedback structure.

The G-causality test is implemented by the regressions:

$$\nabla r^{12}(P_t^{EA}) = c^1 + \alpha_1 \nabla r^{12}(P_{t-1}^{EA}) + \beta_1 \nabla r^{12}(O_{t-1}^{EUR}) + \mu_t^1$$

$$\nabla r^{12}(O_t^{EUR}) = c^2 + \alpha_2 \nabla r^{12}(O_{t-1}^{EUR}) + \beta_2 \nabla r^{12}(P_{t-1}^{EA}) + \mu_t^2$$

Table 3.2 shows the $p-$values for each $F-$test with the lag order p =1 chosen according to the Schwarz Information Criterion (SIC). Due to the differencing used to induce stationarity on the series, that is, the monthly change in annual rates, the lag order p=1 implies effects longer than a year. We do not find evidence of G-causality from E.A. inflation to oil prices, although we find very strong evidence (at 1% significance) that $\nabla r^{12}(O_t^{EUR})$ Granger-cause $\nabla r^{12}(P_t^{EA})$. The replication of this exercise for the U.S. (results available upon request to the authors), shows a p-value of 0.0877 when analyzing G-causality from U.S. inflation to oil prices in dollars. This result supports the view that the relationship between oil prices and inflation is very different between E.A. and U.S. and advise against using our methodology to analyze the relationship between U.S. inflation and oil prices.

Table 3.2: p-values for linear G-Causality test.

lag	$\nabla r^{12}(P_t^{EA}) \nrightarrow \nabla r^{12}(O_t^{EUR})$	$\nabla r^{12}(O_t^{EUR}) \nrightarrow \nabla r^{12}(P_t^{EA})$
1	0.359326	0.000002 ***

Note: The test is calculated with a VAR model. The *lag* order has been selected according to the Schwarz Information criterion (SIC). One/two/three asterisks denote significance at the 10%, 5% and 1% levels, respectively.

3.3. Models

3.3.1. ARIMA Models

The main purpose of our analysis consists in modelling the relationship between the inflation rate in the euro area $\nabla r^{12}(P_t^{EA})$ and the annual percent growth of Brent prices in €, $\nabla r^{12}(O_t^{EUR})$. The basic shortcoming of this approach is that the world market is quoted in US\$, so the latter variable confounds the effects of oil price changes with those due to fluctuations in the exchange rates.

To solve this issue we will take into account that $O_t^{EUR} = O_t^{US\$} \times ER_t$, where $O_t^{US\$}$ denotes the nominal prices of Brent in US\$ and ER_t denotes the exchange rate (€/US\$) at month t, so that the effect of oil price changes in US\$ is separated from the effect of exchange rate variations.

To accomplish the analysis we start by fitting ARIMA models to the annual rates of inflation and Brent prices in € and US\$. The main estimation and diagnostic results are summarized in Table 3.3. These models are used for different purposes, including forecasting and prewhitening, see Box et al. [1994].

Note that the residual standard deviations of the annual rates of Brent prices is approximately 66 times higher than that of inflation in the E.A. This is a critical feature of these variables which explains, e.g., that: (a) the €/US\$ exchange rate is irrelevant to our analysis and (b) the coefficients relating changes in oil prices with changes in inflation are small in absolute terms.

Table 3.3: ARIMA modelling results corresponding to ARIMA$(3,1,0) \times (0,0,1)_{12}$ process for $r^{12}(x_t)$.

Variable	$\nabla r^{12}(O_t^{EUR})$	$\nabla r^{12}(O_t^{US\$})$	$\nabla r^{12}(P_t^{EA})$
ϕ_1	0.048	0.133	0.208
	(0.065)	(0.066)	(0.065)
ϕ_2	-0.088	-0.104	
	(0.065)	(0.066)	
ϕ_3	0.222	0.165	
	(0.065)	(0.066)	
Θ_1	-0.535	-0.547	-0.546
	(0.06)	(0.06)	(0.053)
σ_a	13.557	13.005	0.203
$Q(39)$(p-value)	43.247 (0.16)	49.73 (0.051)	41.096 (0.296)

Note: The figures in parentheses are the standard errors of corresponding parameters.

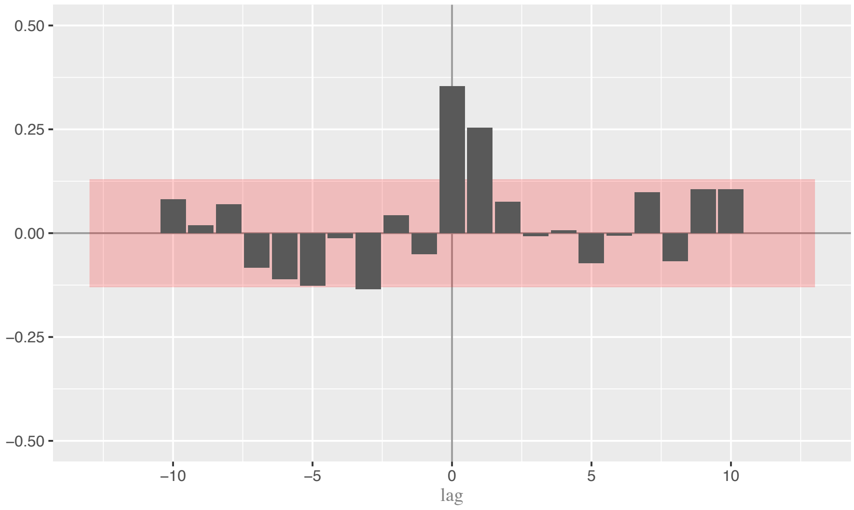


Figure 3.3: Cross-correlations between the prewhitened series of inflation in the euro area, $\nabla r^{12}(P_t^{EA})$ and the lagged annual variation rate of Brent prices in euros. Note that negative lags are actually leads for $\nabla r^{12}(O_t^{EUR})$.

3.3.2. Transfer function models

We start by modelling the relationship between the inflation rate in the euro area $r^{12}(P_t^{EA})$ and the annual percent growth of Brent prices in €, $r^{12}(O_t^{EUR})$. The relationship has been specified by (a) prewhitening both the input and output series using the ARIMA model for the input (see table 3.3), and then (b) computing the cross-correlation function between the prewhitening values of both variables, which is shown in figure 3.3.

The profile of the cross-correlations suggests that inflation is positively correlated with the change in Brent prices in the same month and the month before. In the inverse direction of G-causality (i.e., with current inflation affecting future changes in Brent prices) there is not any significant negative correlation. Accordingly, we confirm our previous findings that G-causality goes from changes in Brent prices to inflation.

On the basis of this statistical analysis, our tentative specification was: (a) a relation term where $r^{12}(P_t^{EA})$ is a function of $r^{12}(O_t^{EUR})$ and $r^{12}(O_{t-1}^{EUR})$, combined with (b) an ARIMA$(0,1,1)\times(0,0,1)_{12}$ model for the error, which coincides with the ARIMA specification chosen for the output, see table 3.3. This specification provides the following estimation results:[9]

$$r^{12}(P_t^{EA}) = (\underset{(0.0009)}{0.0053} + \underset{(0.0009)}{0.0044}L)r^{12}(O_t^{EUR}) + \hat{N}_t^P \tag{3.1}$$

$$(1 - \underset{(0.066)}{0.1389}L)\nabla\hat{N}_t^P = (1 - \underset{(0.055)}{0.4517}\, L^{12})\hat{a}_t^P \tag{3.2}$$

$$\hat{\sigma}_P = 0.184 \qquad \textit{log-lik}= 60.819$$

Model (3.1) confounds the effects of oil price changes with those due to fluctuations in the exchange rates. To solve this issue we should take into account that $O_t^{EUR} = O_t^{US\$} \times ER_t$, so the input variable in model (3.1) can be decomposed in the following way:

$$r^{12}(O_t^{EUR}) \simeq r^{12}(O_t^{US\$}) + r^{12}(ER_t) \tag{3.3}$$

and this decomposition suggests building a new model relating the inflation rate in the euro area, $r^{12}(P_t^{EA})$, with the annual growth of Brent prices in US\$ $r^{12}(O_t^{US\$})$ and the annual growth of the exchange rate, $r^{12}(ER_t)$. The main estimation results for this specification are the following:

$$\begin{aligned} r^{12}(P_t^{EA}) = {} & (\underset{(0.0009)}{0.0057} + \underset{(0.0009)}{0.0047}L)r^{12}(O_t^{US\$}) \\ & + (\underset{(0.004)}{0.0011} + \underset{(0.004)}{0.0021}L)r^{12}(ER_t) + \hat{N}_t \end{aligned} \tag{3.4}$$

$$(1 - \underset{(0.067)}{0.1351}L)\nabla\hat{N}_t = (1 - \underset{(0.055)}{0.4424}\, L^{12})\hat{a}_t \tag{3.5}$$

$$\hat{\sigma}_P = 0.182 \qquad \textit{log-lik}= 63.348$$

where the parameters associated to the exchange rate are non-significant. This result

[9] In these equations the letter L denotes the backshift operator, such that for any sequence ω_t: $L^i\omega_t = \omega_{t-i}$, $i = 0, \pm 1, \pm 2, ..., I$.

justifies the following final model:

$$r^{12}(P_t^{EA}) = (\underset{(0.0009)}{0.0056} + \underset{(0.0009)}{0.0046}L)r^{12}(O_t^{US\$}) + \hat{N}_t^P \tag{3.6}$$

$$(1 - \underset{(0.066)}{0.1351}L)\nabla\hat{N}_t^P = (1 - \underset{(0.055)}{0.4462}\, L^{12})\hat{a}_t^P \tag{3.7}$$

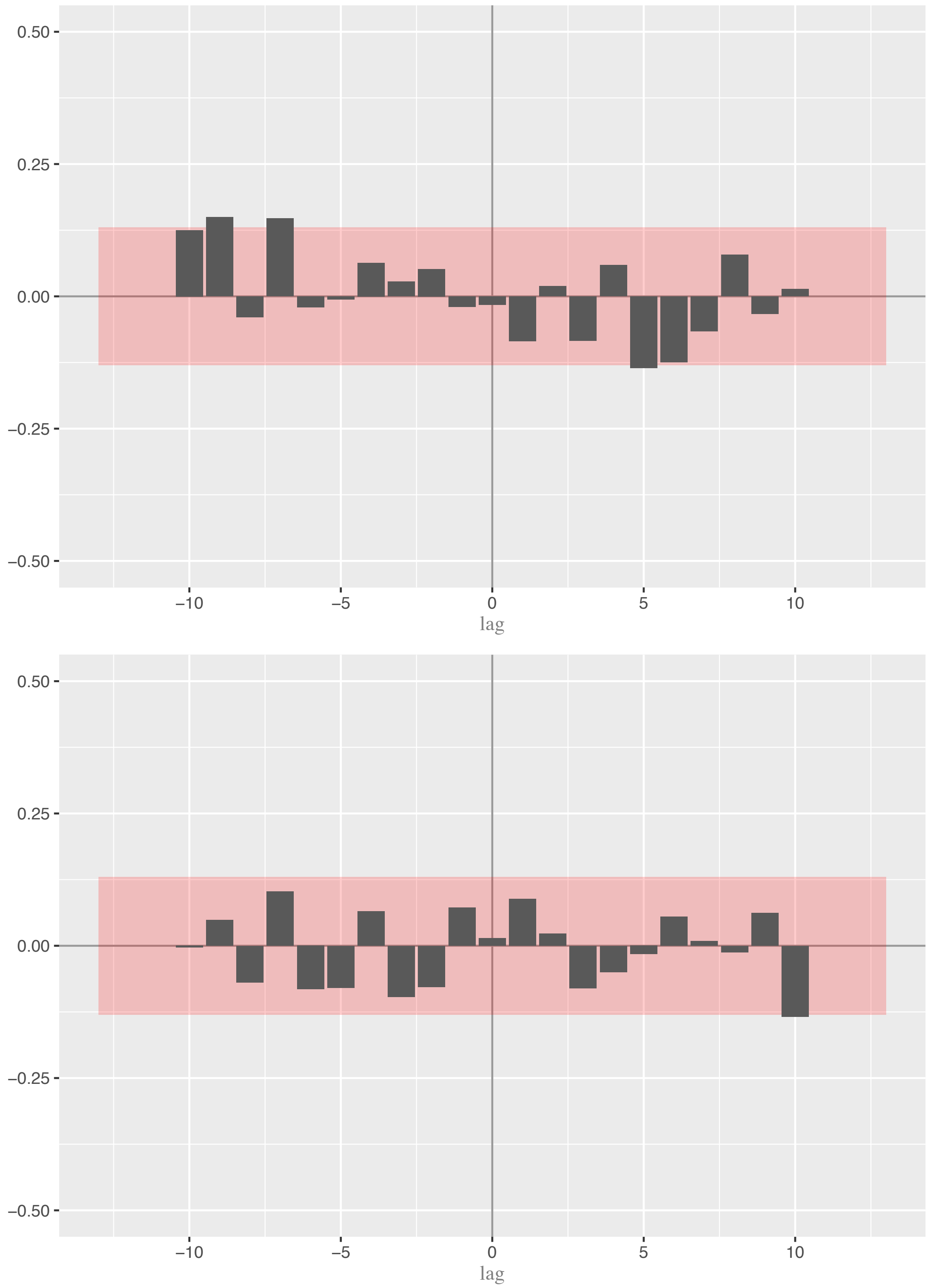
$$\hat{\sigma}_P = 0.182 \qquad \textit{log-lik} = 63.166$$

where the likelihood value is: (a) almost identical to the one achieved in model (3.4)-(3.5), so both models can be considered statistically equivalent and (b) larger than that of model (3.1)-(3.2), implying that the final model would be preferred to models (3.1)-(3.2) and (3.4)-(3.5) according to any Information Criterion.[10]

Model (3.6)-(3.7) has been submitted to a standard diagnostic testing process which includes:

1. computing the sample cross-correlation function of the model residuals against the prewhitened values of the input, see Figure 3.4, first panel, which shows no evidence of additional cross-correlation structure,
2. computing the sample cross-correlation function of the same residuals against the prewhitened values of the €/US$ exchange rate, see Figure 3.4, second panel, to assure that inflation in the E.A. does not display any significant reaction to changes in the exchange rate, and
3. overfitting experiments, in which we arbitrarily augmented the lag structure of model (3.6)-(3.7); the corresponding parameters were non-significant in all cases.

[10] In all the transfer function models, we identified some outliers related with the sharp fall in oil prices started at the end of 2008. Although these outliers are statistically significant, the models reported in the main text do not include the corresponding intervention terms because they do not affect significantly the results of the analysis. We provide them in the Appendix.



Note: The shaded area is approximate 5% significance limits for each cross correlation.

Figure 3.4: Cross correlations between (a) the prewhitened annual variation rate of Brent prices and the lagged residuals of model (first panel), and (b) the same residuals and the prewhitened exchange rate (second panel).

3.4. Results

3.4.1. Assessing the likelihood of deflation

As the results in previous section show, changes in oil pricing have a significant effect on inflation. Accordingly, this variable is relevant to compute short-term inflation forecasts and, in general, to determine the monetary policy. As oil prices are highly volatile and, therefore, difficult to predict *stricto sensu*, it is reasonable to compute inflation forecasts conditional to a variety of oil price scenarios.

Accordingly, we will now compute the inflation paths corresponding to different scenarios for oil prices, using the model (3.6)-(3.7). To this end, we first formulate the basic assumptions described in Table 3.4.

Table 3.4: Scenarios for Brent prices (US$/Barrel) in December 2016 versus December 2015.

Scenario	Assumed price	Annual variation rate
Stable	37.97	0%
Pessimistic	30.00	-21.0%
Extreme	20.00	-47.3%

Note: The assumptions for pessimistic and extreme scenario consider that surplus of oil will persist in 2016 combined with a slowing demand expansion. See e.g., Currie et al. [2015]

After setting these assumptions, we need to compute the most likely path for oil prices to reach the assumed annual variation rates. To this end, we created three new variables by joining: (a) the past history of $r^{12}(O_t^{US\$})$ until December 2015, (b) eleven missing values corresponding to the months between January 2016 and November 2016, and (c) the value of $r^{12}(O_t^{US\$})$ corresponding to December 2016 according to each scenario. The missing values were then interpolated by processing this sample with a fixed-interval smoother, see Anderson and Moore [1979], assuming that the data generating process is the ARIMA model for $r^{12}(O_t^{US\$})$ (see Table 3.3). The output from this procedure can be interpreted as an univariate forecast for the annual change in Brent price, conditional to the corresponding end values[11]. This forecast is then feed to the transfer function in equations (3.6)-(3.7) to compute the corresponding inflation forecast.

[11]This procedure to compute the highest probability path for the exogenous input is a modest theoretical contribution of the chapter.

The results of this exercise are summarized in Table 3.5. As it can be seen, none of the scenarios considered yields a negative inflation forecast.

Table 3.5: Annual inflation rates $r^{12}(P_t^{EA})$ corresponding to different scenarios for changes in brent prices $r^{12}(O_t^{US\$})$ in dollars.

	Stable		Pessimistic		Extreme	
Year-Month	$r^{12}(P_t^{EA})$	$r^{12}(O_t^{US\$})$	$r^{12}(P_t^{EA})$	$r^{12}(O_t^{US\$})$	$r^{12}(P_t^{EA})$	$r^{12}(O_t^{US\$})$
2015-12-01	0.23	-39.09	0.23	-39.09	0.23	-39.09
2016-01-01	0.47	-28.44	0.46	-30.04	0.45	-32.04
2016-02-01	0.36	-30.41	0.34	-33.89	0.3	-38.25
2016-03-01	0.35	-27.51	0.3	-32.72	0.25	-39.23
2016-04-01	0.34	-27.44	0.27	-34.58	0.19	-43.52
2016-05-01	0.24	-27.7	0.15	-36.85	0.05	-48.32
2016-06-01	0.3	-24.83	0.2	-35.95	0.07	-49.87
2016-07-01	0.35	-18.38	0.23	-31.49	0.07	-47.92
2016-08-01	0.46	-9.05	0.31	-24.14	0.13	-43.04
2016-09-01	0.61	-7.37	0.44	-24.25	0.24	-45.39
2016-10-01	0.57	-6.01	0.38	-24.72	0.15	-48.16
2016-11-01	0.6	-2.23	0.4	-22.69	0.15	-48.32
2016-12-01	0.67	0	0.46	-21	0.2	-47.3

These results suggest that the effect of oil prices on inflation is relevant but limited in the short term, as it is not enough by itself to create a long period of deflation. A deflationary spiral may occur however if an anemic inflation affects the agents' expectations and, through them, consumer decisions and economic activity. In this case, the short-term effect deflationary effects of oil prices would affect all the components of consumer prices.

3.4.2. Estimating the short-term effect of changes in oil prices

Now, we will use the transfer function (3.6)-(3.7) to decompose the inflation rate history in two additive components, one driven by the model input (changes in the oil prices) and another one driven by the model errors, being the former an approximation for the short-term effect of changes in oil prices on inflation.

In this case, we can compute the part of annual inflation that can be attributed to changes in Brent prices by propagating the following expression throughout the sample:

$$r^{12}(\hat{P}_t^{O}) = 0.0056\, r^{12}(O_t^{US\$}) + 0.0046\, r^{12}(O_{t-1}^{US\$}) \qquad t = 2, \ldots, n \qquad (3.8)$$

Note that Expression 3.8 results immediately from the transfer function of equation 3.6.[12] On the other hand, the part of annual inflation corresponding to any other factors is trivially computed as:

$$r^{12}(\hat{P}_t^{Other}) = r^{12}(P_t^{EA}) - r^{12}(\hat{P}_t^{O}) \qquad (3.9)$$

Figure 3.5 shows the profile of inflation in the E.A. versus the estimated effect of changes in Brent price, computed according to expression (3.8). It shows clearly that: (a) Brent prices have been a relevant factor to explain changes in consumer prices in the euro area[13] and (b) from 2013 onwards their effect has been either neutral or deflationary.

Figure 3.6 provides further details on the effect of Brent prices from January 2014 to December 2016. It shows that they have been an important deflationary factor during this period, while the effect of other factors remained stable until November 2014, declined in December 2014 and January 2015, and started an inflationary cycle from February 2015 to May 2015.

3.4.3. A proposal to track inflation/deflation risks in real-time

The previous analysis suggests that, while oil prices are an important factor to explain recent deflationary pressures, a prolonged deflationary period would only occur if the negative evolution of crude factors creates a contagion on the other determinants of prices, e.g. through the agents expectations.

This idea suggests that the factor $r^{12}(\hat{P}_t^{Other})$ could be used to track in real-time the risks of deflation. In particular, as most analysts predict that oil prices will continue

[12] Casals et al. [2010] derive a procedure to compute this decomposition for a general transfer function.

[13] During the period analyzed, this factor accounted for 25% of the variance of the stationary transform of inflation.

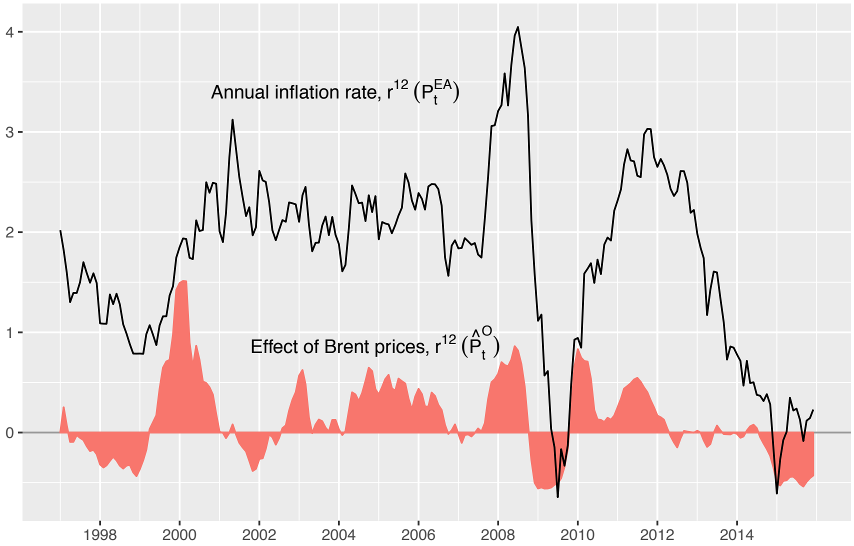


Figure 3.5: Annual inflation rates in the EA vs. the estimated effect of change in Brent prices.

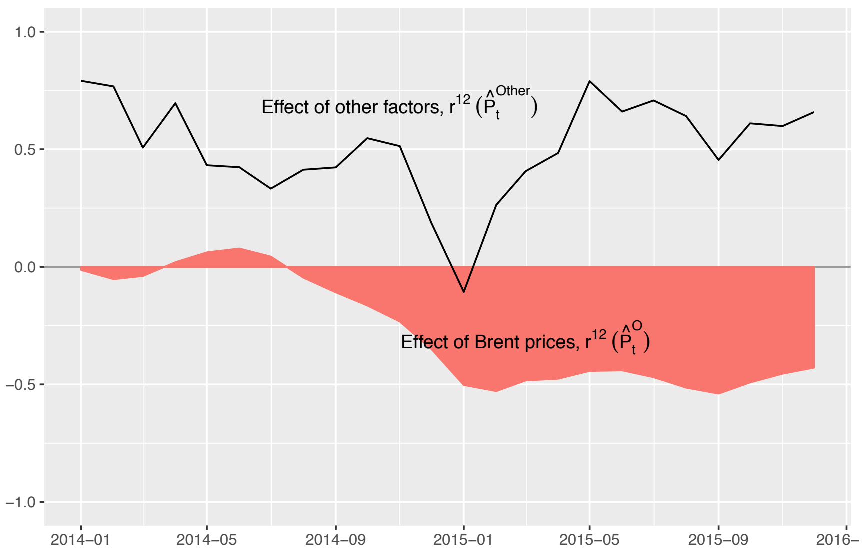


Figure 3.6: Components of inflation effect of Brent prices vs. effects of other factors.

their decline, the future behavior of this component will determine if inflation will stay in positive values or fall into a negative spiral.

This method is flexible so that, if other risk factors are identified (e.g., weak economic growth), they could be added as additional inputs to the transfer functions and taken into account accordingly.

3.5. Conclusions

The effect of oil price changes on inflation rates has received renewed interest. Contrary to the shocks in the 1970s, nowadays it is the deflationary effect of oil prices which is under scrutiny.

In this work, we propose a method to evaluate the effect of oil price changes on inflation, as well as an indicator of inflation adjusted for the short-term effect of oil prices. Tracking such an indicator may be an effective way to assess the risk of deflation in real time.

We apply the methodology to compute twelve-months ahead forecast for inflation in the E.A., conditional to different scenarios of oil price deflation and to estimate which part of the recent evolution of consumer prices can be attributed to changes in oil prices.

Our main findings are: (a) negative inflation is not expected for the twelve-months-ahead forecasts in any of the three scenarios, (b) the short-time effect of oil on consumer prices is important, as it accounts for 25% of the variance of changes in inflation so, (c) a spiral of deflation/economic contraction could finally happen if a long period of anemic inflation/deflation affects the consumer expectations and, through them, the economic activity.

Future research will apply this framework to a disaggregate level of analysis. For example, the risk of deflation for specific countries may be evaluated. In addition, we will explore the effect of oil price variation on some specific components of the inflation rate.

Note that the methods proposed here could be applied to solve similar assessment and tracking needs in other frameworks, where a relevant economic magnitude, e.g., GDP, or unemployment, is affected by a driver variable such as a business climate indicator or some interest rates. In future investigations we plan to explore some of these analyses.

All the calculations have been implemented in E^4, a free MATLAB toolbox for time series modeling, which can be downloaded at www.ucm.es/info/icae/e4. This website provides the source code for all the functions in the toolbox under the terms of the GNU General Public License, as well as a complete user manual and other reference materials. Besides E^4 we also used R and Gretl.

3.A. Appendix

We consider subsample estimations due to the relatively calm shown in first years for oil prices, the peak (in 2008) and collapse (in 2009), related with the 2008-2009 financial crisis, or the sharp decrease in 2014. Therefore we revise carefully the residuals of the transfer function models and we found long streaks of negative residuals in November 2008, May 2009 and July 2009, which profile suggested the step-type intervention effect

$$S_t^T = \begin{cases} 1, \text{if } t \geq T \\ 0, \text{otherwise} \end{cases}$$

, leading to the inclusion of three intervention effects: $S_t^{2008/11}$, $S_t^{2009/05}$ and $S_t^{2009/07}$.

Models (1A)-(2A), (4A)-(5A) and (6A-7A) combine the structure of transfer function models (3.1)-(3.2), (3.4)-(3.5) and (3.6)-(3.7) in the chapter with the intervention terms required to capture the aforementioned step-effects.

As the models show, the results are very robust to the inclusion of the dummy variables, with the rest of the coefficients being very stable so that the prediction of inflation is similar. Nevertheless, according to the Bayesian Information Criteria, the model without the dummies is preferred (-95.49 without intervening and -95.06 afterwards).

- Models 1A and 2A. HICP in the Euro Area against Brent price in euros

$$\begin{aligned} r^{12}(P_t^{EA}) &= (\underset{(8\times10^{-4})}{0.0052} + \underset{(8\times10^{-4})}{0.0042}\,L) r^{12}(O_t^{EUR}) \\ &- (\underset{(0.161)}{0.400} + \underset{(0.155)}{0.286}L + \underset{(0.155)}{0.471}L^2) S_t^{2008/11} \\ &- \underset{(0.155)}{0.362} S_t^{2009/05} - \underset{(0.153)}{0.391} S_t^{2009/07} + \hat{N}_t^P \end{aligned}$$

$$(1 - \underset{(0.068)}{0.118}L)\nabla \hat{N}_t^P = (1 - \underset{(0.065)}{0.466}\, L^{12})\hat{a}_t^P$$

$$\hat{\sigma}_P = 0.174 \qquad \textit{log-lik} = 72.493$$

- Models 4A and 5A. HICP in the Euro Area against Brent price in US$ and the €/US$ exchange rate

$$
\begin{aligned}
r^{12}(P_t^{EA}) &= (\underset{(9\times10^{-4})}{0.0057} + \underset{(9\times10^{-4})}{0.0045}\,L)r^{12}(O_t^{US\$}) \\
&+ (\underset{(0.0043)}{0.0025} + \underset{(0.0043)}{0.0028}L)r^{12}(ER_t) \\
&- (\underset{(0.161)}{0.441} + \underset{(0.157)}{0.308}L + \underset{(0.155)}{0.465}L^2)S_t^{2008/11} \\
&- \underset{(0.154)}{0.348}S_t^{2009/05} - \underset{(0.153)}{0.388}S_t^{2009/07} + \hat{N}_t^P
\end{aligned}
$$

$$
(1 - \underset{(0.068)}{0.114}L)\nabla\hat{N}_t = (1 - \underset{(0.063)}{0.454}\,L^{12})\hat{a}_t
$$

$$
\hat{\sigma}_P = 0.171 \qquad \textit{log-lik} = 75.508
$$

- Models 6A and 7A. HICP in the Euro Area against Brent price in US$

$$
\begin{aligned}
r^{12}(P_t^{EA}) &= (\underset{(9\times10^{-4})}{0.0056} + \underset{(9\times10^{-4})}{0.0043}\,L)r^{12}(O_t^{US\$}) \\
&- (\underset{(0.158)}{0.413} + \underset{(0.154)}{0.297}L + \underset{(0.153)}{0.470}L^2)S_t^{2008/11} \\
&- \underset{(0.154)}{0.346}S_t^{2009/05} - \underset{(0.152)}{0.390}S_t^{2009/07} + \hat{N}_t^P
\end{aligned}
$$

$$
(1 - \underset{(0.067)}{0.119}L)\nabla\hat{N}_t^P = (1 - \underset{(0.063)}{0.461}\,L^{12})\hat{a}_t^P
$$

$$
\hat{\sigma}_P = 0.172 \qquad \textit{log-lik} = 75.005
$$

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