OIL PRICE SHOCKS AND THEIR EFFECTS ON ECONOMIC ACTIVITY AND PRICES: AN APPLICATION FOR PORTUGAL*

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ABSTRACT

In this article, effects of oil shocks on GDP, employment and inflation are estimated for the Portuguese economy, relying on a structural VAR model. In the ongoing period of domestic adjustment it is relevant to have a quantitative measure of these effects, especially since the international economic environment has been cooling sharply and a large uncertainty subsists around the adjustment process. The results of the estimations, for an increase in oil prices of approximately 13 percent in dollars, envisage a depressive effect on the level of GDP in the long run - after five years - of 0.7 percentage points with nearly half of the adjustment taking place in the second year after the shock. The profile of the effect on employment in the private sector is very similar, albeit somewhat smaller. As for the consumer prices, the results translate into higher inflation in the first two years subsequent to the shock (0.25 and 0.05 percentage point in the first and second year, respectively). However this effect shows to be temporary, since as from the third year, the impact reduces slowly, with a virtually nil long-term effect on the price level.

1. Introduction

During the recent years the Portuguese economy has been facing a demanding adjustment process of the macroeconomic imbalances accumulated over more than a decade. This adjustment, which is framed by the Economic and Financial Assistance Program (EFAP), has brought about a significant contraction in economic activity induced by the severe reduction in domestic demand. This reduction was triggered by the fiscal consolidation measures adopted by the authorities so as to meet the deficit targets set in the program. In turn, exports which have proved to be the only component of expenditure that posted positive growth rates during this period, have presented some slowdown recently, in line with the decline in external demand for Portuguese goods and services. This behavior has been triggered, in particular by the progressive slowdown of activity in a broad number of euro area countries, to which a significant share of exports of goods and services are directed. In this context, a quantitative measure of the impact of shocks with depressive effects on overall activity is a relevant piece of information for the projection exercises for the Portuguese economy.

As from the second quarter of 2009, the price of oil has risen significantly, which according to conventional knowledge exerts a contractionary effect on overall activity. This article intends to estimate the effects of oil shocks on economic activity and on inflation for the Portuguese economy. Furthermore, large fluctuations in the price of oil can also exert significant effects on the external balance, owing to the importance of energy goods in total imports.

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Regarding the shocks of this nature, the world economy has been confronted with large fluctuations in oil prices since the early 1970s, with more or less severe and sometimes protracted effects on major macroeconomic variables in various countries. Measuring the effects of oil price changes on the main economic variables, in particular on economic activity and inflation has been a topic of active empirical research for quite some time. The concern in the measurement of these effects was triggered primarily in the wake of the two political events that took place in the 1970s - the OPEC oil embargo during the Yom Kippur War in 1973 and the Iran/Iraq war in 1979. In the sequence of these events economies at a worldwide scale were confronted with significant increases in oil prices, which almost doubled. These sharp growths in prices were followed by significant surges in the rate of inflation and expressive and abrupt reductions in GDP and increases in unemployment at a worldwide scale.

Early important references on this topic in the literature are Rasche and Tatom (1977, 1981) and Tatom (1981). As from the 1980s, Hamilton (1983, 1985 and 1996) stands out as one of the main contributors to this literature. In fact, this author was the first to point out, in his article in 1983 that “almost all U.S. recessions since World War II had been preceded by increases in the price of crude oil.” More or less simultaneously, Darby (1982), Burbidge and Harrison (1984) and Gisser and Goodwin (1986), among others, also had important contributions to this empirical literature. At the theoretical level the most relevant contribution was the seminal work of Bruno and Sachs (1985).

Most the empirical results in this area were derived relying either on single equation models focusing on the interaction of just a few variables or on vector autoregressive (VAR) models with the estimation of the corresponding impulse response functions. Since the very beginning, the estimated magnitude of the effect of rising oil prices on overall activity and on inflation intrigued economists, due to the reduced expression of oil in the production process and the share of oil in overall household expenditure.

The effects of oil prices changes on major macroeconomic variables diminished significantly in the more recent period, casting doubt on the economic relations so far uncovered in the literature and even raising questions on the importance of oil price shocks on economic fluctuations. These new results stimulated further research aimed at answering several questions related with this topic. In particular, the stability of oil prices relationships with certain macroeconomic variables: Hooker (1996) and Hamilton (1996); the possibility of asymmetric effects of rising and falling oil prices on the economy: Mork (1989) and Hooker (2002); the possibility of the existence of non-linear relationships between changes in oil prices and GDP growth: Lee, Ni and Ratti (1995) and Hamilton (2003 and 2011); the identification of additional factors, besides oil shocks that may have played a role in the pronounced impact on the economy in the 1970s, in particular the role of monetary policy: Bernanke, Gertler and Watson (1997) and Barsky and Kilian (2002).

At the theoretical level Rotemberg and Woodford (1996) and Finn (2000) articles stood out in this field, whose research was based on aggregate models for the economy based on simulated data. These papers try to identify conditions and channels through which these models provide results for the oil shocks similar in magnitude to those found in the empirical literature.

In the most recent period, particularly as from 1999, the world economy was confronted with oil price increases of a very similar magnitude to those observed in the 70s, which was followed by effects on output and inflation of a size incomparable to anything witnessed in the 70s. The effects of oil price increases caused very limited changes in the rate of growth of output and inflation. In the sequence of these observations Blanchard and Galli (2007) (B&G hereafter), try to identify possible explanatory factors underlying the changes in the effects of oil prices in the 1970s and in the 2000s. Besides measuring the effects of oil shocks on overall activity and prices for various countries, for two disjoint samples, these authors present possible explanations for the differences in the magnitudes of the estimated impacts for the two sub-periods. In their research they rely on a simple neo-Keynesian model identifying three channels that in the most recent period, may have contributed to more muted impact: (i) the observation of increased flexibility of real wages, (ii) greater commitment of central banks in keeping inflation under control and (iii) lower intensity of oil in the production process and in consumption. The authors
conclude that these three factors played a relevant role in reducing the effects of oil on GDP and inflation in the post-1970 period.

This paper intends to estimate the effects of oil shocks on economic activity and on inflation for the Portuguese economy, relying on a structural VAR model. For this purpose, we will follow closely the method used in B&G.

The paper is organized as follows. In the following section a brief summary of the methodology is presented, as well as the solutions adopted for some of the relevant issues that must be tackled in its formulation. In Section 3 description of the variables that are used in the model as well as references to the transformations to which they were subjected. The estimated results follow in section 4, and conclusions are presented in the final section.

2. Methodology

To estimate the effects of oil shocks on overall activity and prices for the Portuguese economy we use a structural VAR model. These models have been used quite frequently in empirical applications to estimate the effects of changes in oil prices on the economy (Burbidge and Harrison (1984), Hooker (1996) and B&G among others), since they allow to derive a time profiles of the impact of shocks on the set of variables included in the model.

In the design of any VAR model a first issue that arises is the choice of variables to include in its formulation. Due to the intrinsic characteristics of this type of instrument, these models comprise a limited number of variables in their specification. This hinges on the fact that all the variables with a fixed number of lags are included in all the equations of the model, in its reduced form, and on the typically limited size of the macroeconomic time series that are usually available in empirical applications. In this application for Portugal, six variables were included in the model, namely the price of oil, three nominal variables (consumer prices index (CPI), GDP deflator and wages) and two variables in volumes related to overall activity (GDP and employment). The choice of these variables is justified in the light of the objective of the article: measurement of the effects of oil shocks on overall activity and prices. A more detailed description of the series will be presented in the next section.

A second issue that has to be tackled in the estimation phase is related with the number of lags of the variables to be included in the model. Usually, indicators are available, based on statistical tests for pinpointing the number of lags to be included in the model: Akaike information criterion (AIC) or Bayesian information criterion (BIC) among others. However, in this application and given the relative small size of the time series, we will rely on four lags, to avoid problems of over adjustment and to circumvent the degrees of freedom problem:

Finally there is the issue of the identification of shocks in structural VAR model. Since the aim of the study is to estimate the effect of oil shocks on overall activity and prices, it is necessary to identify the part of macroeconomic fluctuations associated with exogenous changes in oil prices. For this purpose, we confine ourselves to the partial identification of the model as in B&G and Rotemberg and Woodford (1996). This identification of the oil price shock is based on the assumption that the series of oil price is not contemporaneously affected by the changes in domestic price and quantity - the other variables included in the model. In other words unexpected changes in oil prices are exogenous with respect to contemporaneous fluctuations of the other variables in the model. This means that the residuals of the

1 The VAR model which was originally developed by Sims (1980), is a linear multivariate model, consisting of n-equations and n-variables, in which the current value of each variable is explained by its lagged values plus current and lagged values of the remaining (n-1) variables. This simple econometric tool allows one to uncover the dynamics between multivariate time series, forcing the imposition of a very limited number of constraints in its formulation, unlike the existing structural models at the time. For a detailed description of this model, see for instance Hamilton (1994).
3. Information on the data

As mentioned previously, the model includes a total of six quarterly variables in its specification: oil price, consumer price index, gross domestic product deflator, wage index for the private sector, gross domestic product and private sector employment (excluding hospitals and the agricultural sector).

All the variables, with the exception of the price of oil, were collected from the National Statistics Institute (INE) and Banco de Portugal. The series of oil price comes from the ECB, although originally it was collected from publications from the International Monetary Fund (IMF). The series for the private sector wages had to be smoothed for the period 1995Q1-2012Q4, since the original series for this subsample presented large volatility. For this purpose we used a centered moving average of five quarters. Furthermore every variable were transformed in first differences of logarithms as is usual in the literature to overcome the non-stationary problem. One must mention, however, that in spite of this transformation the nominal variables still display some non-stationarity, with a similar profile in the initial part of the sample (Chart 1).

This will not constitute a problem for the estimation as discussed below. For the estimation of the model a base sample covering the period 1984Q1-2012Q4 was considered, so to prevent the pre-1984 period from biasing the oil effects for the most recent period. This is a pretty common option in the literature.

During the 1984Q1-2012Q4 period three major oil price shocks occurred, defined as episodes where the accumulated changes in oil prices (in logs) exceeded 50 percent, sustained for a period of over a year. The first episode began in 1999Q2 and lasted six quarters with a cumulative price increase of about 120 percent. The second period of growth started in 2002Q1 and lasted for nearly five years with an overall increase, with minor variations, of almost 130 percent. Finally the last episode that lasted three years began in 2009Q2, with the price of oil increasing two folds (Chart 2). This last episode is distinct from the previous two as it was preceded by an abrupt and significant decline in oil prices.

The same estimation exercise was conducted for a shorter sample (1984Q1-2008Q4), thus excluding the recent period of internal adjustment of the Portuguese economy within the EFAP, in order to examine the robustness of the overall results. This exercise is intended to verify if the current process of adjustment affects the results obtained for the base sample. Thus, this subsample does not include the period of the third major oil shock that occurred as from 2009Q2.

4. Estimation results

The VAR in its reduced form can be specified as:

$$ y_t = A(L) y_{t-1} + u_t $$

where the vector $y_t$ includes the six variables mentioned previously. $A(L)$ is a 6x6 matrix of polynomials in the lag operator $L$. The polynomials are of a third degree so as to accommodate the four lags assumed for the reduced form. The residuals of the equations in the reduced form are approximately normally distributed and do not exhibit significant serial correlation.

Impulse response functions can be obtained from the structural VAR models. These functions compare the time profile of the variables of the model variables subject to an oil price shock with the time profile in a baseline scenario without the oil shock. For a recent description of the virtues and limitations of the VAR model see Stock and Watson (2007). Impulse response functions provide estimates for the reactions of all the variables of the model to specific shocks. In our case they allow to calculate the effects of oil shocks – the sole shock identified in the model - on prices, activity and employment. These functions
Chart 1

VARIABLES INCLUDED IN THE VAR MODEL | FIRST DIFFERENCES IN LOGARITHM

Oil price  
Consumer price index

GDP deflator  
Wages in the private sector

GDP  
Employment in the private sector

Sources: ECB, IMF, INE and Banco de Portugal.
Chart 2

OIL PRICE

Sources: ECB and IMF.

were estimated as cumulative effects, and thus correspond to changes in the level of the variables (in logarithm).

The response functions, which are displayed in Chart 3, represent the effects of an oil price shock with a magnitude equal to one standard deviation of the innovations, and which correspond to an increase of about 13 percent in dollars. In the charts, together with the medians impulse responses, we present confidence intervals, with a standard deviation confidence band, which corresponds to a confidence level of approximately 68% (calculated using the bootstrap procedure based on 5000 resamplings and the correction proposed by Kilian (1998)).

The estimates of the impulse responses follow, in general, the conventional pattern of the effects of oil shock - depressive impact on GDP and employment and inflationary effects on prices. The effect on CPI, points to a gradual rise in prices which extends for a period of two years, reaching a peak after eight quarters (0.3). Thereafter, the impact reduces slowly, with a virtually nil long-term effect – after five years – on the level of price. In terms of inflation, this result translates into a higher inflation rate in the first two years (0.25 and 0.05 percentage points in the first and second year, respectively).

The response patterns for GDP and employment in the private sector show a very similar profile with a negative effect on overall activity and the labor market. The estimates for overall activity convey a loss of about 0.7 percentage points in the level of GDP in the long run, with almost half of the adjustment taking place in the second year after the shock. The time profile of the impulse response function of employment is marginally smaller in magnitude, thus implying a virtually unchanged effect on productivity in the wake of the oil shock. The response of the GDP deflator is less conventional - a negative effect - though statistically non-significant after four quarters as is the case of wages in the private sector. Negative effects for these two variables were also estimated for France and Germany by B&G.

For the United States and for the period 1984Q1-2005Q4, B&G obtained values for the impulse response functions for consumer prices, which point to an accumulated effect of the oil shock in the long run of 0.25 percentage points The effects on overall activity are somewhat more moderate, about one-third of those obtained for Portugal. Esteves and Neves (2004), relying on annual data and a sample that includes part of the 1970s got more significant estimates, in absolute terms, for Portugal, especially with respect to CPI.
Chart 3
IMPULSE RESPONSE FUNCTIONS TO AN OIL PRICE SHOCK | PERCENTAGE DEVIATION VERSUS A BASELINE SCENARIO
(WITHOUT SHOCK)

<table>
<thead>
<tr>
<th></th>
<th>Oil price</th>
<th>Consumer prices</th>
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<tbody>
<tr>
<td>GDP deflator</td>
<td></td>
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<tr>
<td>Wages in the private sector</td>
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<tr>
<td>GDP</td>
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<tr>
<td>Employment in the private sector</td>
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</tbody>
</table>

Source: Author’s calculations.
Note: Quarters in the horizontal axis.
As mentioned earlier, the same structural VAR model was also estimated for a shorter sample - 1984Q1-2008Q4 - to inquire about the sensitivity of the results to the recent adjustment period of the Portuguese economy within the EFAP.

For ease of comparison we display the impulse response functions for the two relevant variables only - CPI and GDP - for the two samples considered (Chart 4). Furthermore, the one standard confidence interval band for the base sample was also included. For the shorter sample the impulse response functions fall within the confidence bands estimated previously. Thus one can conclude that the two are statistically alike, with very similar temporal patterns. Regarding quantitative differences, the long-term effects are somewhat smaller in absolute terms mainly with respect to CPI. In turn, both the time profile and the magnitude of the effect on GDP over the five years period remain virtually unchanged, which ensures robustness to the results estimated with the base sample.

Finally, the same model was also estimated for the period 1993Q1-2012Q4 so as to exclude the period in which nominal variables present some non-stationary features. The results of the response functions did not change significantly, remaining within the confidence bands estimated for the longer sample. These results show that the non-stationary profile of the nominal variables at the beginning of the sample does not seem to be a problem for the estimation.

5. Conclusions

In this article, effects of oil price shocks on GDP and inflation are estimated for the Portuguese economy, relying on a structural VAR model. In the ongoing period of domestic adjustment it is relevant to have a quantitative measure of these effects, especially since the international economic environment has been cooling sharply and a large uncertainty subsists around the adjustment process.

In the structural VAR model, the partial identification strategy adopted allowed to isolate the oil shock and to estimate impulse response functions on the set of variables used in the model - prices, GDP and employment. The estimation exercise was carried out for a base sample covering the period 1984Q1-2012Q4.

The impulse responses functions follow, in general, the conventional pattern for the effects of oil shocks on overall activity and inflation - depressive effect on GDP and inflationary on prices. The increase in oil

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**Chart 4**

**IMPULSE RESPONSE FUNCTIONS TO AN OIL PRICE SHOCK | ESTIMATED FOR DIFFERENT SAMPLES**

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**Source:** Author’s calculations.

**Note:** Quarters in the horizontal axis.
price of approximately 13 percent in dollars - causes, in comparison to a baseline scenario with no oil shock, a gradual rise in consumer prices over the first two years, concentrated predominantly in the first year, and reverses as from the third year. In terms of inflation, this result translates into a higher inflation rate in the first two years (0.25 and 0.05 percentage points in the first and second year, respectively).

The impulse response pattern for GDP and employment in the private sector follow a fairly similar depressive profile, implying a virtually nil effect on productivity in the wake of the oil shock. GDP growth is negatively affected, primarily in the second year after the shock - about a third of a percentage point, and more limited in the first. The estimate for overall activity envisages a loss of about 0.7 percentage points in the level of GDP in the long run, as against a scenario with no shock.

The same exercise for a shorter sample - 1984Q1-2008Q4 -, which excludes the recent period of adjustment of the Portuguese economy, delivered impulse response functions statistically equivalent to the base sample, which ensures robustness to the results herein presented.

These results, besides establishing a fair approximation to the effects of oil shocks on activity and prices for the Portuguese economy, may also serve as comparative benchmarks for impulse response functions derived from general equilibrium models for Portugal.

References


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