REVISITING THE OIL PRICE-MACROECONOMY RELATIONSHIP IN THE US: THE ROLE OF MODEL SPECIFICATION AND SAMPLE PERIOD

Erkal Ersoy, Centre for Energy Economics Research and Policy; Accountancy, Economics, and Finance; School of Social Sciences; Heriot-Watt University, Edinburgh UK. +44(0)131-451-3587, e.ersoy@hw.ac.uk

Overview

An economy's long-run growth and development critically depend on its resilience and susceptibility to shocks (Balassa, 1986; Martin, 2012; Romer and Romer, 2004). Energy shocks have been placed in the centre of this observation, since growth-inducing activities are highly dependent on access to energy. For the past few decades, heavy global dependence on non-renewable energy sources has been considered a significant threat to sustainable economic growth. Hamilton (1983) observed in post-World War II data that about 90% of US recessions were preceded by drastic increases in oil prices, which made the oil price-macroeconomy relationship a central focus of research for decades. Recent political turmoil in the Middle East as well as the desire to control carbon emissions and to incorporate more renewables into the energy mix have increased attention to the topic once again.

For net importers of oil, the nature of the relationship between oil prices and macroeconomic activity seems obvious: an oil price hike should, *ceteris paribus*, slow down economic growth through more expensive imports and other channels. Visually inspecting the data certainly seems to point in this direction as well. However, despite numerous theoretical predictions and empirical studies, debates continue, and many researchers believe that the negative correlation between oil price rises and output growth dissipated after the 1980s.

Having been popularised by Sims (1980), vector autoregressive (VAR) models remain the most widely used empirical approach by researchers investigating the link between oil prices and macroeconomic fundamentals. As with most empirical work, model specification, variable choice, and sample period have been key points of discussion in the estimation of the theoretical relationship. Along this vein, Hamilton (2003) provided evidence for the non-linear nature of the oil price-macroeconomy relationship, Hooker (1996b) investigated the stability of the relationship, and Kilian (2009) argued that the underlying causes of oil price shocks change over time and that this matters for the relationship in question.

This paper is motivated by four controversial questions within the oil price-macroeconomy theme, as discussed in Herrera et al. (2019). First, does the choice of oil price measure matter for empirical results? (as highlighted in Bernanke et al., 1997). Second, do different sample periods lead to different empirical results or is the relationship stable over time? (as highlighted in Blanchard & Galí, 2007; Gronwald, 2012; Hamilton, 1996; Hooker, 1996b). Third, is there asymmetry in the oil price-macroeconomy relationship? (as investigated in Hamilton, 2003). Finally, does volatility of oil prices immediately preceding a shock affect estimated parameters and, ultimately, the outcome? (as introduced in Lee et al., 1995). The final question is also linked to the ideas set forth in Kilian (2009) in that I argue normalising oil price shocks by their volatility aids empirical modelling without the need to model the nature of shocks, which has attracted criticism.

Methods

Using quarterly US data from 1950 through 2015, several model specifications with increasing complexity and coverage are implemented to facilitate an analysis of the four key questions mentioned above. To do so, the study begins with a base model similar to that used by Hamilton (1983) and progressively extends it to incorporate the ideas put forth by Mork (1989) and Lee et al. (1995). This involves (1) modelling oil prices non-linearly by capturing positive and negative oil price shocks separately, and (2) using a univariate generalised autoregressive conditional heteroscedasticity, GARCH (1,1), process to calculate the conditional variance of oil price changes to normalise unanticipated real oil price fluctuations. These normalised oil price changes aim to capture the idea that small price increases within volatile periods are predicted to have little effect on economic agents' behaviour, if they do not generate enough uncertainty to delay irreversible investments (Hooker, 1999). At that stage, time-varying parameters are estimated using a rolling-window technique to provide further insights as to the nature of the oil price-macroeconomy relationship and its evolution over time. Finally, rolling orthogonalised impulse response functions, which cover a 20-quarter period, are calculated following Cholesky decomposition to visualise the VAR results.

Results

Estimations over a few discrete subsamples allow an assessment of the relationship over time before the rolling-window implementation covering a continuum of subsamples. The sample periods analysed separately are 1950:1

through 1986:1, 1974:1 through 2015:2, 1986:1 through 2015:2, and the entire sample period. In these results, statistical significance refers to Granger causality with a null hypothesis that has a binary outcome. The null hypothesis is equivalent to no Granger causality, and the alternative suggests Granger causality. An early observation using standard model specifications is that statistical significance becomes weaker in more recent subsamples. Using asymmetry, test results indicate that oil price increases Granger-cause changes in GDP growth. This provides evidence for the need to model oil prices non-linearly.

Turning to the normalisation process of oil prices, I find that the GARCH (1,1) representation of oil prices to compute conditional variance of oil price shocks is appropriate. Most notably, recent time periods exhibit GARCH behaviour in errors. Analysis of different sample periods showed that the characteristics of the conditional variance process of the error term in oil prices' AR(4) equation have changed over time. More specifically, in earlier sample periods, the sum of ARCH and GARCH coefficients is greater than one suggesting that the conditional variance process is highly persistent. In this context, there is further evidence of an asymmetric impact of oil price changes on output growth in the US: oil price increases have a negative impact on real GDP growth, but oil price decreases do not have any effect.

Impulse response functions suggest that not all point estimates of the impact on output growth of oil price increases are statistically different from zero, implying that the effect of the impulse is transient. However, in all model specifications, increases in the positive oil price variable led to a fall in real GDP growth. Interestingly, a fall in the price is estimated to have a negative impact on output growth as well.

The rolling-window implementation allows a richer analysis of the relationship across time. Regardless of sample period and oil price proxy, the first quarter following an oil price increase showed a negative GDP growth rate followed by an overshooting effect in the second quarter. There is also a dying out effect of the original shock roughly from the eighth quarter onwards—represented by the flattening out of the surface in the figure below. Further, as the starting quarter moves from mid- to late-1970s, both the initial negative impact and the overshooting effect that follows become more pronounced with the largest observed impact corresponding to 1977.

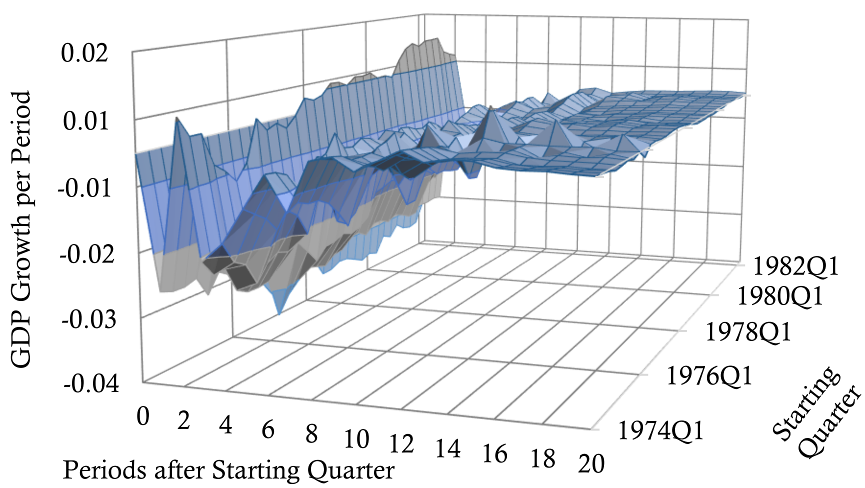

Figure 1. Rolling IRFs with a 10% normalised positive oil price shock using 7-variable system 2.

Conclusions

According to this study, there is limited evidence that the oil price shocks do not Granger-cause fluctuations in output growth rate in recent samples. The findings suggest that the impact of the shocks increased in post-1986 data, and model specification and choice of sample period influence parameter estimates greatly. Further, there is strong evidence for an asymmetric effect of oil prices on output across model specification and sample period; and lastly, normalised positive oil price shocks are more highly correlated with output growth rate than any other oil price variable considered, which provides evidence for the claim that volatility of oil prices before a shock occurs matters.

Impulse response analysis found that positive oil price shocks have a significant negative impact on output growth rate in the US, whereas oil price falls matter much less. Post-1974 data indicate that the effect on annual output growth rate of a 10% increase in oil prices ranges between -0.014 and -0.034% over a horizon of 20 quarters, although most of the impact dissipates about eight quarters after the shock. Finally, this paper provides evidence that the relationship in question can be modelled accurately without resorting to structural assumptions or unreliable proxies to describe oil price behaviour, because adjusting for volatility can suffice.

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