Economics Letters 155 (2017) 84–88

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

# Explaining the time-varying effects of oil market shocks on US stock returns[☆]

Claudia Foroni[a], Pierre Guérin[b], Massimiliano Marcellino[c,*]

[a] European Central Bank, Germany
[b] Bank of Canada, Canada
[c] Bocconi University, IGIER and CEPR, Italy

## HIGHLIGHTS

- We document the emergence of a positive relation between oil price and stock returns from 2006.
- We study the effects of oil market shocks on stock returns using a time-varying SVAR.
- We find evidence of time-variation in the effects of oil-specific demand shocks.
- The short-term interest rate explains well time variation in the parameters of the SVAR.
- This suggests the importance of the ZLB in explaining the positive oil–stock relation.

## ARTICLE INFO

*Article history:*
Received 17 January 2017
Received in revised form 9 March 2017
Accepted 16 March 2017
Available online 21 March 2017

*JEL classification:*
G12
Q43
C32

*Keywords:*
Stock returns
Oil market shocks
Time-varying parameter VAR

## ABSTRACT

This paper documents time-variation in the relation between oil price and US equity returns based on both reduced-form and structural analyses. Our reduced-form analysis suggests that the sign of the relation between real oil returns and real stock returns has changed over time, and that in the recent period this relation has turned positive since early 2007 (but started increasing since 2005). Based on our structural analysis, we find that oil-specific demand shocks have had positive effects on the US stock market since 2009 as opposed to oil supply shocks, which have no large effects on stock returns. We also show that the time variation in the parameters of the structural VAR is very well explained by the level of the US short-term interest rate and shifts in consumer confidence.



## 1. Introduction

It has been argued that commodity-based assets could essentially serve as a hedge against stock market downturns in that the correlation between the US stock market and the oil market was thought to be null. However, the correlation between oil price and stock returns has changed over time, and it has turned positive since early 2007, which has rekindled an interest in evaluating the reaction of US stock returns to oil price fluctuations. The financial press has recently extensively commented on the fact that *"global financial markets are seemingly at the mercy of the oil price, with falls and rebounds in the commodity setting the tone for equity and other asset classes"* (Financial Times, 26 January 2016).

This topic has also attracted interest among academics and policy makers. A seminal contribution is Kilian and Park (2009), who show that the response of aggregate stock returns depends on the sources of the oil price shocks. In particular, they find that higher oil prices driven by unexpectedly strong global economic expansion have persistent positive effects on US stock returns. Former Chairman of the Federal Reserve Bernanke also suggests that the positive oil–stock relation is mostly driven by changes in global demand, reiterating a point first made by Kilian and Park (2009).[1] It is also well documented that the relation between oil and equity returns has been unstable over time (see, e.g., Kilian

☆ Helpful comments from an anonymous Referee and seminar participants at the European Central Bank are gratefully acknowledged. The views expressed in this paper are those of the authors, no responsibility for them should be attributed to the Bank of Canada or the European Central Bank.
* Corresponding author.
*E-mail address:* massimiliano.marcellino@unibocconi.it (M. Marcellino).

1 See the blog entry written by Ben Bernanke published on February 19, 2016 entitled "The relationship between stocks and oil prices", available at

http://dx.doi.org/10.1016/j.econlet.2017.03.017
0165-1765/

and Park (2009) and recent evidence in Mohaddes and Pesaran (2016)).

In this paper, we first document changes in the correlation between real oil returns and real stock returns over time. Kilian and Park (2009) show that the apparent time variation in the correlation between the real price of oil and real equity returns can be explained by shifts in the composition of structural oil demand and oil supply shocks. We extend the structural model of Kilian and Park (2009) to allow for time variation in the coefficients of that model (and hence in the structural impulse responses), and we provide evidence of such time variation.[2] Further analysis shows that the time variation in the impulse responses appears to be correlated with variation in the US short-term interest rate and with shifts in consumer sentiment.

The paper proceeds as follows. In Section 2, we provide a preliminary reduced-form evidence of time variation in the relationship between real stock returns and real oil returns. In Section 3, we use a structural VAR model to study the effects of oil market shocks on US real stock returns. In Section 4, we analyze whether the time variation we detect in the relationship between oil price shocks and real stock returns can be explained by macroeconomic and financial variables. Section 5 concludes.

## 2. A preliminary look at the relation between stock returns and oil returns

As a first-pass evidence, we estimate a univariate time-varying parameter model of the monthly log change in real US stock returns on the contemporaneous log change in the real price of oil (both oil and equity returns are deflated by the US CPI from the Bureau of Labor Statistics). That is, we estimate the following regression

$$\Delta ln(sp_t) = \alpha_t + \beta_t \Delta ln(oil_t) + u_t exp\left(\frac{h_t}{2}\right) \quad (1)$$

where $\alpha_t$ is a time-varying intercept, $\beta_t$ captures the time varying relation between real oil returns and real stock returns, and $u_t$ is the error regression term following a standard normal distribution. We also include time-variation in the innovation of the model via a stochastic volatility process $h_t$. The price of oil is the West Texas Intermediate (WTI) and the stock returns series are obtained from the S&P 500 index returns. We model time variation in the parameters and latent variables $\alpha_t$, $\beta_t$ and $h_t$ based on random-walk type behaviors.

The model is estimated with a standard Bayesian MCMC method and the sample extends from February 1973 to September 2015. Details on the estimation method are reported in the Online Appendix.

The sign of the correlation between real oil returns and real stock returns has changed sign multiple times since the 1970s, albeit this correlation is not meaningfully different from zero for most of the sample (and it is negative around specific events such as the 1990–1991 Gulf war). In the recent period, the correlation coefficient has been increasing since 2005, turned positive in early 2007 and peaked in late 2011 (and the high posterior density interval excludes zero since the start of the financial crisis). As such, this aligns fairly well with the evidence from Lombardi and Ravazzolo (2012) and Datta et al. (2016), who find that the correlation between stock market and oil price has increased markedly since 2008. To conserve space, we report in the Online Appendix the figure with the estimation results and additional comments.

https://www.brookings.edu/blog/ben-bernanke/2016/02/19/the-relationship-between-stocks-and-oil-prices/.

[2] Given the complexity of the model and the size of the sample, there is substantial uncertainty around the estimation, so that we cannot exclude that the data could be also approximated by a time-invariant model.

One caveat of this reduced-form analysis is that it only captures (contemporaneous) correlation and thereby does not allow us to infer any causal relation from the oil market to the US stock market. In the next section, we extend the linear VAR structural model of Kilian and Park (2009), introducing time-variation in all parameters of this model so as to be able to estimate the impact of oil market shocks on the US stock market in a time-varying setting.

## 3. Has the relation between oil market shocks and the stock market changed over time?

In this section, we use a structural VAR model to study the effects of oil market shocks on US real stock returns.[3] The (reduced-form) representation of the time-varying parameter VAR model with stochastic volatility is

$$z_t = A_{0,t} + \sum_{i=1}^{p} A_{i,t} z_{t-i} + e_t, \quad (2)$$

where $e_t$ is a Gaussian white noise process with mean zero and covariance matrix $\Sigma_t$. Following Kilian and Park (2009), the vector $z_t$ includes the following monthly variables: world oil production growth, the Kilian (2009) real economic activity index which is suitable for measuring economic activity in the context of the analysis of oil market, the real price of oil (in log-level) and real S&P500 returns (first difference of logs).

We use monthly data and the sample extends from February 1973 to September 2015. The training sample covers the first 25 monthly observations. The model is estimated with standard MCMC methods along the lines of Del Negro and Primiceri (2015).[4] We use a recursive identification scheme as in Kilian and Park (2009), ordering the variables as follows: first, world oil production growth, second, real economic activity index, third, the real price of oil, and fourth, US real equity returns. Let $e_t$ denote the reduced-form VAR innovations such that $e_t = B_t^{-1}\epsilon_t$. The structural innovations $\epsilon_t$ are derived by imposing exclusion restrictions on the $B_t^{-1}$ matrix. In detail, we impose the following identifying assumptions:

$$e_t = \begin{pmatrix} e_{1t}^{\Delta\, global\, oil\, production} \\ e_{2t}^{global\, real\, activity} \\ e_{3t}^{real\, price\, of\, oil} \\ e_{4t}^{US\, stock\, returns} \end{pmatrix} = \begin{bmatrix} b_{11,t} & 0 & 0 & 0 \\ b_{21,t} & b_{22,t} & 0 & 0 \\ b_{31,t} & b_{32,t} & b_{33,t} & 0 \\ b_{41,t} & b_{42,t} & b_{43,t} & b_{44,t} \end{bmatrix} \times \begin{pmatrix} \epsilon_{1t}^{oil\, supply\, shock} \\ \epsilon_{2t}^{aggregate\, demand\, shock} \\ \epsilon_{3t}^{oil-specific\, demand\, shock} \\ \epsilon_{4t}^{other\, shocks\, to\, US\, stock\, returns} \end{pmatrix}. \quad (3)$$

Time variation in the autoregressive parameters is modeled via driftless random walk processes

$$\theta_t = \theta_{t-1} + \epsilon_t^{\theta}, \qquad \epsilon_t^{\theta} \sim N(0, Q), \quad (4)$$

where $\theta_t = vec(A_t')$, $A_t = [A_{0,t}, \ldots, A_{p,t}]$, and $vec(.)$ is the column stacking operator.

The variance covariance matrix $\Sigma_t$ is decomposed such that $\Sigma_t = B_t D_t B_t'$ where $B_t$ is a lower triangular matrix and $D_t$ a diag-

[3] An analysis on the oil market conducted with a time-varying VAR has been proposed by Kang et al. (2015). We depart from their study by investigating the potential drivers of time-variation.

[4] In particular, the posterior distribution of the states and hyperparameters are based on a burn-in period of 20,000 iterations to converge to the ergodic distribution, and we run 2000 further iterations retaining every second draw to reduce the autocorrelation across draws. The results presented in the paper are thereby based on 1000 draws from the posterior distribution. Recursive means vary little, suggesting evidence in favor of convergence. As an additional convergence check, note that sequential runs of the computer code led to virtually identical results.