



Impacts of oil price shocks on the United States economy: A meta-analysis of the oil price elasticity of GDP for net oil-importing economies[☆]

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ABSTRACT

Policy makers are interested in estimates of the potential economic impacts of oil price shocks, particularly during periods of rapid and large increases that accompany severe supply shocks. Literature estimates of the economic impacts of oil price shocks, summarized by the oil price elasticity of GDP, span a very wide range due to both fundamental economic and methodological factors. This paper presents a quantitative meta-analysis of the oil price elasticity of GDP for net oil importing countries, with a focus on the United States (US). The full range of estimates of the oil price elasticity of GDP for the US in the data is -0.124 to $+0.017$, accounting for different methodologies, data and other factors. We employ a meta-regression model that controls for key determinant factors to estimate the mean and variance of the GDP elasticity across studies. We use a robust estimation technique to deal with heterogeneity of the data and well-known econometric issues that confront meta-analysis. The resulting regression model is used to simulate the oil price elasticity of GDP for the US, with a mean of -0.020% and 68% confidence interval of -0.035 to -0.006 , four quarters after a shock.

1. Introduction

The United States (US) has made considerable progress in reducing oil consumption over the last decade, with even more reductions in oil imports due to the recent boom in domestic production. US petroleum consumption declined by nearly 11% from 2005 to 2012, and was 5% lower than the 2005 level in 2016 (EIA, 2017a). Imports of crude oil and petroleum products were below 2005 levels by 23% in 2012 and by 26% in 2016. Still, oil remains a large component of energy use in the US, accounting for 37% of primary energy consumption and 92% of all transportation fuels in 2016 (EIA, 2017b). The oil market remains vulnerable to market shocks arising from a range of causes: geopolitical events, direct attacks on oil supply infrastructure, rapid changes in global economic activity, extra-market actions by oil producers, oil production and transportation accidents, and natural events, such as hurricanes. Understanding the impacts of oil market shocks on the economy has been a focus of policy attention since the turbulent oil market events of the 1970s. Policy makers are interested in estimates of potential damages to the economy, particularly during periods of rapid and large increases in oil prices that accompany severe supply shocks. Such estimates are needed to quantify the economic costs of oil price shocks, and to evaluate the potential benefits of alternative policy

responses.

Research on the macroeconomic effects of oil market fluctuations is extensive (Barsky and Kilian, 2004; Blanchard and Galí, 2010; Blanchard and Riggi, 2013; Brown and Yücel, 2002; Hamilton, 2009, 2005, 1983; Huntington, 2005; Jiménez-Rodríguez and Sánchez, 2005; Jones et al., 2004; Kilian, 2014, 2008a). This literature has generally shown that significant increases in oil prices exert negative economic impacts in net oil importing countries, but there are many remaining issues. In particular, asymmetry in the economic impacts of increases and decreases in oil prices, differences in the impacts of demand and supply driven shocks, and changes in the sensitivity of the economy to oil market shocks over time have produced vigorous discussions in the oil-economy literature (Bernanke et al., 1997; Blanchard and Galí, 2010; Brown and Yücel, 2002; Hamilton, 2009, 1996; Hamilton and Herrera, 2004; Hooker, 1996; Huntington, 2005; Jones et al., 2004; Kilian and Vigfusson, 2014; Kilian and Lewis, 2011; Kilian, 2009, 2008b; Nordhaus, 2007). The economic impacts of oil market shocks are usually summarized using the elasticity of gross domestic product (GDP), or other measures of economic output, with respect to the oil price (interchangeably referred to as the “GDP elasticity” in this paper). However, estimates of the oil price elasticity of GDP in the oil-economy literature span a wide range. For example, Huntington's (2005) review

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suggests that the mean US GDP elasticity is “ $\sim -5\%$ ” to “ $\sim 0\%$ ”, depending on conditions surrounding the shock. Estimates of the mean US GDP elasticity from recent studies (Cashin et al., 2013; Cologni and Manera, 2008; Peersman and Van Robays (2009) tend to fall in the middle of this range.

The wide range of estimates for the oil price elasticity of GDP in the literature can be attributed to a multitude of factors, both fundamental and methodological. Fundamental factors include differences in the underlying drivers of oil price changes (supply or demand, natural or geopolitical, etc.), the characteristics of oil price shocks (size, duration, speed, etc.), and changes in the structure and management of the economy since the turbulent oil market of the 1970s. Other fundamental factors include the oil intensity of GDP, condition of the economy (i.e. the business cycle phase) and net position of the economy in oil and other commodity trade at the time of a shock, as well as policy options and responses. Therefore, whether estimates of the economic impacts of oil price shocks in a given study are accurate representations of actual impacts or not depends on how well shocks and the channels of impacts are reflected. There has been a continuous effort to improve methods for identifying oil price shocks and quantifying the economic impacts since the 1970s. The ecosystem of models for estimating the oil price elasticity of GDP includes single-equation econometric, multi-equation econometric (typically vector autoregression-type, VAR-type), large macroeconomic (MACRO), dynamic stochastic general equilibrium (DSGE) and computable general equilibrium (CGE) models. Although these approaches have increased our understanding of the oil-economy relationship tremendously, they also represent an important source of variation in estimates of the GDP elasticity. Thus, estimates of the oil price elasticity of GDP in the oil-economy literature depend almost equally on the empirical data and the methodological choices made in the course of the analysis. Given this, policy-related analysis of the impact of oil prices on the economy would need to be aware of the influence of these fundamental and methodological factors, and account for the resulting uncertainties. This suggests that reliance on a single study, or on simple averages and ranges from a few studies, to choose values of the GDP elasticity for policy analysis may be inadequate because these approaches would not account for the multiple, systematic sources of variation in the literature. In this paper, we seek to identify and account for the sensitivity of GDP elasticity estimates to some of the relevant sources of variation to gain insights from multiple studies, while excluding uncertainties that are due to artifacts of the individual studies.

The current paper employs a meta-analysis approach to summarize available estimates of the GDP elasticity from the recent oil-economy literature. This approach enables a systematic evaluation of the mean and sensitivity of the oil price elasticity of GDP to key driving factors. Specifically, within the limits of the data that can be distilled from the literature, we evaluate the role of the following factors in estimates of the oil price elasticity of GDP for net oil-importing economies, with a focus on the US: (i) Modeling/specification approaches; (ii) Period of data coverage; (iii) Size and duration of the oil price shock; (iv) Oil and other characteristics of the economy; (v) Drivers (demand or supply driven) of the oil price shock. We focus on estimates for the US but use a meta-regression approach that includes some recent non-US studies to better understand the influence of these factors. Although there are several qualitative reviews, this paper presents, to our knowledge, the first meta-analysis of the oil price elasticity of GDP and its determinants. This contrasts with other economic parameters, such as price or income-elasticity of demand for fuel or other goods, which are commonly the subject of meta-analysis (Brons et al., 2008; Gallet and Doucouliagos, 2014; Havranek and Kokes, 2015; Labandeira et al., 2017; Sornpaisarn et al., 2013; Stern, 2012). The rest of the paper is arranged as follows. Section 2 presents the meta-analysis methodology used for the analysis. Section 3 discusses the meta-analysis results, highlighting a potential application for policy analysis. The paper ends with conclusions.

2. Meta-analysis approach and data

Meta-analysis is a systematic and quantitative approach for synthesizing multiple studies to estimate the combined mean and variance of a parameter of interest (Rosenthal and DiMatteo, 2001). Meta-analysis can be performed using fixed effects, random effects or multivariate meta-regression models. The fixed and random effects models produce weighted means and associated variances using weights that are based on sample sizes or standard errors of the estimates (Borenstein et al., 2007; Stanley and Doucouliagos, 2015). In addition to estimating combined mean and variance, multivariate meta-regression analysis (MRA) is a well-established approach that uses determinant variables to explore sources of heterogeneity across studies, and is the most common form of meta-analysis in the economic literature (Labandeira et al., 2017; Stern, 2012; Stanley, 2001; Stanley and Jarrell, 1989; Thompson and Higgins, 2002; Van Bergeijk and Lazzaroni, 2015; Van Houwelingen et al., 2002). Given the potential for a high degree of heterogeneity in our data, the meta-regression approach is employed in this paper to estimate the mean and variance of the oil price elasticity of GDP for the US, and to evaluate the role of several key factors.

2.1. Data and sources

The analysis in this paper is restricted to net oil-importing economies¹ and focuses on newer studies, with the initial screening considering those published since the year 2000. To establish the dataset, a search of the literature was performed within the energy economics literature using databases such as ScienceDirect, Scopus, EBSCO, Google Scholar and the general web, with the latter search helping to identify unpublished but potentially significant studies. The literature search produced about 150 papers on topics related to the oil-economy relationship. After initial screening, 19 studies were identified that contain quantitative and accessible estimates of the economic impacts of oil price shocks. One of the final studies was published in 2005 and all others were published since 2008. The author and publication date for these studies are shown in Table 1 and the literature selection criteria are discussed below. Table 1 also includes information on sources, model types, and count of mean estimates of GDP elasticity in our data set. Appendix A contains a list of the 19 papers, as well as the full list of papers initially screened.

The criteria for choosing the studies included in this meta-analysis are:

1. *Studies focusing on oil importing economies:* The ultimate objective of this paper is to evaluate the mean oil price elasticity of the GDP for the US. As a result, the studies selected for inclusion focus on net oil-importing economies which are most relevant to the US economy. This restriction also excludes the complicated oil-economy relationship in oil exporting economies for which oil tends to account for a significant portion of economic growth or foreign exchange earnings. We incorporate information for many oil-importing economies to exploit variations among regions and their responses to oil price shocks when estimating parameters of the meta-regression models. In addition, an important aspect of this paper is to explore the potential roles of oil market and economic conditions, and we consider whether this can be done using cross-sectional variation among regions.
2. *Studies published since 2000:* This paper focuses on recent estimates

¹ Oil exporting economies are excluded due to the widely different role of oil in the social and economic structure of most of these economies relative to oil importing economies. Given this, analyses of the economic impacts of oil price shocks and its driving factors tend to focus on net oil importing economies. Oil-economy analyses for oil exporting countries focus on issues such as revenue management, “dutch disease”, exchange rate responses, etc.

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