# *ON THE WORLD ENERGY PRICE-GDP RELATIONSHIP*

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## Overview

This paper analyzes the macroeconomic impact of high oil prices on each national economy. Using an analytical model, we show that oil price-real GDP elasticity can be estimated roughly from current oil prices, GDP, and oil imports and exports. In contrast to large-scale modeling, our approach is based on simple algebra and clear assumptions, and thus provides policy makers with a more transparent view of the vulnerability of economies to oil price increases, in terms of GDP; our model shows how this vulnerability declined sharply in the late-1980s and stayed low through the 1990s, and how the Euro-zone countries are becoming more vulnerable while Japan remains less so.

## Methods

This paper discusses the impact of changes in world crude oil prices on each national economy. Increases in crude oil prices impose higher production costs on industries for which crude oil and related products are inputs. This effect permeates into the economy through increases in factor prices, and causes recessions.

The International Energy Agency (IEA) conducted a study of this issue (IEA: 2004) by large-scale energy-economic model simulation to calculate decreases in GDP in developed and developing countries resulting from crude oil price increases. The large-scale model simulation showed that a hypothetical increase in world crude oil prices from twenty-five dollars per barrel to thirty-five dollars per barrel results in declines in GDP of 0.3 percent in the U.S., 0.4 percent in Japan, and 0.5 percent in the Euro zone. Frequently cited in the public media around the world, these results had been highly influential in those days as benchmarks in economic policy debates on how to cope with the recent oil price increases in a number of countries.

The IEA report does not provide a detailed description of the model structure. Explanations of the World Energy Model (WEM), which is a main part of the model employed, are found elsewhere in the IEA's publications, but important details of the WEM have not been disclosed to those outside of the IEA; the model thus remains a black box, even as the frequently-cited results it produces continue to be influential. These circumstances do not offer a sound basis for economic policy debate.

The economic literature offers many studies that examine the relationship between oil prices and the macroeconomy. The extensive literature reviews in studies such as Jones, Leiby and Paik (2004) and Brown and Yüncel (2002) indicate that most preceding studies of the issue can be divided into two groups: econometric analyses of existing economic data, and studies employing computational models. These literature reviews also indicate that no consensus has yet been reached on how, why, and to what degree economies are affected by changes in world oil prices.

This paper employs a simple, static general equilibrium model to examine the oil price-macroeconomy relationship. With our model, we can easily calculate the elasticity of the oil price-real GDP relationship. The model thus affords policy makers a clearer view of how oil-importing countries are affected by world oil prices.

The paper is organized as follows. Section 2 presents a static general equilibrium model that represents a national economy importing or exporting crude oil. In Section 3, we derive a formula for estimating oil price-real GDP elasticity. In Section 4, we discuss how our approach is different from past studies. Section 5 provides examples of the use of the formula. The results are compared to those of the IEA study. Section 6 concludes our discussion.

## Results

Consider a simple economy comprising final consumption, energy transformation (oil refineries), and crude oil production sectors. Crude oil is assumed to be the only good that is traded internationally. The final consumption good sector uses capital, labor, and energy products as inputs, and produces a single consumer product. The energy transformation sector produces energy products from crude oil by refining processes, using capital and labor. The crude oil employed in the transformation sector is either produced domestically or imported. Domestic crude oil production requires capital and labor. Domestically produced crude oil is then either supplied to the domestic transformation sector or exported. Let us introduce two assumptions:

*Assumption 1*. The employment $L$ is fixed at a certain exogenous level as a natural employment rate or full employment.

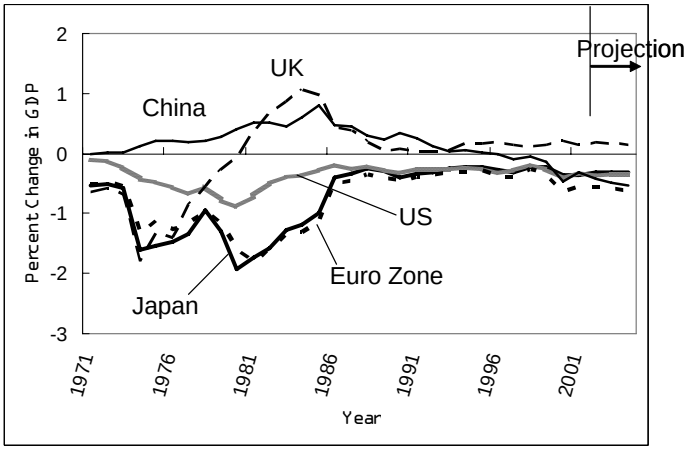
*Assumption 2*. In each production sector, capital and labor are used to produce a composite good. The composite good is separable from other production factors in the sector's production function. Moreover, the production function that produces the composite good from capital and labor inputs is the same for all sectors.

Then, the following proposition holds.

*Proposition (world oil price-real GDP elasticity).* With Assumptions 1 and 2, for the static economy stated above, the oil price-real GDP elasticity in absolute value is estimated as the proportion of net import of crude oil to GDP. That is:

$$\eta \equiv \frac{dY/Y}{dp/p} = -\frac{p(M-X)}{Y}.$$

Our formula facilitates the examination of historical changes in oil price-real GDP elasticity. As stated above, the IEA estimates consider an oil-price increase from twenty-five to thirty-five dollars per barrel, a forty percent increase. For ease of comparison, we adopted the same condition, calculating the percentage changes in real GDP resulting from forty percent increases in oil price, that is, the oil price-real GDP elasticity multiplied by forty for each year. The results are shown below.




Historical Changes in Oil Price-Real GDP Elasticities (multiplied by 40)

## Conclusions

This paper provides an alternative approach for estimating the world oil price elasticity of real GDPs. A simple, static general equilibrium model provides a simple formula for the estimation: the real-oil price elasticity of real GDP in an economy is equalized to the ratio of a country's net import of crude oil to its GDP. The formula provides us an insight into how and to what degree the vulnerability of these economies to oil price shocks is determined.

Compared to large-scale modeling, the approach may be too simple to account for all effects of world oil price increase on a macroeconomy. However, such simplicity has the benefit of affording policy-makers a more transparent, clearer view of the effect of oil price increases. Specifically, the approach shows how the vulnerability of the economies of the OECD countries to increases in world oil prices, in terms of both real GDP and consumer prices, declined sharply in the late 1980s and stayed low through the 1990s; and how in recent years the Euro-zone countries are becoming more vulnerable than before, while Japan is not. The case of the Chinese economy is slightly different; the approach shows that China is becoming much more vulnerable than other countries as it grows and becomes more dependent on imported oil.

## References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