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Oil Price Risks

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Measuring the Vulnerability of Oil Importers

Oil prices more than tripled between January 2004 and March 2008. The effects can be hard on countries with large net oil imports relative to income. This Note sets out a measure of vulnerability to oil price shocks and breaks it down into its components. That allows cross-country benchmarking and helps to show how changes in such factors as energy efficiency and the real exchange rate can make countries more vulnerable or less so.

One measure of the importance of oil to an economy is its "vulnerability," defined as the ratio of net imports of crude oil and oil products to GDP. A rise in oil prices both increases the value to the economy of any domestic oil production and decreases GDP according to the consumption of oil and oil products. For countries that consume more than they produce, a change in the balance of these two effects—the value of net oil imports—is a measure of the adjustment that will have to be made when oil prices rise (in the absence of other, offsetting exogenous shocks). The adjustment will have to be made by deflating the economy to restore the balance of payments or running down foreign exchange reserves.

The vulnerability of an economy can be related to a number of factors through an accounting identity. Such a decomposition analysis allows a study of how vulnerability to increases in oil prices changes over time and how much changes in individual factors contribute to the overall changes in vulnerability. The results may highlight countries that are experiencing atypical changes in vulnerability and point to factors causing those changes. The findings could call for more detailed analysis of why a country might be departing markedly from the global trend of countries with comparable levels of economic development and resource endowments and what steps could reduce its vulnerability.

Measuring vulnerability

Data for constructing a simplified measure of vulnerability are available for a large number of countries between 1996 and 2006 from the U.S. Department of Energy's Energy Information Administration (EIA) and from World Bank databases. For the 123 countries that were net oil importers in 1996 and 2006, the annual average price of three marker crudes—Brent, West Texas Intermediate, and Dubai Fateh—was multiplied by the volume of net oil imports. This underestimates vulnerability for two reasons: all

refined products other than fuel oil are more expensive than crude oil, and the cost of transporting oil to the importing country is excluded.

In 1996, when the average price of crude oil was US$20.40 a barrel, 85 percent of countries had a vulnerability of less than 5 percent (table 1). By 2006, when the average price was US$64.30, only 50 percent did. This dramatic change is strongly correlated with the rise in the oil price, but it also depends on changes in the use of imported oil relative to GDP as well as on movements in the real exchange rate.

In 2007 the average oil price rose by another 10 percent. GDP for many countries would also have risen somewhat, so that vulnerability would not have changed greatly in 2007 as a whole. But the rapid increase in oil prices in the second half of 2007 and the first four months of 2008 to around US$100 a barrel would, if sustained, represent a 50 percent increase since 2006. This oil price rise would represent a very large change relative to GDP even if partially offset by growth of GDP and a favorable exchange rate movement against the dollar. Countries with a vulnerability of greater than 10 percent in 2006 would likely face a further import shock equivalent to 5 percent or more of GDP.

Decomposing changes in vulnerability

Changes in vulnerability can be linked to several factors, including the exchange rate, through an identity that forms the basis for a decomposition analysis that allocates the change in vulnerability to changes in the different factors in the identity (for a detailed explanation, see Ang 2005).

The ratio of net oil imports in U.S. dollars to current GDP in U.S. dollars at a moment in time is equal to the product of six factors:

1. The crude oil price in U.S. dollars
2. The ratio of the volume of net oil imports to domestic oil consumption (import dependence)
3. The ratio of domestic oil consumption to total domestic energy consumption (oil share)
4. The ratio of total domestic energy consumption to real GDP in local currency (energy intensity)
5. The ratio of real GDP in local currency to current GDP in local currency
6. The ratio of current GDP in local currency to current GDP in U.S. dollars.

This identity is valuable because it separates the movements in vulnerability into components that have direct relevance to understanding those movements. The last two factors bring in the movements of domestic prices and the exchange rate, so that together they represent the effect of the real exchange rate. This identity is then manipulated to arrive at a formula that allows addition of each of the five factors (with factors 5 and 6 combined) to give the percentage difference in vulnerability between any two years.

To illustrate the use of this identity, attention is focused on a group of countries whose vulnerability between 1996 and 2006 rose faster than the nominal oil price, that is, by more than a factor of 3.15. For these countries, where growth in GDP offset some of the oil price rise, the increase in the use of oil was such that the oil import bill relative to GDP rose more than the oil price. Thirty-three countries fall into this category, of which 10 are very small island economies. For 18 of the larger countries the changes in vulnerability are decomposed into components related to the factors shown above (table 2; box 1).[1]

The oil price effect results in the largest increase in vulnerability for the economies where the initial ratio of oil imports to GDP was highest. For five countries this effect was equal to or greater than 5 percent of GDP.

In five countries that are oil producers, oil production did not keep up with oil consumption, with the result that the volume of oil imports rose faster than GDP. This was particularly important for Albania, Australia, and China, where half or more of the increase in vulnerability was due to rising import dependence.

Table 1 **Net-oil-importing countries by vulnerability, 1996 and 2006**

Vulnerability[a]	1996	2006
Less than 2.5%	79	19
2.5–5%	26	42
5–7.5%	8	23
7.5–10%	6	18
10–15%	3	12
>15%	1	9

a. Value of net oil imports/GDP.
Source: Authors' calculations.

This effect may have been unavoidable because of the nature of oil reserves in these countries.

In 10 countries the share of oil in total energy use increased, while in 6 it decreased. Further analysis could indicate whether the oil share increased because of relative growth in the transport sector where there were no substitute fuels or because oil increasingly became a fuel of choice for the power sector.

Aggregate energy intensity is determined by three broad factors: the income elasticities of demand for energy at the sector level, the shares of GDP of sectors with different levels of energy intensity, and the levels of energy efficiency in each sector. Energy intensity fell in seven countries between 1996 and 2006, reflecting increasing energy efficiency, an increasing share of less energy-intensive sectors in GDP, or income elasticities of demand for energy less than unity. Energy intensity rose in eight countries; in Guyana and Togo it increased very sharply, while in four more African countries it increased the level of vulnerability by more than 1 percent of GDP. Further analysis would be needed to see which of the factors contributed to this increase and whether it suggests a need for active policies to reduce energy use.

In nine countries the real exchange rate moved to offset some of the impact of the dollar price rise in imports. But in seven countries the movement worsened oil vulnerability. In Burundi, The Gambia, and Malawi this effect was equivalent to another 1 percent of GDP. The real exchange rate effect reflects the impact of a number of domestic policies and does not represent just a strengthening or weakening of the U.S. dollar. Although exchange rates against the dollar have been changing recently, in 2004–06 Madagascar and Malawi experienced substantial nominal depreciation against the dollar, and Uruguay was the only country in the sample to experience a substantial appreciation.

The oil share and energy intensity factors reflect country choices about the use of energy. In Benin, Ethiopia, Madagascar, Namibia, and Togo both factors contributed to the increase in oil vulnerability, suggesting that these countries may need to reappraise their energy policies in case oil prices rise even further.

Table 2 **Decomposition of changes in vulnerability between 1996 and 2006 (percentage of current GDP in U.S. dollars except where otherwise specified)**

Country	Oil price effect	Import dependence effect	Oil share effect	Energy intensity effect	Real exchange rate effect	Vulnerability in 1996	Change in vulnerability	Energy intensity[a] 1996	Energy intensity[a] 2006
Albania	2.5	3.2	1.5	−0.4	−1.4	0.5	5.4	27.9	22.8
Australia	0.7	0.4	−0.1	0.0	−0.2	0.3	0.8	12.3	12.1
Bangladesh	2.1	−0.1	−0.1	0.2	0.2	0.9	2.2	10.2	11.1
Benin	4.9	1.4	0.5	1.4	−1.4	1.8	6.7	8.4	11.5
Burundi	5.4	0.0	−0.2	0.0	1.1	2.2	6.4	9.5	9.6
China	1.4	1.8	0.0	−0.2	−0.3	0.3	2.7	40.9	35.5
Ethiopia	3.0	0.0	0.4	1.0	0.0	1.0	4.3	5.7	8.3
Gambia, The	6.4	0.0	0.1	−0.7	0.9	2.9	6.7	8.9	7.9
Ghana	5.0	0.5	1.7	−1.1	−0.7	2.2	5.4	29.3	22.7
Guyana	17.2	0.0	−0.6	5.2	−1.5	7.1	20.2	21.1	29.8
Madagascar	4.4	0.0	0.6	1.2	0.0	1.6	6.1	6.8	9.1
Malawi	4.0	0.0	−0.4	−0.1	1.3	1.6	4.9	12.5	12.3
Namibia	4.6	0.0	0.5	1.1	−0.8	1.9	5.4	10.4	13.8
New Zealand	1.9	0.5	0.3	−0.4	−0.2	0.8	2.0	16.9	12.9
Paraguay	4.3	0.0	0.9	−0.1	0.4	1.6	5.4	50.7	49.1
Togo	8.8	0.0	2.3	6.9	−1.2	2.1	16.8	10.1	25.0
Uganda	1.9	0.0	0.0	0.0	0.2	0.9	2.1	5.4	5.3
Uruguay	2.9	−0.1	−0.4	0.3	0.5	1.2	3.3	6.6	7.3

a. Thousands of British thermal units (Btu) for every U.S. dollar of GDP in 2000 prices based on market exchange rates.
Source: Authors calculations.

Box 1 Methodology for decomposing changes in vulnerability

Using an accounting identity to decompose changes in vulnerability over time allows the separation of the pure oil price change effect from other changes that can affect vulnerability. For the analysis described in this Note, the following identity is used:

$$V \equiv [\text{ONP\$/GDPC\$}]$$
$$= [\text{ONP\$/ON}] \times [\text{ON/OC}] \times [\text{OC/EC}] \times [\text{EC/GDPRL}] \times [\text{GDPRL/GDPCL}] \times [\text{GDPCL/GDPC\$}]$$

ONP$ = volume of net oil imports per year in barrels times annual crude price in U.S. dollars
GDPC$ = value of GDP in current U.S. dollars
ON = volume of net oil imports per year in barrels
OC = volume of oil consumption per year in barrels
EC = total primary energy consumption per year in quadrillion Btu
GDPRL = value of GDP in constant local currency
GDPCL = value of GDP in current local currency

To analyze the change in vulnerability over a number of years, based on the identity, a log mean Divisia index (LMDI) is used. The change in a country's vulnerability (ΔV) between any two years can be decomposed into the sum of the effects of the change in P (the oil price effect, P_{eff}); the change in I (the share of imported oil in total oil consumption, the import dependence effect, I_{eff}); the change in O (the share of oil in total energy, the oil share effect, O_{eff}); the change in E (the ratio of energy consumed to real GDP, the energy intensity effect, E_{eff}); the change in D (the ratio of GDP in constant to current prices, the inverse of the price deflator effect, D_{eff}); and the change in X (the ratio of current GDP valued in local currency to current GDP valued in U.S. dollars, the exchange rate effect, X_{eff}). The sum of the change in D and the change in X is the real exchange rate effect (R_{eff}).

$$\Delta V \equiv V(T) - V(0) \equiv P_{eff} + I_{eff} + O_{eff} + E_{eff} + R_{eff}$$

The effects, in turn, can be calculated from the following formula using the log mean Divisia index:

$$P_{eff} = [V(T) - V(0)] \times \{ \log [P(T) / P(0)] / \ln [V(T) / V(0)] \}$$

with other factors calculated analogously.

Conclusion

This illustration of the decomposition of vulnerability indicates that it can be a useful tool in focusing attention on movements in the economy that will make a country more vulnerable to oil price shocks. It highlights the role of changes in import dependence, in the oil share in energy, and in the energy intensity of GDP, all of which may be susceptible to instruments of government policy. For any country, more detailed analysis is required to understand the determinants of the level and changes in vulnerability so that appropriate policies can be designed to reduce it.

Notes

The results presented here are drawn from an ongoing study on policy responses to high oil prices that decomposes the change in vulnerability for a larger number of oil importers and exporters.

1. Data for Cambodia from the International Energy Agency differ substantially from the EIA data through 2005 and would place it in this group with changes in vulnerability greater than the oil price change. This Note uses EIA data because they extend through 2006.

Reference

Ang, B. W. 2005. "The LMDI Approach to Decomposition Analysis: A Practical Guide." *Energy Policy* 33: 867–71.

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