Estimation of direct and indirect impact of oil price on growth

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Abstract

Using a new methodology, this paper measures the direct and indirect effects of oil prices on GDP growth of 12 economies. Because of the indirect effect, which is transmitted through a trade matrix, even the net oil exporters like Indonesia and Malaysia cannot escape the negative influence of high oil prices. © 2001 Elsevier Science B.V. All rights reserved.

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JEL classification: E3; Q4

1. Introduction

The spectre of another oil shock emerged in September 2000. A number of studies that followed the influential work of Hamilton (1983) have established that such oil price increases have caused contractions in the US economy (see Hamilton, 2000, and Refs. therein). Of particular interest to us in this study are the Southeast and East Asian economies, which were battered by the Asian financial crisis. There has been widespread concern over how high oil prices impinge on their recovery process (ADB, 2000; Abeysinghe and Wilson, 2000). Using a VARX methodology, this note provides an assessment of the direct and indirect impact of oil prices on the GDP growth of 12 economies.

2. Methodology

High oil prices affect open economies both directly and indirectly. The indirect effect works through an economy’s trading partners. For example, Malaysia and Indonesia are net oil exporters and...
major trading partners of Singapore. Singapore is an oil importer. While higher oil prices impact negatively on Singapore’s GDP growth, Malaysia and Indonesia reap the benefits in terms of higher export revenues. This in turn increases their imports from Singapore. The net effect of oil prices on Singapore, therefore, depends on the magnitude of these direct and indirect effects.

To measure both the direct and indirect effects we need a multi-equation framework. For this we use a structural VARX model formulated in Abeysinghe (2000a,b). Using reduced form bilateral export functions, Abeysinghe derived the following model to link up the GDP series through a trade matrix:

\[ (B_0 \star W_t) y_t = \lambda + \sum_{j=1}^{p} (B_j \star W_{t-j}) y_{t-j} + \sum_{j=0}^{p} \Gamma_{ij} x_{t-j} + \cdots + \sum_{j=0}^{p} \Gamma_{kj} x_{t-kj} + \varepsilon_t \]  

where \( y_t \) is an \((n \times 1)\) vector of GDP growth series, \( x_{ij} (i = 1, \ldots, k) \) are \((n \times 1)\) vectors of growth rates of other explanatory variables, \( B \) and \( \Gamma \) values are unknown parameter matrices and \( \varepsilon_t \) is a random vector with zero mean and \( \text{Var}(\varepsilon_t) = \Omega \). \( W_t \) is a known matrix of weights made up of bilateral export shares such that \( \sum w_{ij} = 1, (j = 1, 2, \ldots, n - 1; i \neq j) \). The asterisk indicates the element-wise (Hadamard) product of the two matrices. For \( n = 3 \) and \( p = 1 \) the parameter matrices take the form:

\[
B_0 = \begin{pmatrix}
1 & -\beta_{01} & -\beta_{01} \\
-\beta_{02} & 1 & -\beta_{02} \\
-\beta_{03} & -\beta_{03} & 1
\end{pmatrix}, \quad B_1 = \begin{pmatrix}
\phi_{11} & \beta_{11} & \beta_{11} \\
\beta_{12} & \phi_{12} & \beta_{12} \\
\beta_{13} & \beta_{13} & \phi_{13}
\end{pmatrix}, \quad W = \begin{pmatrix}
1 & w_{12} & w_{13} \\
w_{21} & 1 & w_{23} \\
w_{31} & w_{32} & 1
\end{pmatrix}
\]

and \( \Gamma \) values are diagonal. The most important feature of this model is that the effective parameter matrices \((B_i \star W_i)\), \( i = 0, 1, \ldots, p \), change over time due to the changing weight matrix \( W_t \) (see Abeysinghe, 2000a, for more details).

The other explanatory variables \((x_{ij})\) enter the model either through the export function or through the other components of the GDP identity. Oil prices affect consumption expenditure, investment expenditure and the trade balance directly, and play a legitimate role in the model. After estimating the model, we can derive the impulse responses of output growth with respect to changes in oil prices \((o_t)\) from

\[ y_t = \lambda^* + R(L) o_t + u_t \]  

where \( R(L) = B^* (L)^{-1} \Gamma(L) \), \( B^* (L) = (B_0^* W_i) - (B_1^* W_i) L - \cdots - (B_p^* W_i) L^p \), and \( \Gamma(L) = \Gamma_0^* + \Gamma_1^* L + \cdots + \Gamma_p^* L^p \). For the country \( i \), the \( ii \)th diagonal element of \( R(L) \) provides the direct impact of oil prices on the GDP growth and the \( ij \) \((j = 1, 2, \ldots, n - 1; i \neq j)\) off-diagonal terms provide the impact through the \((n-1)\) trading partners. Unlike the standard VARs, model (2) does not produce fixed impulse responses. They change as the trading pattern changes. In the model, we use 12-quarter moving averages of export shares so that \( W_t \) changes only slowly over time.

3. Data and estimation

This study covers the same set of economies modeled in Abeysinghe (2000a), namely ASEAN4 (Indonesia, Malaysia, Philippines, Thailand), NIE4 (Hong Kong, South Korea, Singapore, Taiwan),
China, Japan, USA, and the rest of OECD as a group (ROECD). While the countries in the OECD are the major trading partners of ASEAN4 and NIE4, there has been a substantial increase in intra-regional trade within the latter groups. Therefore, these 12 economies form a logical set in an assessment of international transmission of shocks through trade. The computational details of the 12 quarterly GDP series and the corresponding 132 bilateral export shares are given in Abeysinghe (2000a). In our model \( y_i = \Delta \ln(Y_i) \), where \( Y_i \) is the constant dollar seasonally adjusted GDP of country \( i \).

An important question is how to incorporate oil prices into the model. Studies on the US have established that the effect of oil prices on growth is asymmetric. Although a rise in oil price has a significant negative effect on growth, a fall in oil price does not cause an economic expansion (Hamilton, 2000). Following this literature we tried a number of measures designed to capture this asymmetric effect. By defining real oil price as \( o_i = \Delta \ln(O \cdot E_i / P_i) \), where \( O \) is oil price in $US\(^1\), \( E_i \) is the exchange rate of country \( i \) against the $US and \( P_i \) is the CPI of country \( i \), we examined the effect of positive and negative \( o_i \) as in Mork (1989), volatility adjusted positive and negative oil price shocks\(^2\) as in Lee et al. (1995), volatility adjusted positive and negative \( o_i \) as in Hamilton (2000), current oil price relative to the annual average as a variant of Davis et al. (1997) and an IV estimator using Hamilton’s (2000) quantity-dummy variable for past oil shocks as an instrument. Although all these produce expected results for the US economy, they produce insignificant and questionable results for the other countries. We, therefore, reverted to the following simple formulation that allows for a symmetric effect of oil price on growth. As in Hamilton’s IV formulation, if oil price changes are truly exogenous, the symmetric effect seems quite plausible especially for the oil producers in our sample, Indonesia and Malaysia.

Preliminary estimates based on \( \Delta \ln(O), \Delta \ln(O \cdot E_i) \) and \( \Delta \ln(O \cdot E_i / P_i) \), as measures of \( o_i \), show similar results. A closer examination of a data plot shows that the changes in oil price is so dominant that the above conversions do not have much effect on the variation in oil prices. The only marked departure of \( \Delta \ln(O) \) from the other two occurs in Indonesia during the period of Asian crisis. Because of the similarity of estimates we carried out our analysis based on \( o_i = \Delta \ln(O \cdot E_i) \). Moreover, it is not difficult to verify that, since oil price affects the CPI inflation in a distributed lag manner, \( \Delta \ln P_i \) can be substituted away with a sufficient number of lags of \( \Delta \ln(O \cdot E_i) \) in the model\(^3\).

For the oil price we use the $US spot price of Brent crude oil, which is available only since 1982Q1. This constrains our sample to the period 1982Q1–2000Q2. The exchange rate we use for the ROECD is the German Mark against the $US\(^4\). As in Abeysinghe (2000a) we set the maximum lag length in (1) to \( p = 4 \). For Indonesia a (0,1) dummy was used for the Asian crisis period.

Since \( y_i \) values and possibly \( o_i \) are endogenous, we estimated the model equations by 2SLS using four lags of each \( y_i \) and four lags of \( o_i \) as instruments. An \( F \)-test on the coefficients of oil price in individual equations shows that the coefficients are in general statistically insignificant. However, the

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\(^1\)In our initial work we used the US oil price series WP0561 downloaded from Hamilton’s website.

\(^2\)These are one-step forecast errors of real oil price from an AR(6) model with a GARCH(1,1) error process.

\(^3\)From a theoretical point of view what we need is the relative price of oil, relative to the price of a close substitute. The real price of oil defined above seems to be a poor proxy for the relative price because of the direct dependence of CPI on oil price. It should also be noted that the common practice of comparing the current levels of nominal and real prices of oil could be misleading, because the gap between the two can be increased arbitrarily simply by pushing the base of CPI far back into the past.

\(^4\)The Brent price is from the International Energy Agency and the average exchange rates are from IFS.
sum of these coefficients remains persistently negative for oil importers and positive for oil exporters. It should be noted here that these tests do not consider the indirect effects that we are interested in. What we require are tests on the impulse responses. Theoretical work on this aspect remains to be done within the framework of our model. As pointed out by Kilian and Chang (2000) existing methodologies do not necessarily provide reliable confidence intervals for large VAR models.

4. Direct and indirect effects

After estimating the model parameters, the impulse responses were generated by fixing the average $W_t$ matrix at $t=2000Q2$. The cumulative impulse responses (multiplier effects) of GDP growth in response to a 50% increase in oil price are plotted up to 20 quarters in Fig. 1. Some graphs show the presence of seasonal effects. Table 1 provides a summary. The long run effects reported in the table are the average effects over 12–20 quarters. Most of the impulse responses tend toward zero after about 12 quarters.

This exercise reveals some useful observations. Both Indonesia and Malaysia are net oil exporters. The direct impact of high oil prices on these two is positive. They, however, cannot escape the contractionary effect coming through the trading partners. In the long run, they also lose out. This result is likely to hold in general for oil exporting open economies.

All the other economies in the study are net oil importers. Both direct and indirect effects on them are negative. Singapore is an interesting case. Since Indonesia and Malaysia are two major trading partners of Singapore, the indirect effect of high oil prices on Singapore is slightly positive initially. However, as Indonesia and Malaysia start to feel the pinch, Singapore will also experience a larger negative indirect effect.

Singapore and Taiwan appear to have similar long run effects. Surprisingly, the indirect effect on Taiwan is much smaller compared to Singapore. Philippines and Thailand seem to be the worst affected followed by South Korea.

Both Hong Kong and China are not much affected, mainly due to the ‘China-effect’. China is an oil producer. During the past 7 years, however, China has become a net oil importer. Nevertheless, the impact of high oil prices on China is small. Hong Kong seems to be insulated by China, which has emerged as the major trading partner of Hong Kong.

Fig. 1 provides an interesting contrast between USA and ROECD. The direct impact of oil price on the US economy is much larger than the indirect effect whereas the opposite holds for ROECD. This reflects the fact that US is relatively a closed economy and ROECD is a collection of small open economies. Japan seems to fall in between.

5. Conclusion

The results of this exercise show that the transmission effect of oil prices on growth may not be that important for a large economy like the US but it could play a critical role in small open economies. We also have to bear in mind that the actual working of a new shock depends on how it interacts with the consumer and investor confidence just as we have seen during the Asian financial crisis. Further
Fig. 1. Direct, indirect and total impact of a 50% increase in oil price on GDP growth. Direct (box line), Indirect (plus line), Total (solid line).
Table 1
Impact of a 50% increase in oil price on GDP growth (%)

<table>
<thead>
<tr>
<th></th>
<th>Direct impact</th>
<th>Impact through trading partners</th>
<th>Total impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>After 4 qtrs</td>
<td>1.5</td>
<td>−1.3</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>2.5</td>
<td>−3.2</td>
</tr>
<tr>
<td>Malaysia</td>
<td>After 4 qtrs</td>
<td>2.3</td>
<td>−2.1</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>3.6</td>
<td>−3.9</td>
</tr>
<tr>
<td>Philippines</td>
<td>After 4 qtrs</td>
<td>−2.6</td>
<td>−0.2</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−5.5</td>
<td>−0.7</td>
</tr>
<tr>
<td>Thailand</td>
<td>After 4 qtrs</td>
<td>−3.7</td>
<td>−0.3</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−5.7</td>
<td>−1.2</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>After 4 qtrs</td>
<td>0.6</td>
<td>−0.1</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−0.1</td>
<td>−1.1</td>
</tr>
<tr>
<td>S Korea</td>
<td>After 4 qtrs</td>
<td>−1.7</td>
<td>−0.6</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−2.1</td>
<td>−1.5</td>
</tr>
<tr>
<td>Singapore</td>
<td>After 4 qtrs</td>
<td>−1.6</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−1.1</td>
<td>−1.2</td>
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<tr>
<td>Taiwan</td>
<td>After 4 qtrs</td>
<td>−1.4</td>
<td>−0.1</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−2.3</td>
<td>−0.5</td>
</tr>
<tr>
<td>China</td>
<td>After 4 qtrs</td>
<td>0.2</td>
<td>−0.1</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−0.2</td>
<td>−0.1</td>
</tr>
<tr>
<td>Japan</td>
<td>After 4 qtrs</td>
<td>−0.8</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−0.2</td>
<td>−0.2</td>
</tr>
<tr>
<td>US</td>
<td>After 4 qtrs</td>
<td>−0.3</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−0.7</td>
<td>−0.1</td>
</tr>
<tr>
<td>Rest of OECD</td>
<td>After 4 qtrs</td>
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<td>−0.1</td>
</tr>
<tr>
<td></td>
<td>Long run</td>
<td>−0.2</td>
<td>−0.4</td>
</tr>
</tbody>
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Efforts are needed to obtain more refined and stronger estimates of oil price elasticities for the countries in our study.

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References


