Energy Policy 36 (2008) 1164–1168
ENERGY POLICY
www.elsevier.com/locate/enpol

The asymmetric relationship between oil revenues and economic activities: The case of oil-exporting countries

Mohsen Mehrara*

Economics Department, University of Tehran, Tehran 14155-6445, Iran

Received 5 August 2007; accepted 1 November 2007
Available online 10 January 2008

Abstract

This paper examines the nonlinear or asymmetric relationship between oil revenues and output growth in oil-exporting countries, applying a dynamic panel framework and two different measures of oil shocks. The main results in this paper confirm the stylized facts that in heavily oil-dependent countries lacking the institutional mechanisms de-linking fiscal expenditure from current revenue, oil revenue shocks tend to affect the output in asymmetric and nonlinear ways. The findings suggest that output growth is adversely affected by the negative oil shocks, while oil booms or the positive oil shocks play a limited role in stimulating economic growth. The findings have practical policy implications for decision makers in the area of macroeconomic planning. The use of stabilization and savings funds and diversification of the real sector seems crucial to minimize the harmful effects of oil booms and busts.

Keywords: Oil shocks; Asymmetric relationship; Oil-exporting countries

1. Introduction

Oil price fluctuations are a major source of disturbance for the economies of oil-exporting countries given the relative importance of the oil sector in production and exports and uncertainty in the world oil markets. Studies empirically related to the effects of oil price fluctuations on macroeconomic variables were almost exclusively devoted to oil-importing economies, with little attention being paid to exporting countries (e.g., Hamilton, 1983, 1988, 1996, 2000; Mory, 1993; Mork et al., 1994; Lee et al., 1995; Sadorsky, 1999; Davis and Haltiwanger, 2001; Cunado and De Gracia, 2003; Huang et al., 2005). These studies have identified asymmetries in how GDP responds to oil price changes in oil-importing countries, namely GDP falls more in response to oil price increases than it rises following oil price decreases. This paper explores whether an analogous dynamic occurs within the oil-exporting countries. In other words, does a negative oil revenue shock have merely an opposite effect as does a positive oil shock or are there differences in degrees?

Intuitively, in an oil-dependent economy, the exogenous increase in export revenue will release foreign exchange constraints, stimulating economic activities from both supply and demand sides. But, what is often less well understood is that this goes hand-in-hand with the real appreciation and a contraction in tradable sectors including non-oil exports, so that the natural resource blessing could become a curse. Sterilization of the oil revenue can only delay the real appreciation but not eliminate it, if there is to be any benefit from the oil.[1] This is often taken as the main symptom of the Dutch disease (Devlin and Lewin, 2004). Revenue streams from ‘‘black gold’’ can finance productive physical and social investment, or fuel unsustainable consumption booms and eventual fiscal crises.

On the downside, when the windfall revenue subsequently falls, the oil-dependent economies suffer from under-capacity with their access to capital and intermediate imports restricted, particularly in the presence of capital

*Tel.: +98 021 88029007; fax: +98 021 22274900.
E-mail address: mmehrara@ut.ac.ir

[1] Indeed, if the full amount of the transfer or windfall were invested offshore, there would be no effect on the balance of payments (the outflow exactly equaling the inflow) and no effect on disposable income. Hence the real appreciation would be avoided, but there would be no welfare gain until the repatriation of income from the offshore investment began.

0301-4215/$ - see front matter
doi:10.1016/j.enpol.2007.11.004

market imperfections (Hausmann and Rigobon, 2003). Moreover, the real exchange rate becomes overvalued. So, it may not be possible to recover lost non-oil export markets or resuscitate the relevant sectors, notably, agriculture and manufacturing, even if the real overvaluation is corrected by a subsequent depreciation. Additionally, adjustments to the real exchange rate are unlikely to be smooth. Under these conditions, we expect the adverse oil shocks to be much more important than the positive ones.

Budgets usually adjust asymmetrically too. If government spending is more likely to increase following a positive shock than decrease following a negative one, then oil revenue increases might increase growth more than would oil revenue decreases retard growth. But, rapid growth in public spending, which often follows oil price increases, reduces spending quality and introduces entitlements, including recurrent cost commitments, which are often not sustainable in the long run. Efficiency often suffers from a high proportion of unfinished projects as well as from capital investments that cannot be effectively used because of shortages of recurrent resources. Overall, it seems that oil booms contribute little to economic growth, while oil busts may have strong deterrent effects on output.

This paper examines whether oil price fluctuations have asymmetric effects on output growth by means of applying a dynamic panel framework allowing us to capture both inter-country and inter-temporal variation. Moreover, in order to account for the possible asymmetries and other types of nonlinearities between oil revenue and macroeconomic variables, we shall use two different transformations of oil revenue data, each one suggesting a different channel through which oil prices may affect industrial production levels. The paper is organized in four sections. Section 2 discusses the data and methodology. Section 3 presents results. Section 4 concludes.

2. Data and methodology

In this section we investigate the asymmetric effects of positive and negative shocks of oil revenue changes on economic activities for 13 oil-exporting countries (Algeria, Colombia, Ecuador, Indonesia, Iran, Kuwait, Libya, Mexico, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela) using annual data over the period 1965–2004.

Following the work of Levine and Renelt (1992), which searched for a set of robust variables to model growth and the theoretical contributions to the new growth theory literature following Romer (1990), a degree of convergence on the most appropriate empirical specification for modeling growth has occurred.[2] Most models include as explanatory variables: investment, population growth, initial per capita GDP, and initial human capital. We include these, together with proxies of oil revenue shocks. Oil shocks are included because our samples include oil-exporting countries and the empirical literature demonstrates clearly that terms of trade shocks have a significant impact on growth.[3] So, the equation is specified as follows:

$$\begin{aligned}\Delta \ln y_{it} &= \alpha\Delta \ln y_{i,t-1} + \beta_1 \ln GDPC_{i,73} + \beta_2 SCH_{i,73} \\ &\quad + \beta_3\Delta \ln POP_{it} + \beta_4\left(\frac{INV}{GDP}\right) + \sum_{j=0}^{k}\gamma_j OILSHOCK^{+}_{i,t-j} \\ &\quad + \sum_{j=1}^{k}\delta_j OILSHOCK^{-}_{i,t-j} + \Delta\varepsilon_{it}, \qquad (1)\end{aligned}$$

where y_{it} is the real industrial value added (based on constant local currency); $GDPC_{i,73}$ the initial GDP per capita at 1973 (based on constant local currency); $SCH_{i,73}$ the level of secondary school enrollment at 1973; POP_{it} the population; $(INV/GDP)_{it}$ the ratio of gross domestic investment to GDP; $OILSHOCK^{+}_{it}$ the proxy of positive oil revenues shock; $OILSHOCK^{-}_{it}$ the proxy of negative oil revenues shock; ε_{it} the disturbance term; ln the natural logarithm; and Δ is a difference operator.

Since industrial sector roughly corresponds to output in the traded goods sector and is most closely related to what are traditionally thought of business cycle shocks, we use real industrial value added (based on constant local currency) as a reasonable proxy for measuring output in the traded goods sector.[4] It comprises value added in mining, manufacturing, construction, electricity, water, and gas. We define oil revenues ($oilrev_{it}$) in real terms, taking the ratio of nominal oil revenues in US dollars to the US Producer Price Index. Oil revenue shocks are constructed based on annual changes of the logarithm of real oil revenue ($\Delta\, ln\, oilrev_{it}$). The data are obtained from World Development Indicators (WDI) and OPEC Bulletins.

If we reject the null hypothesis, $H_0: \delta_j = \gamma_j$ for $j = 1, \ldots, k$, effects are asymmetric. Moreover, if δ or γ does not equal zero, then large changes in the oil revenue have significant effects on output growth.

Eq. (1) has an obvious intuitive appeal in that it models growth in a dynamic context and permits us to track the short-run effects of oil shocks. However, including lag induces a correlation between the error term and the lagged dependent variable. To provide consistent estimates, an instrumental variable procedure based on the generalized method of moments (GMM) is adopted. Under the assumptions that (a) the error term, ε, is not serially correlated, and (b) the explanatory variables, X, are weakly exogenous (i.e., the explanatory variables are assumed to be uncorrelated with future realizations of the error term),

[2] For a review of evidence, see Temple (1999).

[3] See for example Bevan et al. (1993).

[4] It might also be argued that, in general, the use of GDP data for measuring business cycle activity in a developing country context can be problematic. Oil and agriculture, which account for a large share of aggregate output, is more influenced by external or weather conditions than cyclical factors. Poor measurement of services and informal sector activities may also impart significant biases.

Arellano and Bond (1991) propose the following moment conditions:

$$E[y_{i,t-s}(\varepsilon_{i,t}-\varepsilon_{i,t-1})]=0 \quad \text{for } s\geqslant 2, \quad t=3,\ldots,T, \tag{2}$$

$$E[X_{i,t-s}(\varepsilon_{i,t}-\varepsilon_{i,t-1})]=0 \quad \text{for } s\geqslant 2, \quad t=3,\ldots,T. \tag{3}$$

Efficient GMM estimation of this equation employs period-specific sets of instruments corresponding to lag values of the dependent and other weakly exogenous variables.

2.1. Measures of oil shocks

A number of different measures of oil price shocks have been suggested in the literature. Hamilton (1983) uses the log-difference of the nominal price of oil, Mork (1989) distinguishes between positive and negative log-differences of the relative oil price, and Lee et al. (1995) propose an oil shock variable based on the ratio of oil shocks to their conditional volatility. Hamilton (1996) advocates "net oil price increase", defined as the percentage increase of oil price over the previous year's maximum if it is positive and zero otherwise, as the measure of oil price shocks. In this study, we use two different proxies of oil revenue shocks allowing for the possible asymmetric effects of oil revenue changes. The constructed proxies of negative oil revenue shocks ($OILSHOCK^-$) are: oil revenue decrease ($\Delta oilrev^-$), and scaled oil revenue decrease (SOD). Indeed two different measures of negative oil revenue shocks ($OILSHOCK^-$) for a typical oil-exporting country corresponding to those suggested in the literature are defined as follows:

$$\Delta \ln oilrev_{it}^- = -\min(0, \Delta \ln oilrev_{it}),$$

$$SOD_{it} = -\min\left(0, \hat{e}_{it} \Big/ \sqrt{\hat{h}_{it}}\right),$$

where

$$\Delta \ln oilrev_{it} = \alpha_0 + \sum_{j=1}^{k} \alpha_j \Delta \ln oilrev_{i,t-j} + e_{it},$$

$$e_{it}|I_{i,t-1} \sim N(0, h_{it}),$$

$$h_{it} = \gamma_0 + \gamma_1 e_{i,t-1}^2 + \gamma_2 h_{i,t-1}.$$

The following counterparts are used as the proxies of positive oil revenue shocks ($OILSHOCK^+$):

$$\Delta \ln oilrev_{it}^+ = \max(0, \Delta \ln oilrev_{it}),$$

$$SOI_{it} = \max\left(0, \hat{e}_{it} \Big/ \sqrt{\hat{h}_{it}}\right),$$

where SOI stand for scaled oil revenue increase.

3. Emprical results

Two specifications of the dynamic panel model, corresponding to the two proxies of oil shocks, were estimated using the econometric methodology presented above. Table 1 reports GMM estimates of these specifications. The dependent variable is industrial value added growth. Firstly, the results of estimation confirm the joint significance of the engaged coefficients apart from specifications used in Table 1. This is confirmed by means of test F of the null hypothesis that all coefficients except the constant are zero. On the other hand, the Sargan test confirms for the two specifications no correlation between the used instruments and the residuals. The test for autocorrelation also confirms no second-order correlation for the two specifications.

In specification (1), the proxies of oil revenue decrease ($\Delta oilrev^-$) and oil revenue increase ($\Delta oilrev^+$) are included in the regression as the measures of negative and positive oil shocks, respectively. We have also included 1-year lags in both specifications to avoid the dynamic misspecifications. Moreover, lags pick up the impact of oil shocks in subsequent years. In the first specification, although positive changes of real oil revenue have a contemporaneous positive effect (0.38) on output growth, the impact effect is trivial in magnitude and just marginally significant at the 10% level. Moreover, a negative and significant effect is obtained for the coefficient associated to lagged positive shock (−0.41), so that an oil boom has a transitory effect on real output and this effect dies out or may be reversed after 1 year. Indeed the arrangement of signs on the positive oil shocks ($\Delta \ln oilrev_{it}^+$ and $\Delta \ln oilrev_{i,t-1}^+$): positive in year 1 and negative in year 2, suggest evidence of an inverse U curve effect of oil boom on output growth. An oil boom with appreciation of the real exchange rate possibly increases consumption imports and

Table 1
Estimation of model (dependent variable: output growth)

Regressors	Specification (1)	Specification (2)
$\Delta \ln y_{i,t-1}$	0.28***(4.67)	0.34***(4.98)
$\ln GDPC_{i,73}$	−0.07***(3.41)	−0.06**(−2.19)
$SCH_{i,73}$	0.01*(1.69)	0.09(1.13)
$\Delta \ln POP_{it}$	0.82**(2.23)	0.64**(2.44)
$(INV/GDP)_{it}$	0.17**(2.14)	0.14**(2.28)
$\Delta \ln oilrev_{it}^-$	−0.63***(4.98)	–
$\Delta \ln oilrev_{it}^+$	0.38*(1.73)	–
$\Delta \ln oilrev_{i,t-1}^-$	−0.06*(1.69)	–
$\Delta \ln oilrev_{i,t-1}^+$	−0.41*(1.71)	–
SOD_{it}	–	−8.45***(7.34)
SOI_{it}	–	4.67**(2.09)
$SOD_{i,t-1}$	–	−2.77*(1.74)
$SOI_{i,t-1}$	–	−1.59(1.40)
$H_0: \delta_1=\gamma_1, \delta_2=\gamma_2$	12.34***	15.23***
R^2	69%	64%
F-statistics	7.56***	11.56***
Sargen test	26.87	22.08
Serial correlation test	0.89	1.06

Notes: Values in parentheses are t-values. ***, **, * indicate the estimate is significant at 1%, 5% and 10%; respectively. For Sargan test, the null hypothesis is that the instruments used are not correlated with the residuals. For the test for autocorrelation, the null hypothesis is that the errors in the first-difference regression exhibit no second-order serial correlation.

thus deteriorates competitiveness, retarding non-oil export and output growth in the following years. The other past lags were found to be insignificant.

The coefficient associated with $\Delta oilrev_{it}^{-}$ is negative and significant at high level so that negative oil shock has a strongly deterrent effect on output growth. Moreover, the coefficient for the lag of negative oil revenue shock is also significant at the 10% significance level, implying that negative oil shocks tend to persist for a longer period and are more important in magnitude than the positive ones. From specification (1), we can say that positive oil revenue shocks do not matter that much for output growth, but negative shocks do. We reject the null hypothesis of symmetry at all significance levels. In other words, there is strong evidence for an asymmetric effect.

In specification (2) or scaled specification we use the proxies of *SOD* and *SOI* to capture the nonlinear or asymmetric effects of negative and positive oil shocks. The scaled specifications were developed by Lee et al. (1995) and Hamilton (1996), respectively, to account for the fact that oil price increases after a long period of price stability have more dramatic macroeconomic consequences than those that are merely corrections to greater oil price decreases during the previous year.

In specification (2), positive oil revenue shocks (*SOI*) have a contemporaneous positive and significant effect on output growth. But, the coefficient for the lagged positive shock in this specification is not significant. The negative oil shock effects (*SOD*) are negative and significant in both years, with a contemporaneous impact effect of -8.45 and an additional effect of -2.77 in the subsequent year. The effects of large negative oil revenue shocks are over twice as large as effects from positive shocks. The null hypothesis of symmetry is rejected at the 1% significance level. Again, there is strong evidence of an asymmetric effect.

All of the (control) independent variables have the predicted sign. Thus, a low initial GDP is associated with faster growth in output so that the negative convergence effect is confirmed at various levels of significance. Moreover, as expected, investment ratio has a positive and significant impact on economic growth. Faster population growth is associated with faster output growth (and possibly with slower output per capita). Although the initial level of schooling (as a measure of educational attainment which controls for the level of human capital in the country) has a positive effect on output growth, the coefficient is not significant in the second specification.

4. Conclusions

This paper investigates the asymmetric relationship between oil revenue shocks and industrial production in 13 oil-exporting countries using a dynamic panel framework and two different measures of oil shocks. We conclude that negative oil revenue shocks dominate positive shocks. While oil bust seriously hamper economic growth with high persistence, oil booms play a limited role in stimulating economic growth. Indeed, on the downside, output contracts; on the upside, growth increases little or may even decrease, which is taken as a symptom of the Dutch disease.

The rich-resource countries suffering from a weak and undiversified economic base without stabilizing mechanisms in order to cushion shocks would be so vulnerable to boom–bust cycles, incurring costly instability. There is therefore a strong case for making cautious revenue projections, for holding larger than normal reserves, for minimizing outstanding public debt and for using hedging techniques in order to cushion shocks. Policymakers must deploy institutional mechanisms to manage oil booms and busts through expenditure restraint, self-insurance, and diversification of the real sector. To achieve sustainable growth in the future, these countries must take policy measures that substantially enlarge and diversify their economic base. Moreover, to insulate the economy from oil revenue volatility requires de-linking fiscal expenditures from current revenue. So, an "oil revenue fund" (or, more generally, a "natural resource fund") is one such institutional mechanism for managing the oil revenues.

Another way that policy makers could decrease the degree of the asymmetry would be to lower borrowing constraints so that agents could better smooth consumption and so not cut spending as drastically following a negative price shock. Perhaps developing deeper capital markets is one solution.

References

Arellano, M., Bond, S., 1991. Some test of specification for panel data: Monte Carlo evidence and an application to employment equations. Review of Economic Studies 58, 277–292.

Bevan, D., Collier, P., Gunning, J., 1993. Trade stocks in developing countries. European Economic Review 37, 557–565.

Cunado, J., De Gracia, F.P., 2003. Do oil price shocks matter? Evidence for some European countries. Energy Economics 25, 137–154.

Davis, S., Haltiwanger, J., 2001. Sectoral job creation and destruction response to oil price changes. Journal of Monetary Economics 48, 465–512.

Devlin, J., Lewin, M., 2004. Managing oil booms and busts in developing countries, Draft Chapter for: Managing Volatility and Crises, A Practitioner's Guide.

Hamilton, J., 1983. Oil and the macroeconomy since World War II. Journal of Political Economy 91 (2), 228–248.

Hamilton, J., 1988. A neoclassical model of unemployment and the business cycle. The Journal of Political Economy 96 (3), 593–617.

Hamilton, J., 1996. This is what happened to the oil price–macroeconomy relationship? Journal of Monetary Economics 38, 215–220.

Hamilton, J., 2000. What is an oil shock? Journal of Econometrics 113, 363–398.

Hausmann, R., Rigobon, R., 2003. An alternative explanation of the resource curse. In: Jeffrey, D., Rolando, O., Annalisa, F. (Eds.), Fiscal Policy Formulation and Implementation in Oil-Producing Countries. International Monetary Fund, Washington, DC.

Huang, B.N., Hwang, M.J., Peng, H.P., 2005. The asymmetry of the impact of oil price shocks on economic activities: an application of the multivariate threshold model. Energy Economics 27, 455–476.

Lee, K., Ni, S., Ratti, R., 1995. Oil shocks and the macroeconomy: the role of price variability. The Energy Journal 16 (4), 39–56.

Levine, R., Renelt, D., 1992. A sensitivity of cross country growth regressions. American Economic Review 82, 946–963.

Mork, K.A., 1989. Oil and the macroeconomy: when prices go up and down: an extension of Hamilton's results. Journal of Political Economy 97 (3), 740–744.

Mork, K., Olsen, O., Mysen, T., 1994. Macroeconomic responses to oil price increases and decreases in seven OECD countries. Energy Journal 15 (4), 19–35.

Mory, J.F., 1993. Oil prices and economic activity: Is the relationship symmetric? Energy Journal 14 (4), 151–161.

Romer, D., 1990. Endogenous technological change. Journal of Political Economy 98, 71–102.

Sadorsky, P., 1999. Oil price shocks and stock market activity. Energy Economics 21, 449–469.

Temple, J., 1999. The new growth evidence. Journal of Economic Literature 37, 112–156.