1992

Effects of oil on macroeconomic activity in developing countries: a cointegration analysis

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DEPARTMENT OF ECONOMICS

EFFECTS OF OIL ON MACROECONOMIC ACTIVITY IN DEVELOPING COUNTRIES:

A COINTEGRATION ANALYSIS

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Working Paper 92-4

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ISSN 1035 4581
ISBN 0 86418 219 8

ABSTRACT

The paper reports the results of a simple cointegration analysis applied to bivariate causality models and quarterly data on crude oil consumption, GDP and inflation in Thailand to investigate the long-term relationships in the sense of Granger between oil and these two major macroeconomic aggregates. For the period 1966:1 to 1991:1, the empirical evidence indicates that oil consumption, output growth and inflation rate as formulated in our models are not random walks. In addition, oil consumption is significantly cointegrated with economic growth and, unfortunately, inflation rate.

The research is supported in part by an Economics Department Research Grant in 1992. Associate Professor Keith Maclaren, Department of Econometrics, Monash University, was kind enough to provide some data for the project.

1. INTRODUCTION

In terms of an integrated social accounting system as adopted in recent years by the OECD or in terms of a production technology in the economic theory of the firms, energy in general and oil in particular plays an important role as an input. In spite of this importance, recent energy studies either (a) neglect the benefits of oil on output growth and concentrate entirely on the environmental effects or costs of oil consumption (Sathaye and Ketoff, 1991), or (b) take output growth as an exogenous variable determined outside the economic system (Brinner, Shelby, Yanchar and Cristofaro, 1991). Viewed in this context, one side of the benefit-cost analysis of oil (or energy) consumption is seriously lacking substantive evidence. As a result, our knowledge of the relationship between oil (or other natural resources) and economic growth in developed economies and especially in developing countries and based on more recent and improved data (Dunkerley, 1982, Pindyck, 1980) still needs much improvement.

The purpose of our paper is threefold. First, as a contribution to macroeconomic analysis in general and to development economics in particular, we propose to investigate the long term relationship between oil and economic growth, and using as an example the case of Thailand. The case of Thailand is facilitated by the fact that it is a fast growing economy in Asia and, in addition, fairly long quarterly data for our variables of interest are readily available. The second purpose is methodological in nature in that the paper departs from conventional regression (Pindyck, 1980) or seemingly unrelated regression (Tran Van Hoa et al, 1983 and Tran Van Hoa, 1992a) models and makes use of a fairly novel theory of cointegration (Engle and Granger, 1987) to provide substantive evidence on this long term relationship. Finally, as a contribution to efficient management of the energy sector (Munasinghe, 1992) in Thailand, the possible negative effects of oil consumption on inflation are also investigated.

2. COINTEGRATION ANALYSIS IN BIVARIATE CAUSALITY MODELS

The early concept of causality in the sense of Wiener was proposed by Granger (1969) to investigate possible causation between economic variables. The concept is based on the cross spectrum decomposition and, using current and lagged correlations among these variables, deals specifically with short-run fluctuations. Empirical applications of this Granger causality test have been extensive in the past two decades or so and involve many important areas of economics, such as money and income (Sims, 1972), wage and price inflation (Fels and Tran Van Hoa, 1981), and energy and GNP (Abosedra and Baghestani, 1989), to name a few.

The theory of cointegration (Engel and Granger, 1987) also deals with causation between economic variables, but is focussed particularly on long-term relationships. The basic idea of the theory is that "causal or correlated" economic series may wander in the short run, but they will not drift apart in the long run or in the equilibrium. Thus, in the short run, the equilibrium error may not be zero, but in the long run, systematic differences between the causal or cointegrated variables should disappear.

The empirical tests of both the Granger-Wiener causality and the Engel-Granger cointegration theories assume that the variables in the models must be statistically stationary, and the reliability of their results depends not only on the correct information set used but also crucially on the usually unknown lag structure of these variables. In the case of the cointegration theory, the appropriate tests include cointegration regression analysis, Dickey-Fuller and augmented Dickey-Fuller regression procedures, and restricted and unrestricted vector autoregressive methods (Engle and Granger, 1987). More recent developments of the cointegration theory include the maximum likelihood approach of Johansen (1991) within the unified framework of vector autoregressive and error correction models.

Below, we depart significantly from these studies and make use of a simple procedure (Pindyck and Rubinfeld, 1991) to test for unit roots or random walks among our variables of interest. We then apply the convenient cointegration regression method (Engle and Granger, 1987) to investigate the long-run relationships between oil consumption and output growth, and between oil consumption and inflation.

Thus, in our study, the test of unit roots for a variable say Y consists simply of estimating the unrestricted regression equation (also known as the reduced form error correction model)

$$Yt\text{-}Yt\text{-}1 = a1 + a2Tt + (a3\text{-}1)Yt\text{-}1 + a4DYt\text{-}1 + ut \quad (1)$$

and the restricted regression equation (with $a2=0$ and $a3=1$)

$$Yt\text{-}Yt\text{-}1 = a1 + a4DYt\text{-}1 + ut \quad (2)$$

In (1) and (2), T is a time trend, DYt-1 = Yt-1-Yt-2, the a's are the parameters to be estimated, and the u's the error terms.

Then, using the resulting OLS estimated residual sums of squares from (1) and (2), an F statistic is computed and compared to the critical values of the distribution tabulated by Dickey and Fuller (1981) or any other subsequently tabulated critical values. The hypothesis of random walk for Y is rejected if the estimated F value is greater than the critical F value tabulated for an appropriate significance level.

In the case of bivariate (Y and X for example) models in which both Y and X are stationary or not random walks, the test of cointegration between Y and X is simply carried out by estimating by OLS the cointegrating regression equation (Engle and Granger, 1987)

$$Yt = b1 + b2Xt + et \qquad (3)$$

and by testing whether the residuals (i.e., the estimated e) from this equation are stationary.

If Y and X are not cointegrated, then any linear combination of Y and X will not be stationary. In this case, the residuals e will be nonstationary. However, for a series e to be a random walk, E(et-et-1) = 0, and accordingly, the Durbin-Watson (DW) statistic must be zero. The test of cointegration between Y and X is therefore the test whether DW = 0 (Engle and Granger, 1987).

3. THE DATA AND SUBSTANTIVE RESULTS

In our study below, we formulate two bivariate causality models for two pairs of economic variables (a) oil consumption (OIL) and output growth (GDP), and (b) oil consumption and inflation rate (INFL). The raw data used to calculate OIL, GDP and INFL are quarterly data in the form of the levels and are available for the period 1966:1 to 1991:1. Each variable thus has a sampling size of 101. These data are obtained either from the International Financial Statistics (IFS) databanks of the International Monetary Fund (in the case of OIL and INFL) or from the estimates of the Economic Modelling and Forecasting Group, Chulalongkorn University, Bangkok, Thailand (in the case of GDP). To approximate inflation, we use the consumer price index. The raw data for OIL are crude oil consumption.

Making use of the general economic modelling approach we proposed earlier (Tran Van Hoa, 1991 and 1992b), the variables in each of these bivariate causality models are expressed in terms of their percentage rates of quarter-to-quarter change. In this case, the models may be interpreted as econometric models of the Johansen-class and are fundamental in computable general equilibrium macroeconomic analysis. The parameters of these models are the elasticities that affect the causation in a linear manner.

The results of the tests of unit roots or random walks for the three economic variables OIL, GDP and INFL as defined above are given in Table 1. From the results given in this table, we note that, at the 5 per cent or even 1 per cent significance level, all estimated F statistics are greater than the tabulated critical F values. We can thus reject the hypothesis of random walks for each of the three variables under study. These findings are interesting in that, contrary to what Nelson and Plosser (1982) and Abosedra and Baghestani (1989) have observed, our major economic variables as defined for the models are in fact not random walks. The importance of the association between the concept of growth (that is, the rate of change) used in economic models and the concept of stationarity in econometrics may be worth more formal investigations.

The results of the tests of cointegration between oil consumption (OIL) and economic growth (GDP), and between oil consumption (OIL) and inflation rate (INFL) are given in Table 2. From the results given in this table, we note that, at the 5 per cent or even 1 per cent significance level, all DW statistics are greater than the tabulated critical DW values. We can thus reject the hypothesis of no cointegration between these two pairs of variables.

The economic implications of our tests of unit roots and cointegration based on the energy and economic data from Thailand for the period under study (that is, from 1966:1 to 1991:1) are interesting and need summarising. First, oil, inflation and more importantly output growth are not random walks, thus refuting statistical evidence in previous energy and macroeconomic studies. Secondly, there exists a significant long-term relationship between oil consumption and economic growth. Unfortunately for energy management and economic development, there also exists a significant long-term relationship between oil consumption and inflation rate. It is clear from our findings that a proper economic energy policy must be balanced between these two important measurements of welfare. While a construction of a composite index such as the misery index, which is based on a weighting of growth and inflation over the period under study, is a more reasonable measurement of welfare, it is beyond the scope of the present paper.

4. CONCLUSIONS

In the paper, we have proposed two simple bivariate causality models incorporating the concept of growth (that is, the rate of change) in major economic variables and have made use of the cointegration analysis to investigate the long-term relationships between oil consumption, output growth, and inflation in Thailand. The study is simple in its bivariate form and in its methodology but it addresses (and provides evidence for) the important question of economic benefits and costs in energy consumption in both the industrially advanced economies and in the developing countries.

Our study argues that the concept of growth is natural in economic modelling studies, and our empirical evidence indicates that the concept is natural to applications of many recent important statistical methods that depend on the property of stationarity in economic series.

While we have found statistical evidence to support the thesis that, in Thailand, oil consumption in particular is a co-movement of economic growth, oil consumption is also seen to be associated with inflation. Since economic growth reflects the standard of living or measures the welfare of a country, it is the main preoccupation of economics. We have therefore provided statistical evidence to support the view that, in Thailand and for the period under study, oil consumption drives economic growth and development, and economic growth is attenuated by the peril of increasing prices.

Whilst our findings are limited by the small size of the models used, they nevertheless provide a useful perspective on the economic benefits and costs of energy usage. A more complete study of the benefits and costs of oil usage in particular and energy consumption in general in Thailand or in any developed and developing economies can be achieved by means of economy-wide econometric models incorporating many sectors and many economic activities. This is however beyond the scope of the present paper.

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TABLE 1

Dickey-Fuller Tests for Unit Roots for Oil, GDP and Inflation Thailand 1966:1 to 1991:1

	a1	a2	a3-1	a4	F-ratio
OIL					
Unrestricted	17.70	-0.14	-1.26	-0.01	
	(2.7)	(1.4)	(10.2)	(0.3)	
Restricted	-0.24			-0.26	51.73
	(0.1)			(5.1)	
GDP					
Unrestricted	4.07	0.01	-1.25	0.17	
	(2.1)	(0.2)	(12.4)	(4.0)	
Restricted	-0.05			0.01	
	(0.04)			(0.2)	76.40
INFLATION					
Unrestricted	0.76	-0.14	-0.45	-0.08	
	(1.7)	(0.2)	(4.9)	(1.5)	
Restricted	-0.03			-0.15	
	(0.2)			(2.4)	12.30

Notes: Refer to Equations (1) and (2) in the text. t-values in brackets. The estimated F-ratios have 90 and 2 degrees of freedom. For a sample size of 100, the critical F values are respectively 6.49 and 8.73 at the 5 per cent and 1 per cent significance levels.

TABLE 2

Engel-Granger Cointegration Tests for Oil and GDP and Inflation Thailand: 1966;1 to 1991:1

	b1	b2	b3	b4	b5	DW
GDP on OIL						
with dummies	8.80 (7.7)	-0.01 (0.3)	0.74 (0.5)	-14.92 (9.2)	-7.00 (4.3)	2.16
without dummies	3.46 (3.9)	0.02 (0.5)				2.25
INFLATION on OIL						
with dummies	1.20 (2.9)	0.01 (1.9)	0.02 (0.03)	0.79 (1.4)	0.13 (0.2)	1.01
without dummies	1.44 (6.8)	0.01 (1.8)				1.04

Notes: Refer to Equation (3) in the text. Dummies denote the three seasonal (0,1) dummy variables with associated parameters b3, b4 and b5. The critical DW value for testing DW=0 with a sample size of 100 is respectively 0.386 and 0.511 at the 5 per cent and 1 per cent significance levels. t-values in brackets. Similar results for the DW values are obtained when OIL is regressed on GDP and INFLATION.

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