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Saudi Arabia's evolving growth mechanism: patterns derived from cointegration analysis

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AFTER MORE THAN 20 years of relatively high oil revenue, Saudi Arabia and other economies in the Middle East remain overwhelmingly dominated by revenue from this source. In addition, while considerable industrial diversification into non-oil sectors has been achieved, conventional analysis has often suggested that it is not apparent that the non-oil sectors can sustain growth and development without a steady infusion of government expenditure (Looney, 1990, 1992, 1993, 1995).

On a more fundamental level, it might be argued that, beginning in the mid-1980s, the decline in oil revenue, together with its increased instability, affected the path of development. For example, Ghamdi (Ghamdi, 1992) presents strong evidence that Saudi government consumption and investment expenditure experienced instability that was positively related to the instability of total revenue. However, the effect was more marked for development expenditure, supporting the view that revenue instability did have an impact on the country's goals of development.

While not questioning this assertion, the research below uses a relatively new analytical technique — cointegration analysis (Dolado, Jenkinson *et al*, 1990) — to focus on a somewhat different issue. Since the late 1970s, one of the country's main economic objectives has been to de-link its economy from the uncertainty created by fluctuating oil prices. Have the country's key macroeconomic components evolved to the point whereby they are no longer dominated by movements in oil prices? If so, what areas have achieved the greatest progress and how does the current macro-mechanism differ from that of the past?

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Saudi Arabian growth patterns

Looking at trends over time, it is apparent that changes have occurred in several key macroeconomic relationships during the 1980s and into the 1990s. With regard to investment and growth of the non-oil economy:

— government investment, as a share of non-oil GDP, has declined fairly dramatically since 1979, a pattern that also appears associated with the government's fiscal deficits;

— on the other hand, private investment has retained a fairly stable share of non-oil GDP, although experiencing a slight downward trend;

— the fiscal deficit share of non-oil GDP peaked in 1987 and, after that date, stabilised somewhat with regard to its share of non-oil GDP.

The relationship between consumption and the non-oil economy has also undergone several notable changes:

— as with its investment, the public sector's consumption has declined with regard to its share of non-oil GDP;

— also as with investment, government consumption has shown a slight tendency in recent years to increase its share of non-oil GDP;

— private consumption has also experienced a gradual decline with regard to non-oil GDP. This expenditure category appears to be stabilising at slightly over 60 per cent of non-oil GDP.

The pattern associated with public and private expenditure and non-oil GDP has also undergone a distinctive change:

— as with consumption and investment, both private and public sector expenditure have fallen with regard to the country's non-oil GDP;

— the decline in private sector expenditure has been more stable, with public sector expenditure experiencing much greater fluctuation;

— the decline in public sector expenditure (as indicated by its trend) has also been somewhat sharper than in the case of private expenditure;

— GDP associated with the oil sector has shown the greatest fluctuation of all, falling below non-oil GDP for the first time in 1983. Since that date, oil GDP seems to be stabilising at somewhere between 40–60 per cent of non-oil GDP.

While these patterns are valuable in describing certain changes that are taking place in Saudi Arabia, they are of less use in identifying whether the country's economic growth mechanism has undergone a fundamental alteration. Specifically, have the links between government expenditure, the private sector and the non-oil economy changed in a way that alters the link between oil prices and the non-oil economy? Unfortunately, many of the shorter-run patterns noted above may not be indicative of changing, longer-run equilibrium relationships in the Kingdom. Specifically, fluctuations in oil prices may cause such short-run movement in many of the key macro series, masking more fundamental longer-run patterns.

Long-run equilibrium patterns

Fortunately, over the past few years, important advances have been made in cointegration techniques to estimate long-run relationships (Cuthbertson, Hall *et al*, 1992). The basic idea of cointegration is that two or more variables may be regarded as defining a long-run relationship if they move closely together in the long run, even though they may drift apart in the short run. This long-run relationship is referred to as a cointegrating vector. Because there is a long-run relationship between the variables, a regression containing all the variables of a cointegrating vector will have a stationary error term, even if none of the variables taken alone is stationary.

It can be shown (Stock, 1987) that, in the case of a cointegrated non-stationary series, ordinary least squares (OLS) estimates of the cointegrating vector are not only consistent, but converge on their true parameter values much faster than in the stationary case. This proposition does not require the assumption that the regressors be uncorrelated with the error term. In fact, the estimates will remain consistent if any of the variables in the cointegrating vector is used as the dependent variable.

More generally, most of the classical assumptions underlying the general linear model are not required in order for OLS or maximum likelihood estimates of the cointegrating vector to have desirable properties. This is particularly important, because errors in variables and simultaneity — both of which would normally be cause for concern in the data set used here — will not affect the desirable properties of the estimates. Moreover, because the cointegration approach focuses on long-run relationships, problems associated with variations in infrastructure utilisation and with autocorrelation do not arise.

A popular approach to cointegration has been to use unit-root tests, such as the Dickey-Fuller (DF) or the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981), to determine the degree of integration of the relevant variables. Since we are primarily interested in finding longer-run relationships between macro variables, the DF and ADF tests are simply undertaken to ensure that the cointegration analysis is undertaken on sets of variables that individually are not stationary. More

Table 1
Saudi Arabia: unit root tests for stationarity — levels, 1960 1994

Statistic	Without trend		With trend	
Real oil price *(non-oil GDP deflator)*				
DF	–2.6190	(–2.9558)	–2.6000	(–3.5562)
ADF(1)	–2.1160	(–2.9591)	–2.0312	(–3.5615)
Dubai spot price *($/b)*				
DF	–1.1577	(–2.9499)	–1.0229	(–3.5468)
ADF(1)	–1.1819	(–2.9528)	–0.9518	(–3.5514)
Government investment				
DF	–3.0878	(–2.9558)	–2.8741	(–3.5562)
ADF(1)	–2.6307	(–2.9591)	–2.0125	(–3.5615)
Government consumption				
DF	–2.4378	(–2.9558)	–1.0050	(–3.5562)
ADF(1)	–2.6975	(–2.9591)	–0.8399	(–3.5615)
Private consumption				
DF	–0.7602	(–2.9558)	–0.8834	(–3.5562)
ADF(1)	–0.8417	(–2.9591)	–1.6920	(–3.5615)
Private investment				
DF	–2.0565	(–2.9558)	–0.7423	(–3.5562)
ADF(1)	–1.5473	(–2.9591)	–1.1437	(–3.5615)
Non-oil GDP				
DF	–1.6090	(–2.9558)	–0.6449	(–3.5562)
ADF(1)	–1.4278	(–2.9591)	–0.3585	(–3.5615)
Defence expenditure				
DF	–2.4096	(–2.9558)	–1.0920	(–3.5562)
ADF(1)	–1.9773	(–2.9591)	–1.1835	(–3.5615)
Non-oil price index				
DF	–0.3430	(–2.9558)	–0.9565	(–3.5562)
ADF(1)	–1.1698	(–2.9591)	–2.5678	(–3.5615)
Non–defence expenditure				
DF	–1.6119	(–2.9558)	–1.1216	(–3.5562)
ADF(1)	–1.8050	(–2.9591)	–0.9908	(–3.5615)
GDP				
DF	–2.8598	(–2.9499)	–0.1869	(–3.5468)
ADF(1)	–2.1505	(–2.9528)	–0.7261	(–3.5514)

Notes: All variables in logarithmic form.
DF = Dickey-Fuller test.
ADF = Augmented Dickey-Fuller test.
95% critical values (MacKinnon, 1991) in brackets.
Computations were performed using Microfit 3.0 (Pesaran and Pesaran, 1991).

precisely, the ADF test consists of running a regression of the first difference of the series against the series lagged once, lagged difference terms and, optionally, a constant and a time trend. With two lagged difference terms, the regression is:

$$\Delta y_t = \beta_1 y_{t-1} + \beta_2 \Delta y_{t-1} + \beta_3 \Delta y_{t-2} + \beta_4 + \beta_5 t \quad (1)$$

Several decisions are involved in running the ADF test regression. One is whether to include a constant term in the regression. Another is whether to include a linear time trend. The actual test for a unit root is a test on the coefficient of y_{t-1} in the regression. If the coefficient is significantly different from zero, then the hypothesis that y contains a unit root is rejected and the hypothesis that y is stationary is not rejected. In this regard, a large negative t-statistic rejects the hypothesis of a unit root and suggests that the series is stationary. Under the null hypothesis of a unit root, the reported t-statistic does not have the standard t distribution and one must consult special tables for critical values.

The results for both the case with and that without a time trend for the DF and ADF tests (**tables 1** and **2**) suggest (based on the critical values in brackets) that, generally, the levels of each variable are non-stationary and thus suitable for cointegration analysis.

As noted, a group of non-stationary time-series is cointegrated if there is a linear combination of them that is stationary; that is, the combination does not have a stochastic trend. The linear combination is called the cointegrating equation and its normal interpretation is a long-run equilibrium relationship.

Because we are interested in identifying structural changes that may be taking place in Saudi Arabia, cointegration tests were conducted in a two-step fashion. First cointegration tests were run on oil prices and a series of macro variables over the (1960–94) period for which we have consistent data. Then the same tests were run for the shorter 1960–82 period. Next, it was assumed that any longer-run equilibria found in the 1960–94 period, and not present in the 1960–82 period, effectively incorporated the shift in patterns initiated by the oil price declines beginning in the early 1980s. Similarly, equilibria found in the 1960–82 period, but not present in the longer 1960–94 period, were assumed to be destroyed by these same oil price declines.

In testing for cointegration between oil prices and various macroeconomic variables, we used the procedures of Johansen and Juselius (1990) and began with the vector autoregression (VAR):

$$X_t = \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \Pi_k X_{t-k} + \mu + \varepsilon_t \; (t = 1, \ldots, T) \quad (2)$$

where X_t is a (p x 1) vector, $\varepsilon_1 \ldots \varepsilon_T$ are drawn from a p-dimensional i.i.d. normal distribution with covariance Λ, and $X_{-k+1}, \ldots X_0$ are fixed. Equation (2) can be reparameterised as:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \ldots \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \varepsilon_t \quad (3)$$

Table 2
Saudi Arabia: unit root tests for stationarity — first differences, 1960 1994

Statistic	Without trend		With trend	
Real oil price *(non-oil GDP deflator)*				
DF	–6.9774	(–2.9591)	–6.9131	(–3.5615)
ADF(1)	–4.5961	(–2.9627)	–4.5742	(–3.5671)
Dubai spot price *($/b)*				
DF	–5.6781	(–2.9528)	–5.6969	(–3.5514)
ADF(1)	–3.4072	(–2.9558)	–3.4737	(–3.5562)
Government investment				
DF	–7.3588	(–2.9591)	–7.7174	(–3.5615)
ADF(1)	–4.0459	(–2.9627)	–4.2881	(–3.5671)
Government consumption				
DF	–5.7144	(–2.9591)	–6.7043	(–3.5615)
ADF(1)	–3.6983	(–2.9627)	–4.8260	(–3.5671)
Private consumption				
DF	–3.6840	(–2.9591)	–3.6662	(–3.5615)
ADF(1)	–2.5346	(–2.9627)	–2.5426	(–3.5671)
Private investment				
DF	–5.3091	(–2.9591)	–5.2957	(–3.5615)
ADF(1)	–3.1342	(–2.9627)	–3.1639	(–3.5671)
Non-oil GDP				
DF	–5.7936	(–2.9591)	–6.0436	(–3.5615)
ADF(1)	–3.0324	(–2.9627)	–3.3121	(–3.5671)
Defence expenditure				
DF	–4.9360	(–2.9591)	–4.8571	(–3.5615)
ADF(1)	–2.2621	(–2.9627)	–2.1424	(–3.5671)
Non-oil price index				
DF	–2.0284	(–2.9591)	–1.9911	(–3.5615)
ADF(1)	–2.3361	(–2.9627)	–2.3033	(–3.5671)
Non-defence expenditure				
DF	–5.7589	(–2.9591)	–6.0605	(–3.5615)
ADF(1)	–3.3633	(–2.9627)	–3.7449	(–3.5671)
GDP				
DF	–3.3201	(–2.9528)	–4.0038	(–3.5514)
ADF(1)	–2.1703	(–2.9558)	–2.8527	(–3.5562)

Notes: All variables in logarithmic form.
DF = Dickey-Fuller test.
ADF = Augmented Dickey-Fuller test.
95% critical values (MacKinnon, 1991) in brackets.
Computations were performed using Microfit 3.0 (Pesaran and Pesaran, 1991).

where:

$$\Gamma_I = -(I + \prod_1 + \ldots\ldots \prod_I) \; (i = 1, \ldots\ldots k-1),$$

and:

$$II = -(I - \prod_1 \ldots\ldots - \prod_k) \qquad (4)$$

The Johansen and Juselius procedure investigates whether the coefficient matrix $\prod$ contains information about long-run relationships among the variables of the system. If $0 < \text{rank}(\prod) = r < p$, then there are matrices α and β of dimension $(p \times r)$, such that $\prod = \alpha\beta'$, and there are r cointegrating relations among the elements of X_t. β is interpreted as a matrix of cointegrating vectors and provides the property that the elements in $\beta' X_t$ are stationary, even though X_t is non-stationary. α is a matrix of error correction parameters.

The first set of cointegration tests (**tables 3** and **4**) produced several interesting patterns. For the 1960–82 period (table 3), both government consumption and investment experienced a long-run equilibrium relationship with real oil prices. That is, despite short-run fluctuations in oil prices, a longer-run pattern was subsequently reestablished with government expenditure, no doubt after initial periods of inertia catching up with expanded revenue. Similarly, during this period, fluctuating oil prices may have broken their pattern with non-oil GDP from time to time. Yet, an equilibrium pattern was subsequently restored, with non-oil GDP catching up to (generally) rising oil prices.

Several of these patterns did not hold up for the period as a whole (table 4). However:

— perhaps because it was slower to adjust, it took the whole period for the infrastructure to establish a long-run equilibrium with oil prices. The same may be true for defence expenditure that is often quite capital-intensive;

— at the same time, however, the pattern between government investment and oil prices was broken, as was the link between non-oil GDP and oil prices;

— finally, several patterns were established over the whole period that were not discernible in the period up to 1982. These include the cointegration of both private consumption and investment with oil prices.

These results suggest that the factors responsible for maintaining non-oil GDP may have shifted over time. To test for this, a similar set of cointegration tests was performed with non-oil GDP and the main macro-variables. Again, two sets of

Table 3
Saudi Arabia: cointegration test for long-run equilibrium between real oil prices and macro variables, 1960–82

Eigenvalue	Likelihood ratio	5% critical value	1% critical value	Hypothesised no. of CEs
Government investment				
0.586	18.734	15.41	20.04	None *
0.051	1.065	3.76	6.65	At most 1
Government infrastructure				
0.411	10.614	15.41	20.04	None
0.000	0.011	3.76	6.65	At most 1
Government consumption				
0.553	16.262	15.41	20.04	None *
0.005	0.115	3.76	6.65	At most 1
Defence expenditure				
0.373	10.015	15.41	20.04	None
0.031	0.647	3.76	6.65	At most 1
Non-oil GDP				
0.555	19.788	15.41	20.04	None *
0.163	3.579	3.76	6.65	At most 1
Private investment				
0.441	11.704	15.41	20.04	None
0.003	0.060	3.76	6.65	At most 1
Private consumption				
0.366	9.165	15.41	20.04	None
0.001	0.033	3.76	6.65	At most 1
Non-oil deflator				
0.598	19.786	15.41	20.04	None *
0.073	1.524	3.76	6.65	At most 1

*Notes: * denotes rejection of the hypothesis at five per cent significance level.*
Test assumptions: linear deterministic trend in the data;
maximum lag in VAR model is one year.

Table 4
Saudi Arabia: cointegration test for long-run equilibrium between real oil prices and macro variables, 1960–94

Eigenvalue	Likelihood ratio	5% critical value	1% critical value	Hypothesised no. of CEs
Government investment				
0.264	13.304	15.41	20.04	None
0.140	4.388	3.76	6.65	At most 1
Government infrastructure				
0.356	16.918	15.41	20.04	None *
0.132	4.119	3.76	6.65	At most 1 *
Government consumption				
0.281	14.359	15.41	20.04	None
0.151	4.777	3.76	6.65	At most 1 *
Defence expenditure				
0.308	16.427	15.41	20.04	None *
0.179	5.734	3.76	6.65	At most 1 *
Non-oil GDP				
0.210	8.865	15.41	20.04	None
0.066	1.999	3.76	6.65	At most 1
Private investment				
0.444	19.675	15.41	20.04	None *
0.086	2.614	3.76	6.65	At most 1
Private consumption				
0.402	17.728	15.41	20.04	None *
0.910	2.777	3.76	6.65	At most 1
Non-oil deflator				
0.416	17.847	15.41	20.04	None *
0.073	2.210	3.76	6.65	At most 1

*Notes: * denotes rejection of the hypothesis at five per cent significance level.*
Test assumptions: linear deterministic trend in the data;
maximum lag in VAR model is two years.

Table 5
Saudi Arabia: cointegration test for long-run equilibrium between non-oil GDP and macro variables, 1960–82

Eigenvalue	Likelihood ratio	5% critical value	1% critical value	Hypothesised no. of CEs
Total government investment				
0.375	9.885	15.41	20.04	None
0.000	0.007	3.76	6.65	At most 1
Government infrastructure investment				
0.370	9.625	15.41	20.04	None
0.018	0.375	3.76	6.65	At most 1
Government non-infrastructure investment				
0.346	8.710	15.41	20.04	None
0.010	0.203	3.76	6.65	At most 1
Government consumption				
0.350	8.663	15.41	20.04	None
0.001	0.033	3.76	6.65	At most 1
Defence expenditure				
0.255	6.216	15.41	20.04	None
0.001	0.027	3.76	6.65	At most 1
Private investment				
0.461	14.563	15.41	20.04	None
0.071	1.552	3.76	6.65	At most 1
Private consumption				
0.389	9.885	15.41	20.04	None
0.000	0.016	3.76	6.65	At most 1
Nominal oil price				
0.535	17.982	15.41	20.04	None*
0.124	2.667	3.76	6.65	At most 1

*Notes: * denotes rejection of the hypothesis at five per cent significance level.*
Test assumptions: linear deterministic trend in the data;
maximum lag in VAR model is one year.

tests were performed: the first (**table 5**) for the period 1960–82, and the second (**table 6**) covering the entire 1960–94 period.

Despite a number of long-run equilibria between oil prices and various macro aggregates during the 1960–82 period, only one variable, the nominal oil price, was cointegrated with non-oil GDP during the same time interval. In the longer run, however, a number of equilibrium relationships were established. In particular, both private investment and consumption became cointegrated with non-oil GDP. On the government side, and somewhat unexpectedly, defence expenditure established a long-run equilibrium with non-oil GDP.

Conclusions

While the cointegration analysis produced a number of interesting patterns, their interpretation is difficult and will require further study. However, several tentative hypotheses might be put forth as a starting point for more detailed and extensive analysis.

Tentatively, we conclude that the shifts noted from 1960–82 to the longer period reflect a final equilibration of the oil price declines of the early 1980s. If this is the case, it may be possible to be more optimistic than many observers about the future of the economy. In particular, government expenditure appears to have broken its link with oil prices, so that the potential appears to exist for the authorities to pursue a less constrained course of macroeconomic stabilisation and development expansion.

The development of a long-run equilibrium between defence expenditure and the non-oil economy is also encouraging. A possible interpretation is that this pattern is indicative of a linkage being established between the government's military sale offset programme and the non-oil economy; specifically, that the hoped-for linkages between technology transfer and domestic investment are finally taking hold to produce a more vibrant local economy. Another interpretation might be that the health of the non-oil economy, not oil prices, is the ultimate constraining factor in affecting allocations to the defence budget. If this is the case, it suggests that the country's defence expenditure is being undertaken on a more sustainable basis than the "boom and bust" oil-related pattern often noted in the popular press.

Even more encouraging is the development of a long-run equilibrium between private sector expenditure and the non-oil economy. Tentatively, these findings suggest that Saudi Arabia's development strategy of attempting to diversify away from oil, through encouraging the private sector to take more responsibility for the kingdom's development, is finally paying off.

Table 6
Saudi Arabia: cointegration test for long-run equilibrium between non–oil GDP and macro variables, 1960–94
two-year lag

Eigenvalue	Likelihood ratio	5% critical value	1% critical value	Hypothesised no. of CEs
Government investment				
0.313	13.369	15.41	20.04	None
0.067	2.099	3.76	6.65	At most 1
Government infrastructure				
0.273	10.676	15.41	20.04	None
0.046	1.392	3.76	6.65	At most 1
Government non-infrastructural investment				
0.273	10.676	15.41	20.04	None
0.046	1.392	3.76	6.65	At most 1
Government consumption				
0.218	9.592	15.41	20.04	None
0.080	2.435	3.76	6.65	At most 1
Defence expenditure				
0.310	15.490	15.41	20.04	None *
0.134	4.347	3.76	6.65	At most 1 *
Private investment				
0.378	17.800	15.41	20.04	None *
0.110	3.513	3.76	6.65	At most 1
Private consumption				
0.536108	26.60796	15.41	20.04	None **
0.138785	4.332933	3.76	6.65	At most 1 *
Nominal price of oil				
0.111	5.971	15.41	20.04	None
0.083	2.529	3.76	6.65	At most 1

*Notes: * (**) denotes rejection of the hypothesis at five per cent (one per cent) significance level.*
Test assumptions: linear deterministic trend in the data; maximum lag in VAR model is two years.

References

Cuthbertson, K., S.G. Hall, et al (1992), Applied Econometric Techniques, The University of Michigan Press, Ann Arbor, USA.

Dickey, D.A., and W.A. Fuller (1981), "Likelihood ratio statistics for autoregressive time-series with a unit root," Econometrica 49: 1057–72.

Dolado, J., T. Jenkinson, et al (1990), "Cointegration and unit roots," Journal of Economic Surveys 4(3): 249–274.

Ghamdi, A.M.A. (1992), "Economic development and revenue instability: the Saudi experience," METU Studies in Development 19(1): 67–80.

Johansen, S., and K. Juselius (1990), "Maximum likelihood estimation and inference on cointegration — with applications to the demand for money," Oxford Bulletin of Economics and Statistics 52, No. 2, 169–210.

Looney, R.E. (1990), Economic Development in Saudi Arabia: Consequences of the Oil Price Decline, JAI Press, Greenwitch, Connecticut, USA.

Looney, R.E. (1992), "Real or illusory growth in an oil-based economy: government expenditures and private sector investment in Saudi Arabia," World Development 20: 1367–1376.

Looney, R.E. (1993), "The budgetary impact of defence expenditures in the Middle East," Middle East Business and Economic Review 5: 38–49.

Looney, R.E. (1995), "A post-Keynesian assessment of alternative Saudi Arabian austerity strategies," Kuwait University Journal of the Social Sciences 23(3, Autumn): 251–273.

MacKinnon, J.J. (1991), Critical Values for Cointegration Tests, Long-run Economic Relationships: Readings in Cointegration, R.F. Engle and C.W. Granger, Oxford University Press, Oxford, UK.

Pesaran, H.M., and B. Pesaran (1991), Microfit 3.0: An Interactive Econometric Package, Oxford University Press, Oxford, UK.

Stock, J.H. (1987), "Asymptotic properties of least squares estimations of cointegrating vectors," Econometrica 55: 1035–56.