The Single-Equation Models, Co-Integration Tests, and OPEC Behavior:

Parallel Action or Cartelization?

A. F. Alhajji, Ph.D

College of Business Administration
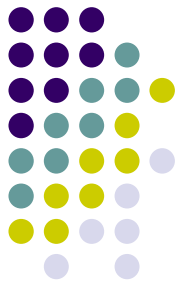
Ohio Northern University

a-alhajji@onu.edu

Literature Review

- Griffin, 1985 (AER)
- Loderer 1985 (JOF)
- Salehi-Isfahani,1987 (WP)
- Jones, 1990 (EJ)
- Dahl and Yücel, 1991 (EJ)
- Kandel, 1992, (WP)
- Gülen, 1996, (EJ)
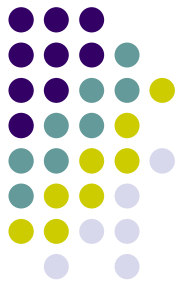- Ramcharran, 2001, (EE)
- Ramcharran, 2002, (EE)

Static, single-equation models

$$\ln Q_j = \delta + \alpha \ln P + \beta \ln Q_{o\text{-}j} + \varepsilon$$
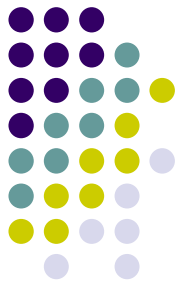
Dynamic, single-equation models

$$\ln Q_{jt} = \delta + \alpha \ln P_t + \beta \ln Q_{o\text{-}jt} +$$

$$\ln Q_{jt\text{-}1} + \varepsilon$$

Problems

- **Stationarity**
- **Serial auto-correlation**
- **Multicolinearity**
- **Quarterly vs. yearly data**
- **Parallel Action**

Correlation (Full Sample, QTR)
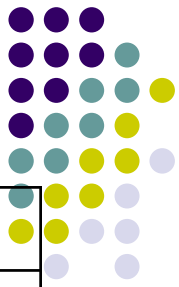
Country	OPEC		Country	Non-OPEC
ALGERIA	0.583		Brazil	0.662
INDONESIA	0.448		CANADA	0.416
IRAN	0.680		CHINA	0.922
IRAQ	0.227		EGYPT	0.915
KUWAIT	0.410		MEXICO	0.969
LIBYA	0.760		NORWAY	0.883
NIGERIA	0.848		UK	0.864
QATAR	0.788		US	-0.537
SAUDI	0.836			
UAE	0.702			
VENEZUELA	0.779			

Correlation (1983-2003, Qtr)

	OPEC	NONOPEC		NONOPEC	OPEC
ALGERIA	0.920	0.125	Angola	0.373	0.926
INDONESIA	0.557	-0.428	Argentina	0.272	0.854
IRAN	0.918	-0.056	Brazil	0.774	0.66
IRAQ	-0.055	0.692	CANADA	0.468	0.867
KUWAIT	0.261	0.161	CHINA	0.415	0.886
LIBYA	0.854	-0.131	EGYPT	-0.495	-0.054
NIGERIA	0.916	0.164	Malaysia	0.913	0.203
QATAR	0.859	0.445	MEXICO	0.441	0.589
SAUDI	0.921	-0.097	NORWAY	0.176	0.958
UAE	0.929	0.030	UK	0.350	-0.013
VENZUELA	0.930	0.156	US	-0.267	-0.942
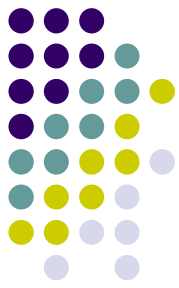
Non-stationery Quarterly Data

- **ADF test (Augmented Dickey-Fuller)**
- **Used AIC (Akaike info Criterion) to determine lag length**
- **Maximum lag =12**
- **All in "Ins"**
- **Most data has unit root**

  - **OPEC (D1 is stationary, n=118)**
  - **Non-OPEC (D2 is stationary, n=115)**
  - **Price (D1 is stationary, n=115)**
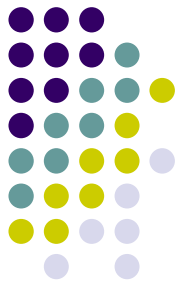
Results of ADF Tests

- **OPEC**
  - Only production data of Kuwait and Libya is stationery

- **Non-OPEC**
  - Only production data of Norway and the UK is stationery

  - **Most of the data is stationary after the first difference.**

OPEC (Quarterly Data)

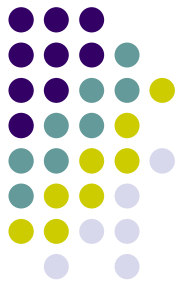- Algeria (D1 is stationary, n=118)
- OPEC – Algeria (D1 is stationary, n=118)
- Kuwait (Stationary, n=118)
- OPEC-Kuwait (stationary at 10%, D2 at 1%, n=108)
- Libya (Stationary, n=120)
- OPEC-Libya (D1 is stationary, n=118)
- Indonesia (Stationary at 10%, D1 at 1%, n=115)
- OPEC-Indonesia (D1 is stationary, n=118)
- Iran (Stationary at 10%, D1 at 5%, n=113)
- OPEC-Iran (D1 is stationary at 5%, n=111)

OPEC (Quarterly Data)

- Iraq (Stationary at 10%, D1 at 1%, n=118)
- OPEC-Iraq (D1 is stationary, n=118)
- **Nigeria (D1 is stationary, n=114)**
- **OPEC-Nigeria (D1 is stationary, n=118)**
- Qatar (D1 is stationary, n=119)
- OPEC-Qatar (D1 is stationary, n=118)
- Saudi Arabia (D1 is stationary, n=111)
- OPEC-Saudi (D1 is stationary, n=117)
- **UAE (D1 is stationary, n=115)**
- **OPEC-UAE (D1 is stationary, n=117)**
- Venezuela (D1 is stationary, n= 118)
- OPEC-Venezuela (D1 is stationary, n=118)

Non-OPEC (Quarterly Data)

- **Canada (D1 is stationary, n=112)**
- **Non-OPEC-Canada (D2 is stationary, n=115)**
- **China (D2 is stationary, n=114)**
- **Non-OPEC – China (D2 is stationary, n=110)**
- **Egypt (D1 is stationary, n=107)**
- **Non-OPEC – Egypt (D2 is stationary, n=110)**
- **Mexico (Stationary, n=119)**
- **Non-OPEC – Mexico (D2 is stationary, n=115)**

Non-OPEC (Quarterly Data)

- **Norway (Stationary, n=117)**
- **Non-OPEC-Norway (Stationary at 5%, n=108)**
- **USA (D1 is stationary, n=115)**
- **Non-OPEC-USA (D2 is stationary, n=110)**
- **UK (Stationary, n=116)**
- **Non-OPEC-UK (D2 is stationary, , n=115)**
- **USSR (D2 is stationary, n=77), 1974 Q4 to 1993 Q4**
- **Non-OPEC-USSR (D1 is stationary at 5%, n=79)**
- **Russia: 1992 Q2 to 2003 Q1 (D2 stationary, n=38)**
- **Non-OPEC-Russia: (Stationary, n=39)**
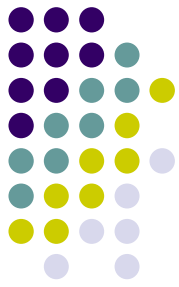
Auto-correlation (Evidence)

- **Static Models: Durbin-Watson Statistics**

- **Dynamic Models: LM Test**

- **All results suffer from serial auto-correlation**

- **AR is used to eliminate AC**

Evidence of Multicolinearity
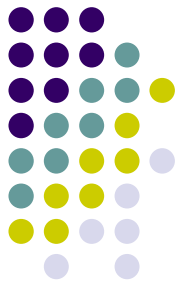
- **It exists in dynamic models when several variables are included such as GDI and lag GDI to test for the Target Revenue model. Most of the models in the literature suffer from this problem.**

Results of OPEC static single-equation models (QTR)

	InP	InOthers	R2	D-W
Algeria	(0.057)*	0.266*	0.35	0.47
Indonesia	0.043*	0.185*	0.18	0.32
Iran	(0.29)*	0.954*	0.36	0.43
Iraq	0.152	0.312	0.00	0.25
Kuwait	(0.135).	1.194*	0.10	0.27
Libya	0.067***	0.956*	0.53	0.47
Nigeria	0.059**	0.826*	0.67	1.08
Qatar	(0.055).	1.084*	0.59	0.39
Saudi	0.159*	0.998*	0.39	0.26
UAE	(0.176)*	0.695*	0.52	0.27
Venezuela	(0.165)*	0.637*	0.61	0.39

Results of **Non-OPEC** static single-equation models (QTR)
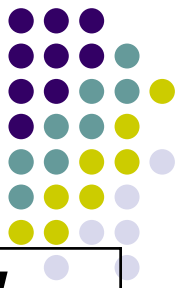
	InP	InOthers	R2	D-W
Canada	(0.203)*	0.391*	0.51	0.27
China	(0.108)*	2.011*	0.83	0.14
Egypt	0.033	3.403*	0.79	0.27
Mexico	0.120*	4.422*	0.91	0.19
Norway	(0.682)*	8.590*	0.70	0.10
Russia	0.191*	(0.474)***	0.20	0.15
UK	1.047*	14.95*	0.75	0.10
US	0.121*	(0.440)*	0.56	0.07
USSR	0.174*	0.278*	0.40	0.10

Which group is a cartel?
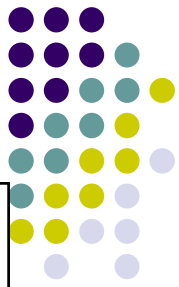
OPEC	InOthers	R^2	Non-OPEC	InOthers	R^2
Algeria	0.266*	0.35	**Canada**	0.391*	0.51
Indonesia	0.185*	0.18	**China**	2.011*	0.83
Iran	0.954*	0.36	**Egypt**	3.403*	0.79
Iraq	0.312	0.00	**Mexico**	4.422*	0.91
Kuwait	1.194*	0.10	**Norway**	8.590*	0.70
Libya	0.956*	0.53	**Russia**	(0.474)***	0.20
Nigeria	0.826*	0.67	**UK**	14.95*	0.75
Qatar	1.084*	0.59	**US**	(0.440)*	0.56
Saudi	0.998*	0.39	**USSR**	0.278*	0.40
UAE	0.695*	0.52			
Venezuela	0.637*	0.61			

Results of OPEC dynamic single-equation models (QTR)
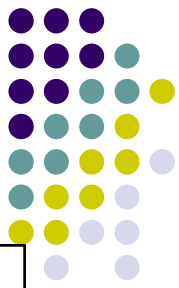
OPEC	lnP	lnOthers	lag lnQ	R2
Algeria	(0.015).	0.074**	0.751*	0.70
Indonesia	0.001	0.052**	0.792*	0.72
Iran	(0.073)***	0.045	0.836*	0.79
Iraq	(0.074).	(0.005).	0.887*	0.77
Kuwait	(0.105).	0.113	0.859*	0.77
Libya	0.016	0.302*	0.675*	0.76
Nigeria	(0.049)**	0.508*	0.390*	0.74
Qatar	(0.020).	0.269*	0.776*	0.85
Saudi	0.021	0.248*	0.837*	0.87
UAE	(0.043)**	0.130*	0.817*	0.86
Venezuela	(0.037)**	0.084***	0.843*	0.87

Results of non-OPEC dynamic single-equation models (QTR)
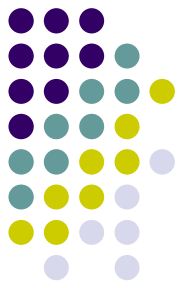
n-OPEC	lnP	lnOthers	lag lnQ	R2
Canada	(0.025)**	0.092*	0.892*	0.91
China	(0.016)**	0.097	0.913*	0.98
Egypt	0.036	0.160	0.922*	0.95
Mexico	0.028*	0.122	.944*	0.99
Norway	0.012	(0.040).	0.970*	0.98
Russia	0.021***	0.250*	0.976*	0.97
UK	0.029	(0.600).	0.982*	0.98
US	0.014*	(0.003).	0.974*	0.99
USSR	(0.005).	(0.081)*	1.052*	0.99

OPEC AR Models

OPEC	lnP	lnOthers	AR1	AR2	AR3	R2
Algeria	0.013	0.412*	0.830*			0.74
Indonesia	0.015	0.278*	0.839*			0.75
Iran	0.036	0.106	0.877*			0.78
Iraq	(0.023).	(0.091).	0.881*			0.77
Kuwait	(0.032).	0.965*	1.547*	(979)*	0.274*	0.86
Libya	0.128*	1.030*	0.895*	(0.214)**		0.80
Nigeria	(0.049).	0.844*	0.453*			0.75
Qatar	0.032	0.861*	0.584*	0.326*		0.87
Saudi	0.019	0.570*	0.899*			0.86
UAE	(0.042).	0.810*	0.810*			0.87
Venezuela	(0.046).	0.210**	1.170*	(0.636)*	0.397*	0.88

Non-OPEC AR Models
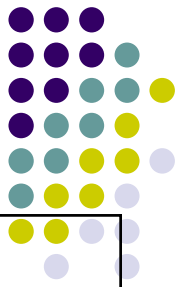
n-OPEC	lnP	lnOthers	AR1	AR2	AR3	R2
Canada	(0.004)	0.046	0.970*			0.91
China	(0.018)	0.243	0.627*	0.312*		0.98
Egypt	(0.169)*	(1.470)*	0.960*			0.95
Mexico	0.025	(0.209)	0.967*			0.99
Norway	(0.141)	-1.591	0.964*			0.98
Russia	0.003	(0.082)	1.422**	(0.455)*		0.95
UK	(0.144)	1.620	1.439*	(0.477)*		0.99
US	(0.0001)	0.285	0.994*			0.99
USSR	(0.008)	-0.040	1.245*	0.17	(0.413)*	0.98

Co-integration results

- Data for all countries but four has unit root

- Used Johansen Cointegration test

- Based on trace statistic, Eigen value, Max-Eigen statistic

Results of Co-integration Test
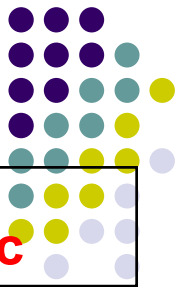
	OPEC		Non-OPEc
Algeria	Yes	**Canada**	Yes
Indonesia	No	**China**	Yes
Iran	Yes	**Egypt**	Yes
Iraq	No	**Mexico**	Yes
Kuwait	S	**Norway**	S
Libya	S	**Russia**	Yes
Nigeria	No	**UK**	S
Qatar	No	**US**	Yes
Saudi	Yes	**USSR**	Yes
UAE	No		
Venezuela	No		