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NOTE:

The following Poster represents *Work in Progress* for presentation and discussion at the EMEE2010 workshop. It therefore must not be referred to without the consent of the author(s).

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The Dynamics of Global Crude Oil Production (Work in Progress)

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Motivation

Crude oil production and prices are key economic variables, but we feel that the understanding of their interaction over time and for different producers is incomplete. We analyze the dynamic response of crude oil output to past prices and other important control variables.

We aim to disentangle the determinants of global oil production both by major country group and on the individual country level. We address methodological issues in the literature and aim to isolate the effects of prices on quantities more clearly than the literature does.

State of the Literature

Two major streams: models evaluating consequences of physical attributes/exhaustibility and tests of strategic producer behavior

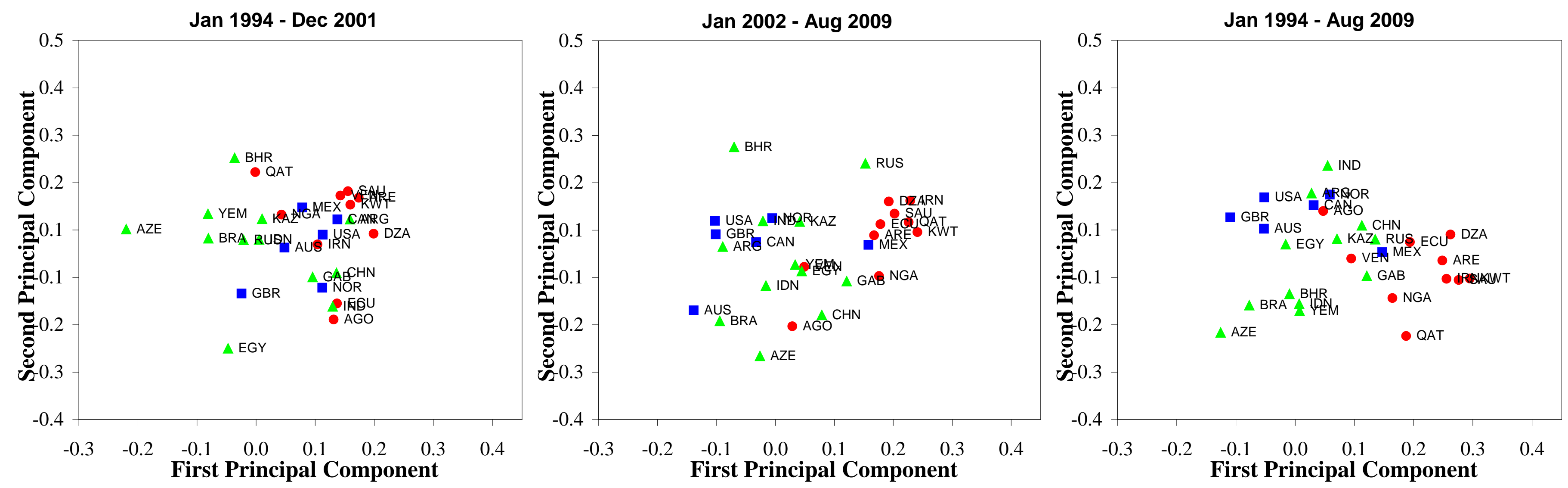
- Physical attributes:
 - Hotelling (1931): resource exhaustibility
 - Hubbard (1956): oil depletion
- Strategic behavior:
 - e.g. Griffin (1985): empirical testing of popular hypotheses: Cartel behavior, competitive behavior, revenue targeting
 - No thorough dynamic analysis exists and methodological challenges call into question validity of results

Data and Hypotheses

Data

- Comprehensive country-level dataset at (mostly) monthly frequency
 - Global oil production (EIA)
 - Regional oil prices (EIA, OPEC Bulletin)
- Real economic activity (Kilian, 2009)
- Investment in oil production capacity
 - Rig count (Baker Hughes Inc.)
- Institutional quality (Kaufman, Kraay and Mastruzzi, 2009)
 - Six indicators from World Bank
- Nonstationarity of all variables
 - Application of HP filter and use of HP cyclical component for analysis

Figure 2: Principal Components Analysis: Oil Production (HP Cyclical Component), Various Samples



Hypotheses

Hypothesis 1: Crude oil output responds to prices and other control variables over a range of lags from the short to the long term.

Hypothesis 2: The response is heterogeneous among the three main groups of countries, OPEC, OECD and non-OECD/non-OPEC, as well as on the level of individual countries.

Methodology and Empirical Evidence

Methodology

- Two-step estimation procedure:

$$1. \text{Purge direct oil price effect from real activity and investment: } RIG_{t,i} = \alpha_i + \sum_{s=1}^S \beta_{s,i} WTI_{t-s} + \varepsilon_{t,i} \quad RA_t = \varphi + \sum_{s=1}^S \gamma_s WTI_{t-s} + \mu_t$$

$$2. \text{Main regression using residuals from auxiliary regressions by OLS with Newey-West standard errors: } Q_{t,i} = \omega_i + \sum_{k=1}^K \delta_{k,i} WTI_{t-k} + \sum_{l=1}^L \theta_{l,i} \bar{I}_{t-l,i} + \sum_{m=1}^M \tau_{m,i} REAL_{t-m} + \Psi_i INST_{t,i} + \eta_{t,i}$$

- Group level regressions using WTI price, country level regressions using regional prices, where available

- Lag length optimization based on BIC algorithm

Results (Full Lag Structure)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
|--|------------------------|-----------------------|-----------------------|----------------------|------------------------|------------------------|-----------------------|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|------------------------|
| | Aggregated Groups | | | OPEC | | | OECD | | | Non-OECD/Non-OPEC | | | |
| | OPEC | OECD | Non-OECD/Non-OPEC | Saudi Arabia | UAE | Iran | Nigeria | Norway | United Kingdom | WTI | Indonesia | Russia | China |
| Real oil price, monthly average (-1) | 0.00226 (0.854) | 0.00841 (0.661) | -0.00826* (0.095) | 0.0154 (0.354) | 0.0328 (0.173) | 0.0459*** (0.005) | 0.0532** (0.000) | 0.0593** (0.000) | 0.0593** (0.000) | -0.0215 (0.549) | -0.0267*** (0.000) | 0.00583 (0.398) | 0.0131 (0.378) |
| Real oil price, monthly average (-2) | 0.0847*** (0.045) | -0.0416*** (0.000) | -0.0147* (0.063) | -0.0147* (0.030) | 0.0915*** (0.000) | 0.0407 (0.338) | -0.0304 (0.000) | -0.140*** (0.000) | 0.0650*** (0.000) | 0.0223 (0.195) | 0.0201*** (0.000) | 0.0190* (0.080) | 0.0190* (0.080) |
| Real oil price, quarterly average (-1) | 0.0688 (0.207) | -0.111*** (0.000) | -0.0150 (0.914) | 0.0303 (0.740) | 0.176*** (0.000) | 0.142*** (0.000) | 0.214*** (0.000) | -0.0860 (0.109) | -0.685*** (0.000) | -0.259** (0.025) | 0.0159 (0.253) | 0.0448*** (0.000) | 0.0193 (0.497) |
| Real oil price, quarterly average (-2) | 0.0688 (0.207) | 0.00286 (0.892) | -0.0239 (0.284) | -0.0193 (0.658) | 0.0874* (0.029) | 0.0204 (0.294) | 0.0629 (0.208) | 0.0213 (0.467) | -0.0962 (0.000) | -0.0354 (0.523) | -0.0388** (0.000) | 0.00587 (0.750) | 0.00531 (0.750) |
| Real oil price, quarterly average (-3) | 0.499 (0.287) | -0.736*** (0.000) | -0.284*** (0.000) | -0.284*** (0.000) | 0.0584 (0.330) | 0.0180 (0.017) | -0.550** (0.026) | 0.189 (0.206) | -2.355*** (0.000) | -3.667*** (0.000) | 0.0685 (0.651) | -0.0273 (0.848) | 0.168** (0.020) |
| Real oil price, yearly average (-1) | 0.818* (0.121) | -0.861*** (0.000) | -0.347*** (0.000) | -0.0634 (0.831) | 0.116 (0.636) | 0.512** (0.033) | -3.06*** (0.000) | -7.141*** (0.000) | -0.988* (0.089) | 0.0628 (0.750) | 0.489*** (0.000) | 0.363*** (0.000) | 0.304** (0.010) |
| Real oil price, yearly average (-2) | 0.774* (0.062) | -0.665*** (0.000) | -0.735*** (0.000) | -0.458*** (0.000) | 0.0458*** (0.046) | 0.0201 (0.861) | -3.81*** (0.000) | -7.421*** (0.000) | -0.0971 (0.847) | 0.0794 (0.605) | 0.323** (0.026) | 0.460*** (0.000) | 0.460*** (0.000) |
| Real oil price, yearly average (-3) | 0.818* (0.086) | -1.847*** (0.000) | -0.417*** (0.000) | -0.0201 (0.915) | 0.447* (0.061) | -0.299 (0.102) | -3.306*** (0.000) | -7.141*** (0.000) | -0.988* (0.089) | 0.0628 (0.750) | 0.489*** (0.000) | 0.363*** (0.000) | 0.304** (0.010) |
| Real oil price, yearly average (-4) | 0.774* (0.146) | -0.665*** (0.000) | -0.735*** (0.000) | -0.458*** (0.000) | 0.0458*** (0.000) | 0.0201 (0.190) | -3.81*** (0.000) | -7.421*** (0.000) | -0.0971 (0.375) | 0.0794 (0.375) | 0.323** (0.052) | 0.460*** (0.001) | 0.460*** (0.001) |
| Real oil price, yearly average (-5) | 0.244 (0.000) | -1.971*** (0.000) | -0.468*** (0.000) | -0.223 (0.195) | 0.186 (0.061) | -0.156 (0.070) | 0.578 (0.000) | -2.890*** (0.000) | -5.552*** (0.000) | -1.273*** (0.000) | 0.160 (0.290) | 0.285** (0.011) | 0.255** (0.016) |
| Real oil price, yearly average (-6) | 0.250 (0.232) | -1.599*** (0.000) | -0.208* (0.051) | -0.233 (0.113) | 0.223* (0.051) | 0.00332 (0.971) | 0.570* (0.071) | -2.404** (0.011) | -4.012*** (0.000) | 0.125** (0.025) | 0.159 (0.025) | 0.139 (0.141) | 0.139 (0.141) |
| Real oil price, yearly average (-8) | 0.0230 (0.895) | -0.0122** (0.000) | -0.417*** (0.000) | -0.132 (0.351) | 0.00864 (0.953) | -0.0269 (0.815) | -0.750*** (0.000) | -2.901*** (0.000) | -2.690*** (0.000) | -0.521*** (0.000) | 0.0925 (0.183) | 0.0957* (0.070) | 0.0946* (0.071) |
| Real oil price, yearly average (-9) | -0.0166 (0.797) | -0.440*** (0.000) | -0.0534* (0.012) | -0.186* (0.088) | 0.0504 (0.585) | -0.0638 (0.456) | -1.136*** (0.000) | -1.790*** (0.000) | -0.233** (0.018) | 0.176*** (0.007) | -0.0115 (0.692) | 0.0594 (0.263) | 0.0594 (0.263) |
| Rig count, residual, (-1) | 0.238 (0.514) | -0.719*** (0.000) | -0.0311 (0.712) | -0.201 (0.122) | 0.0806* (0.065) | 0.389 (0.255) | 0.0094 (0.393) | 0.268 (0.198) | 0.599** (0.039) | -0.381 (0.336) | 0.0638 (0.494) | n/a (n/a) | n/a (n/a) |
| Rig count, residual, (-2) | 0.669 (0.199) | -0.740*** (0.000) | 0.0897 (0.576) | 0.173* (0.065) | -0.00525 (0.969) | -0.128 (0.548) | 0.0573 (0.753) | 0.334 (0.148) | 0.704*** (0.000) | -0.692* (0.068) | 0.217 (0.236) | n/a (n/a) | n/a (n/a) |
| Rig count, residual, (-3) | 0.774* (0.054) | -0.665*** (0.000) | -0.735*** (0.000) | -0.458*** (0.000) | 0.0458*** (0.000) | 0.0201 (0.062) | -3.81*** (0.000) | -7.421*** (0.000) | -0.0971 (0.248) | 0.0794 (0.052) | 0.323** (0.001) | 0.460*** (0.001) | 0.460*** (0.001) |
| Rig count, residual, (-4) | 0.121 (0.713) | -0.302** (0.034) | -0.0309 (0.867) | 0.329 (0.337) | -0.105 (0.355) | -0.089** (0.000) | 0.299* (0.041) | 0.299* (0.041) | -0.722 (0.062) | -0.0117 (0.330) | 0.117 (0.330) | n/a (n/a) | n/a (n/a) |
| Real econ activity residual, yearly average (-1) | 0.000590 (0.542) | 0.00373*** (0.000) | 0.00321*** (0.000) | 0.000787 (0.563) | 0.00633*** (0.000) | -0.00689*** (0.000) | 0.0162*** (0.000) | 0.0223*** (0.000) | -0.000874 (0.000) | -0.000843 (0.202) | -0.000605 (0.677) | -0.00119** (0.331) | -0.00119** (0.1017) |
| Real econ activity residual, yearly average (-2) | -0.00123 (0.450) | 0.00165 (0.403) | 0.00231*** (0.000) | -0.00198 (0.706) | -0.00176 (0.337) | -0.00708*** (0.000) | -0.0103*** (0.000) | -0.00141 (0.300) | 0.0128*** (0.000) | -0.00330 (0.270) | 0.000701 (0.574) | 0.000281 (0.340) | 0.00155 (0.167) |
| Real econ activity residual, yearly average (-3) | -0.00326* (0.066) | 0.00441** (0.000) | -0.00136 (0.142) | 0.00112 (0.687) | 0.00182 (0.583) | -0.00402*** (0.000) | 0.00314 (0.888) | 0.0190** (0.002) | 0.00514*** (0.000) | 0.00140* (0.067) | 0.000114 (0.617) | -0.000161 (0.853) | -0.000161 (0.853) |
| Real econ activity residual, yearly average (-4) | -0.00530*** (0.000) | 0.00277** (0.000) | -0.00334 (0.000) | -0.00159 (0.706) | -0.00986*** (0.000) | -0.00188* (0.000) | 0.000499 (0.900) | 0.00524*** (0.000) | 0.0157*** (0.000) | 0.00126 (0.164) | -0.00185** (0.000) | 0.000936* (0.083) | 0.000936* (0.083) |
| Real econ activity residual, yearly average (-5) | -0.00199** (0.011) | 0.000433 (0.544) | 0.00182** (0.000) | -0.000342 (0.846) | -0.00024 (0.955) | -0.00062*** (0.000) | 0.00104 (0.478) | 0.000862** (0.009) | 0.00722*** (0.000) | 0.000366 (0.814) | 0.000719 (0.106) | -0.000771 (0.152) | -0.00191** (0.001) |
| Real econ activity residual, yearly average (-6) | -0.00310 (0.301) | 0.00566** (0.018) | 0.00731*** (0.000) | -0.00114 (0.416) | 0.00075** (0.001) | -0.0143*** (0.000) | 0.00077 (0.129) | 0.0101 (0.000) | 0.0348*** (0.000) | -0.00145 (0.720) | 0.00122 (0.330) | -0.000882 (0.195) | -0.00124 (0.338) |
| Real econ activity residual, yearly average (-7) | -0.00548*** (0.001) | 0.00840** (0.057) | 0.00448** (0.003) | -0.00356 (0.324) | -0.00875* (0.047) | -0.00759 (0.000) | 0.00264 (0.950) | 0.00626** (0.000) | 0.00626** (0.000) | -0.00125 (0.872) | 0.000880 (0.794) | -0.000437 (0.590) | -0.00201** (0.034) |
| Real econ activity residual, yearly average (-9) | -0.00613*** (0.000) | 0.0117*** (0.002) | 0.00252* (0.088) | -0.00335* (0.097) | -0.0110** (0.030) | -0.00407** (0.011) | 0.00369 (0.477) | 0.0125 (0.347) | 0.0111*** (0.000) | 0.0108* (0.073) | 0.00195 (0.451) | -0.00157* (0.002) | -0.00157* (0.048) |
| Voice and accountability | 0.0510 (0.745) | -0.202 (0.111) | -0.0430 (0.685) | 0.105 (0.499) | -0.111 (0.475) | -0.196 (0.104) | -0.115 (0.571) | -0.224** (0.023) | 0.753** (0.004) | -0.524** (0.004) | 0.361 (0.394) | 0.0666** (0.000) | 0.194** (0.009) |
| Political stability | 0.0779 (0.512) | 0.0948 (0.565) | 0.980*** (0.000) | 0.0802*** (0.000) | -0.0700 (0.418) | -0.439*** (0.000) | 0.255** (0.011) | 0.313** (0.011) | 0.467*** (0.000) | 0.145*** (0.000) | 0.00427 (0.790) | -0.0596** (0.001) | -0.177*** (0.000) |
| Government effectiveness | 0.240 (0.240) | -0.555* (0.070) | -1.163*** (0.000) | -0.183** (0.083) | -0.00623 (0.979) | -0.241** (0.070) | 1.098*** (0.000) | -0.573*** (0.000) | 0.284 (0.573) | -0.234 (0.107) | 0.0614*** (0.000) | 0.170*** (0.000) | 0.170*** (0.000) |
| Regulatory quality | 0.252 (0.136) | 1.254 (0.113) | 2.900*** (0.000) | -0.128 (0.454) | -0.168** (0.030) | -0.320*** (0.000) | -0.0994 (0.001) | -0.403*** (0.000) | 0.155 (0.181) | 0.149 (0.181) | -0.0611 (0.361) | -0.00986 (0.905) | -0.141** (0.001) |
| Control of corruption | -0.337*** (0.001) | 1.725 (0.108) | 0.359*** (0.000) | -0.133** (0.003) | 0.217*** (0.006) | 0.192** (0.038) | -0.342** (0.001) | 0.912*** (0.000) | -0.224 (0.280) | 0.224 (0.249) | 0.217*** (0.000) | -0.0298* (0.030) | -0.167*** (0.000) |
| Constant | -0.339** (0.015) | 0.442*** (0.004) | 0.196*** (0.000) | -0.147 (0.229) | -0.0726 (0.704) | -0.685*** (0.000) | 0.0244 (0.932) | 0.755** (0.009) | 2.438*** (0.000) | 0.220 (0.312) | 0.0657*** (0.003) | -0.0602** (0.029) | -0.0489 (0.180) |
| Observations | 109 | 109 | 109 | 109 | 109 | 96 | 109 | 109 | 109 | 109 | 109 | 134 | 134 |

Results (Based on BIC procedure)

| Country | Month 1 | Month 2 | Month 3 | Quarter 2 | 2nd half | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 |
|---------|---------|---------|---------|-----------|----------|--------|--------|--------|--------|--------|--------|--------|--------|
| OPEC | | 0.04 | | | | | | | | -1.76 | | | |
| OECD | | -0.14 | | | | | | | | -1.75 | | | |
| NON | | | | | -0.13 | | | | 0.58 | | | 0.21 | |
| USA | | -0.34 | | | | | | | | -3.72 | | | |
| CHN | | | | | | -0.71 | | | | | -0.83 | | |
| NGA | | | | | -0.7 | 0.65 | | | | | | | |
| SAU | | 0.09 | | | | -0.9 | | | | -1.72 | | | 0.25 |
| ARE | | 0.17 | | | | 1.4 | | | | | 2.48 | | |
| IRN | | | | 0.08 | | | 0.4 | | | | | | |