Exogenous Oil Supply Shocks:

How Big Are They and

How Much Do They Matter for the U.S. Economy?

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Motivation

● Wars and other exogenous political events in OPEC countries cause oil production shortfalls.

<u>Examples:</u> Iranian revolution (1978/79), Iran-Iraq War (1980-1988), Persian Gulf War (1990/91),
Iraq War (2003), Civil unrest in Venezuela (2002/03), and <u>perhaps</u> the Yom Kippur
War/Arab oil embargo (1973/74)

● Three key questions:

1. How large are the exogenous fluctuations in the production of oil?
2. What are the dynamic effects of exogenous oil production shortfalls on U.S. real GDP growth and CPI inflation?
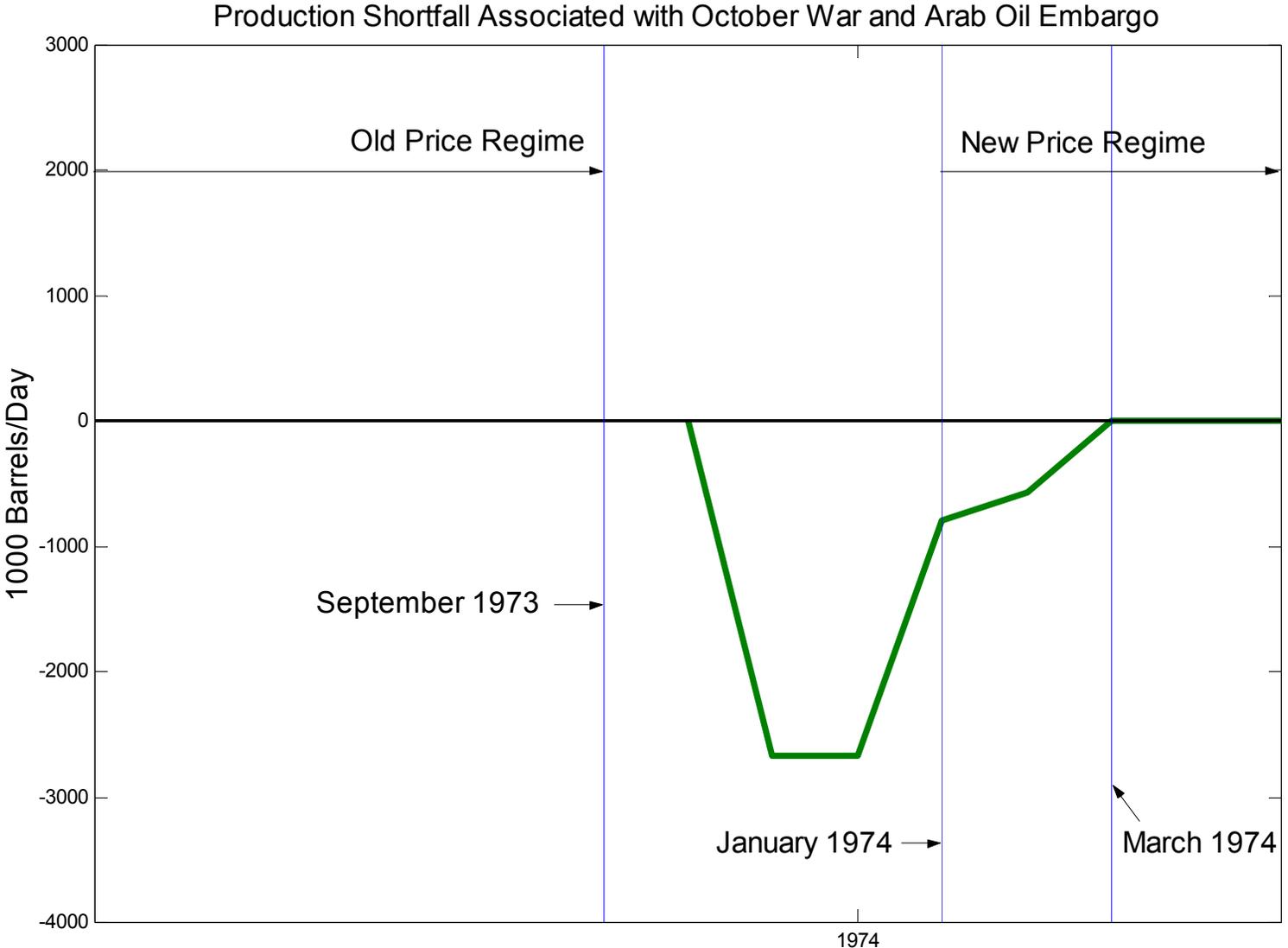3. To what extent do exogenous oil supply shocks explain changes in the price of oil?

Part 1: Measuring Exogenous Oil Supply Shocks:

● Any attempt to identify the timing and magnitude of these exogenous production shortfalls requires explicit assumptions about the counterfactual path of oil production in the absence of the exogenous event in question.

● The strategy is to generate the counterfactual production level for the country in question by extrapolating its pre-war production level based on the average growth rate of production in other countries that are subject to the same global macroeconomic conditions and economic incentives, but not affected by the war.

● Which countries belong into the benchmark group must be decided on a case-by-case basis drawing on historical accounts and industry sources.

Example 1: Counterfactual for the

October 1973 War and the 1973/74 Arab Oil Embargo

● It is well known that oil production from <u>Arab OPEC countries</u> fell between September and November of 1973, whereas oil production in the <u>rest of the world</u> did not. This observation suggests that we take non-OPEC oil producers as our benchmark.

● Simply comparing the production decisions in non-OPEC countries and Arab-OPEC countries in late 1973 would be misleading, however, because of differences in economic incentives across these countries.

● <u>1971 Tehran/Tripoli agreements</u> between the oil companies and Middle Eastern OPEC oil producers:

- Duration of five years

- Moderate improvement in the financial terms that host governments received from oil companies for each barrel of oil extracted by the oil companies …

- … in exchange for assurances that these governments would allow the oil companies to extract as much oil as they saw fit on those terms.

The October 1973 War and 1973/74 Embargo: Production

Crude Oil Production Relative to Non-OPEC Countries

Old Price Regime

New Price Regime

September 1973 →

January 1974 →

March 1974

1000 Barrels/Day

- - - Iraq
- · - Iran
—— Saudi Arabia
—— Kuwait
—— Other Arab OPEC

1974

The October 1973 War and 1973/74 Embargo: Production Shortfall

Production Shortfall Associated with October War and Arab Oil Embargo

Example 2: Iraq

Event:	Starting date:	Production Benchmark:
Iranian revolution	1978.10	Total OPEC – Iraq, Iran, Saudi Arabia
Iran-Iraq war	1980.10	Total OPEC – Iraq, Iran, Saudi Arabia
Persian Gulf War	1990.8	Total OPEC – Iraq, Iran, Saudi Arabia, Kuwait
Venezuelan Crisis	2002.12	Total OPEC – Iraq, Iran, Saudi Arabia, Kuwait, Venezuela
Iraq War	2003.03	Total OPEC – Iraq, Iran, Saudi Arabia, Kuwait, Venezuela

Iraq: Actual and Counterfactual Production

Crude Oil Production: Iraq
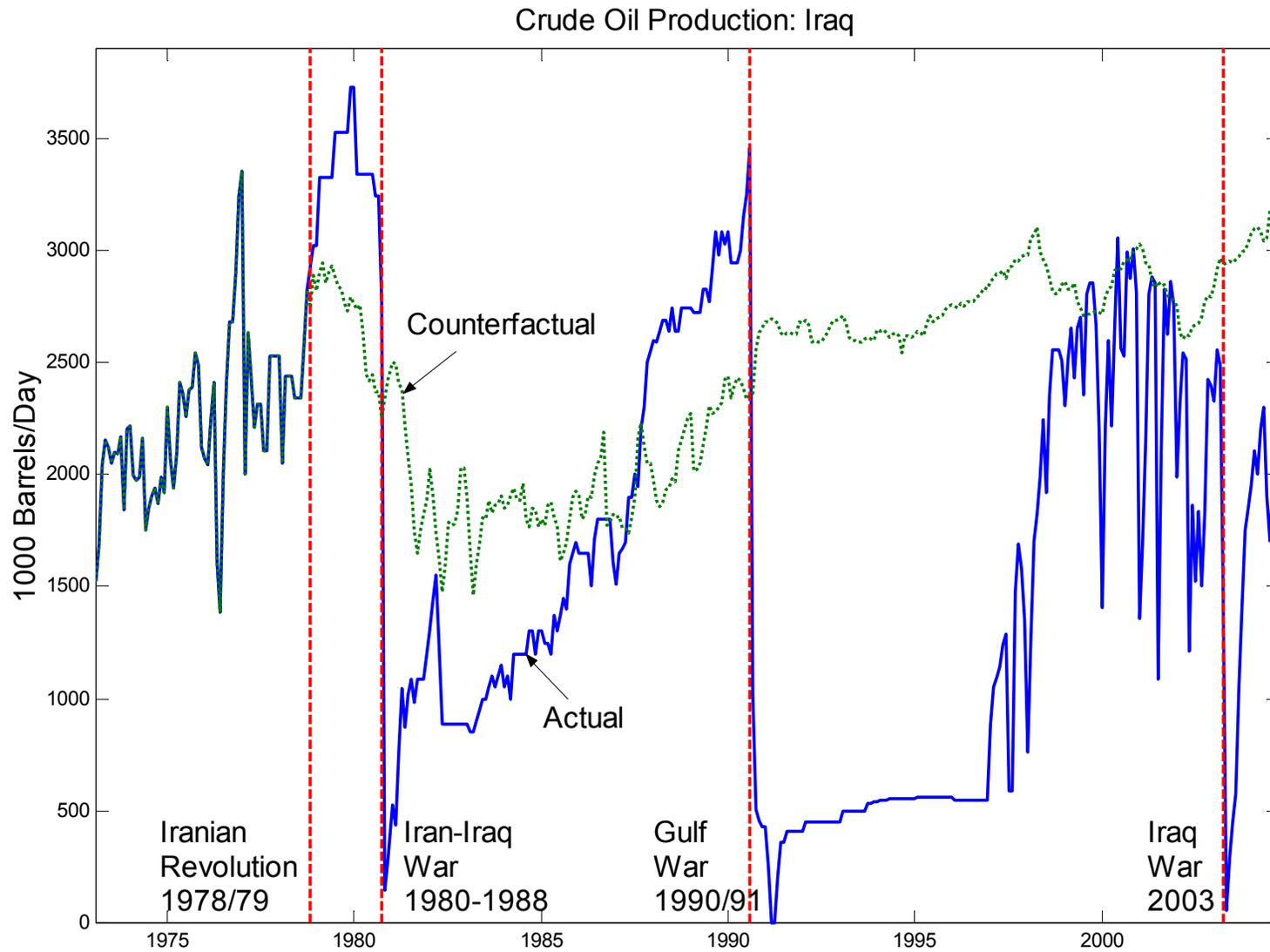
From Production Shortfalls to Supply Shocks

Procedure for Constructing a Historical Series of Exogenous OPEC Oil Supply Disturbances:

1. Sum all OPEC oil production shortfalls discussed so far (including the 1973/74 event which may or may not have been exogenous).

2. Express this time series as a share of world crude oil output.

3. A natural measure of the exogenous OPEC oil supply shock is the change in the normalized production shortfall over time.

Baseline Exogenous Oil Supply Shock Series for all of OPEC

First Difference of Exogenous Oil Production Shortfall: OPEC
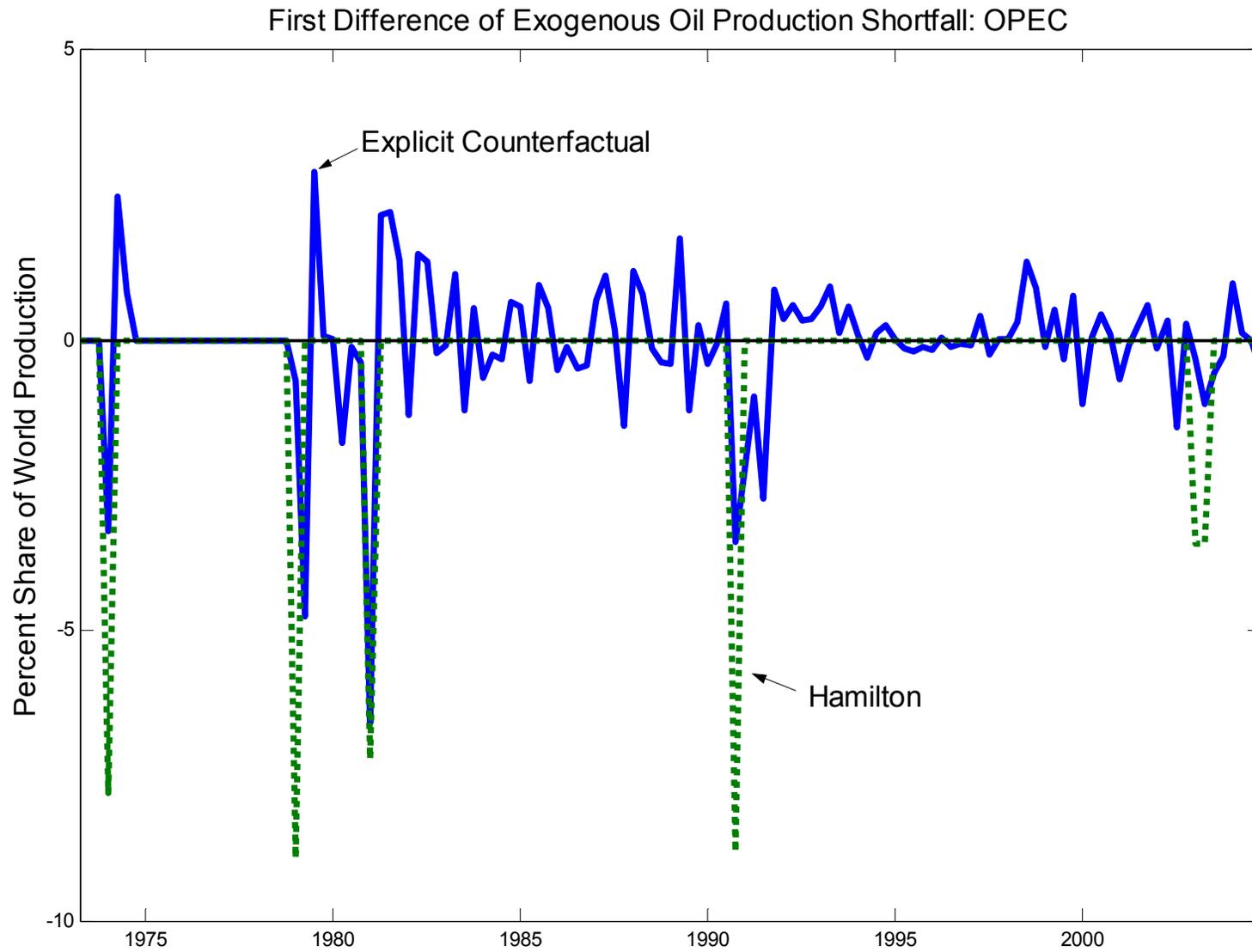
Part 2: The Dynamic Effects of Exogenous Oil Supply Shocks

● Let x_t denote the date t observation of the exogenous oil supply shock series, Δy_t the corresponding percent growth rate in real GDP and π_t the percent change in the consumer price index. The ultimate object of interest are the impulse responses $\partial \Delta y_{t+i}/\partial x_t$ and $\partial \pi_{t+i}/\partial x_t$, $i = 1, 2, 3...$

● For each country, the first-order effect of a given increase in x_t on Δy_{t+i} and π_{t+i}, respectively, may be computed based on the fitted value of the linear ordinary least squares (OLS) regressions

$$\Delta y_t = \alpha + \sum_{i=1}^{4} \beta_i \Delta y_{t-i} + \sum_{j=1}^{8} \gamma_j x_{t-j} + u_t \quad \text{and} \quad \pi_t = \delta + \sum_{i=1}^{4} \lambda_i \pi_{t-i} + \sum_{j=1}^{8} \eta_j x_{t-j} + v_t,$$

where the error terms u_t and v_t are serially uncorrelated, given the inclusion of four lags of the dependent variable and eight lags of the exogenous oil supply shock.

● Level responses for real GDP and the level of consumer prices may be obtained by cumulating the estimated impulse responses. Confidence intervals for these impulse responses may be constructed by drawing from the asymptotic normal distribution of the slope parameters and simulating the standard errors of the impulse response estimators.

Dynamic Effects of a 10% World Oil Supply Disruption on United States
Direct Estimate Based on Baseline Counterfactual
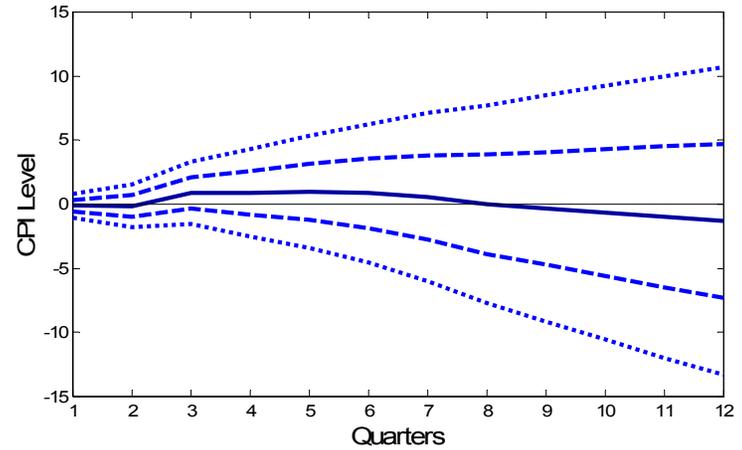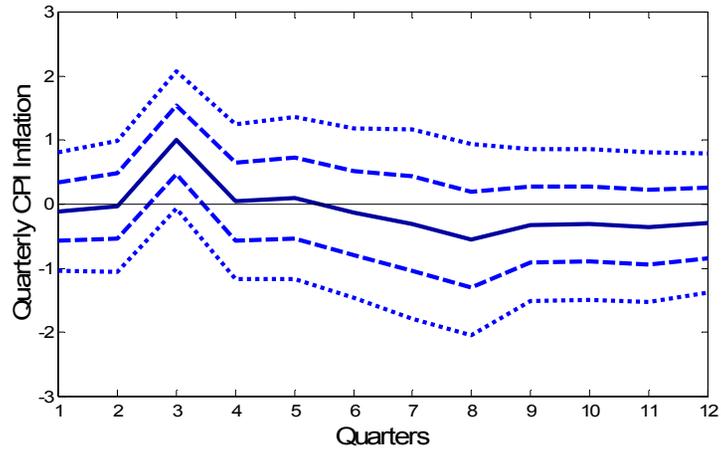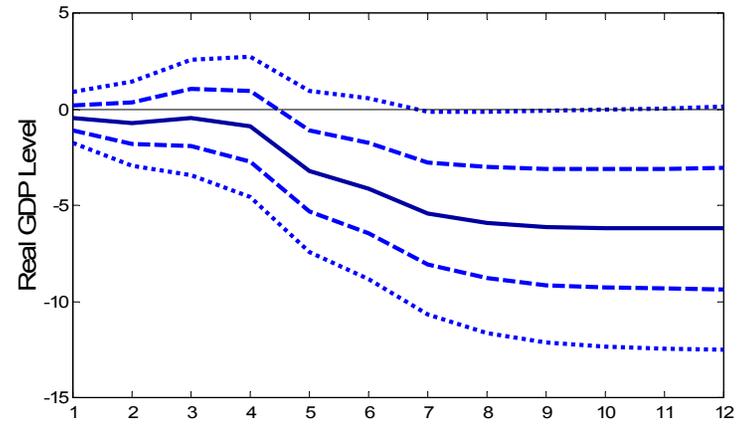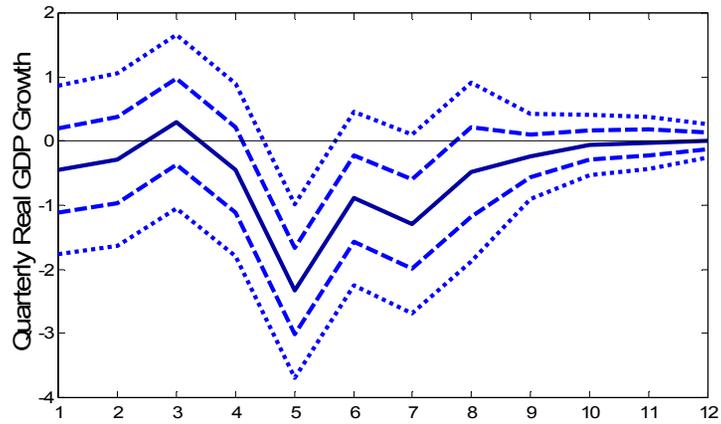
Beyond dynamic multipliers …

There is a tendency to think of exogenous oil supply shocks as adverse oil supply shocks. This need not be the case:

● Historically, exogenous production shortfalls have tended to be temporary. In that case, by construction, negative shocks to oil production are followed by positive shocks.

● In assessing the overall impact of exogenous oil supply shocks, it is therefore more informative to conduct a <u>counterfactual</u> historical simulation.

U.S. Real GDP Growth and CPI Inflation Relative to Long-Run Average and Estimated Effect of Exogenous Oil Supply Shocks

Excess Relative to 1973.1-2004.III Average
Effect of Exogenous Oil Supply Shock
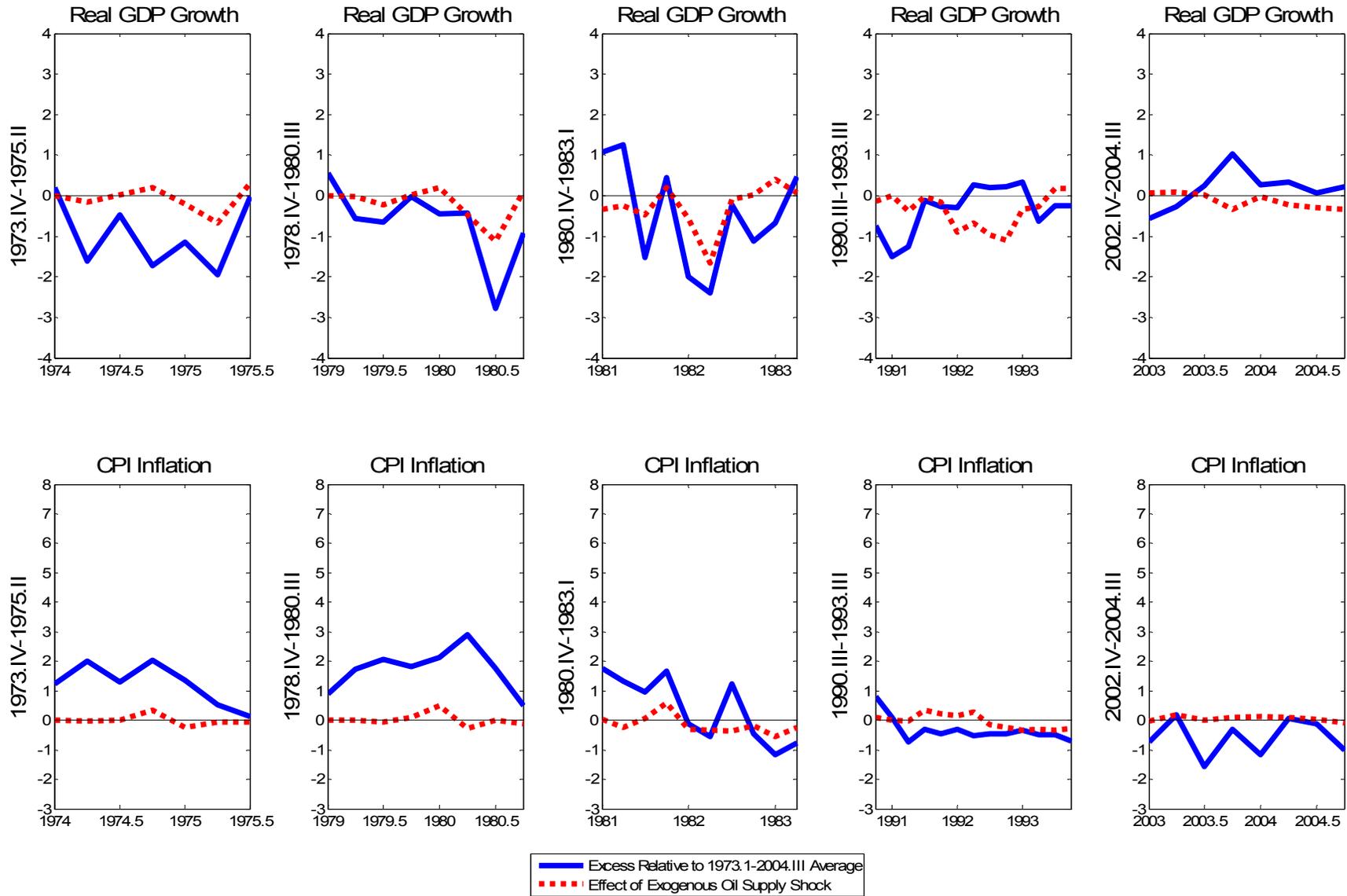
Part 3: The (Tenuous) Link from Exogenous Oil Supply Shocks to Oil Price Shocks

1. There is widespread recognition today that oil prices since 1973 must be considered endogenous with respect to global macroeconomic conditions.

2. Recently the case has been made that, nevertheless, nonlinear transformation of the price of oil designed to capture "oil price shocks" (such as net oil price increases) effectively identify the exogenous component of the price of oil. This is not the case:

- Oil price shocks may occur in the absence of exogenous oil events.
- Exogenous oil events are not necessarily followed by oil price shocks.
- The exogenous oil events of 1973/74, 1978/79 and 2002/03 were followed by price shocks in non-oil industrial commodities. No such price shocks occurred in 1980/81 or 1990/91.

3. We can, however, assess the predictive power of exogenous oil supply shocks for changes in the real price of oil.

How Well Do Exogenous Oil Supply Shocks Predict

Changes in the Real Price of Oil?

1. None of the existing measures of exogenous oil supply shocks explains the oil price data well.

2. Alternative explanations:

- The unexplained variation in oil prices in 1973/74, 1979/80 and 2003/04 can be explained by shifts in the demand for oil.

- The unexplained variation in oil prices in 1990/91 can be attributed to shifts in uncertainty about Saudi oil supplies.

- The 1980/81 oil price increases is well-explained by exogenous oil supply shocks, as defined in this paper.

Instrumental Variable Regressions for U.S. Real GDP Growth

Regressand:	Exogenous oil supply shocks measured as quantitative dummies								Exogenous oil supply shocks as proposed in this paper				
Δgdp_t	1947.II-2001.III		1947.II-2004.III		1973.I-2004.III		1973.I-2004.III		1973.I-2004.III				
Regressors:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**
c	0.95	0.78	0.87	0.73	0.68	0.54	0.74	0.58	0.57	0.57	0.56	0.40	0.49
Δgdp_{t-1}	0.20	0.22	0.20	0.21	0.20	0.20	0.16	0.17	0.17	0.21	0.23	0.15	0.19
Δgdp_{t-2}	0.11	0.12	0.13	0.14	0.12	0.13	0.06	0.07	0.11	0.08	0.03	0.28	0.08
Δgdp_{t-3}	-0.04	-0.04	-0.05	-0.05	0.02	0.03	0.03	0.05	0.11	0.09	0.06	0.18	0.06
Δgdp_{t-4}	-0.17	-0.18	-0.15	-0.15	-0.07	-0.07	-0.06	-0.06	-0.09	-0.08	-0.01	-0.14	-0.00
Δnp^{oil}_{t-1}	-0.03	-	-0.02	-	-0.02	-	-0.02	-	0.03	-	-	-	-
Δnp^{oil}_{t-2}	-0.05	-	-0.05	-	-0.04	-	-0.05	-	-0.09	-	-	-	-
Δnp^{oil}_{t-3}	-0.01	-	-0.00	-	-0.00	-	-0.01	-	0.06	-	-	-	-
Δnp^{oil}_{t-4}	-0.06	-	-0.07	-	-0.03	-	-0.04	-	-0.01	-	-	-	-
Δrp^{oil}_{t-1}	-	-0.03	-	-0.03	-	-0.02	-	-0.03	-	0.05	0.06	-0.04	-0.01
Δrp^{oil}_{t-2}	-	-0.06	-	-0.06	-	-0.04	-	-0.06	-	-0.08	-0.06	-0.12	-0.06
Δrp^{oil}_{t-3}	-	-0.02	-	-0.01	-	-0.01	-	-0.02	-	0.07	0.04	0.06	-0.02
Δrp^{oil}_{t-4}	-	-0.07	-	-0.07	-	-0.04	-	-0.04	-	-0.02	-0.01	0.03	-0.01
F test	**2.95**	**2.43**	**2.83**	**2.39**	**1.74**	**1.46**	**1.87**	**1.443**	**0.37**	**0.33**	**0.45**	**0.23**	**0.77**
(p-value)	**(0.02)**	**(0.05)**	**(0.03)**	**(0.05)**	**(0.15)**	**(0.22)**	**(0.12)**	**(0.225)**	**(0.83)**	**(0.86)**	**(0.77)**	**(0.92)**	**(0.55)**

Notes: The instruments include a constant, four lags of real GDP growth and eight lags of the exogenous oil supply shock. Columns (1)-(6) are based on the PPI for domestic crude oil as reported by the BLS and Hamilton (2003); columns (7)-(13) are based on the average price of imported crude oil as reported by the U.S. Department of Energy, extended backwards from 1974.I to 1973.I as in Barsky and Kilian (2004). The F-test refers to the null that oil prices changes have no effect on real GDP growth. Column (11) excludes the Saudi production response; column (12) drops the embargo; column (13) includes Saudi Arabia in the benchmark starting in 1974.

Dynamic Effects of a 10% Oil Price Increase: United States

IV Point Estimate with One-Standard Error Band and Two-Standard Error Band
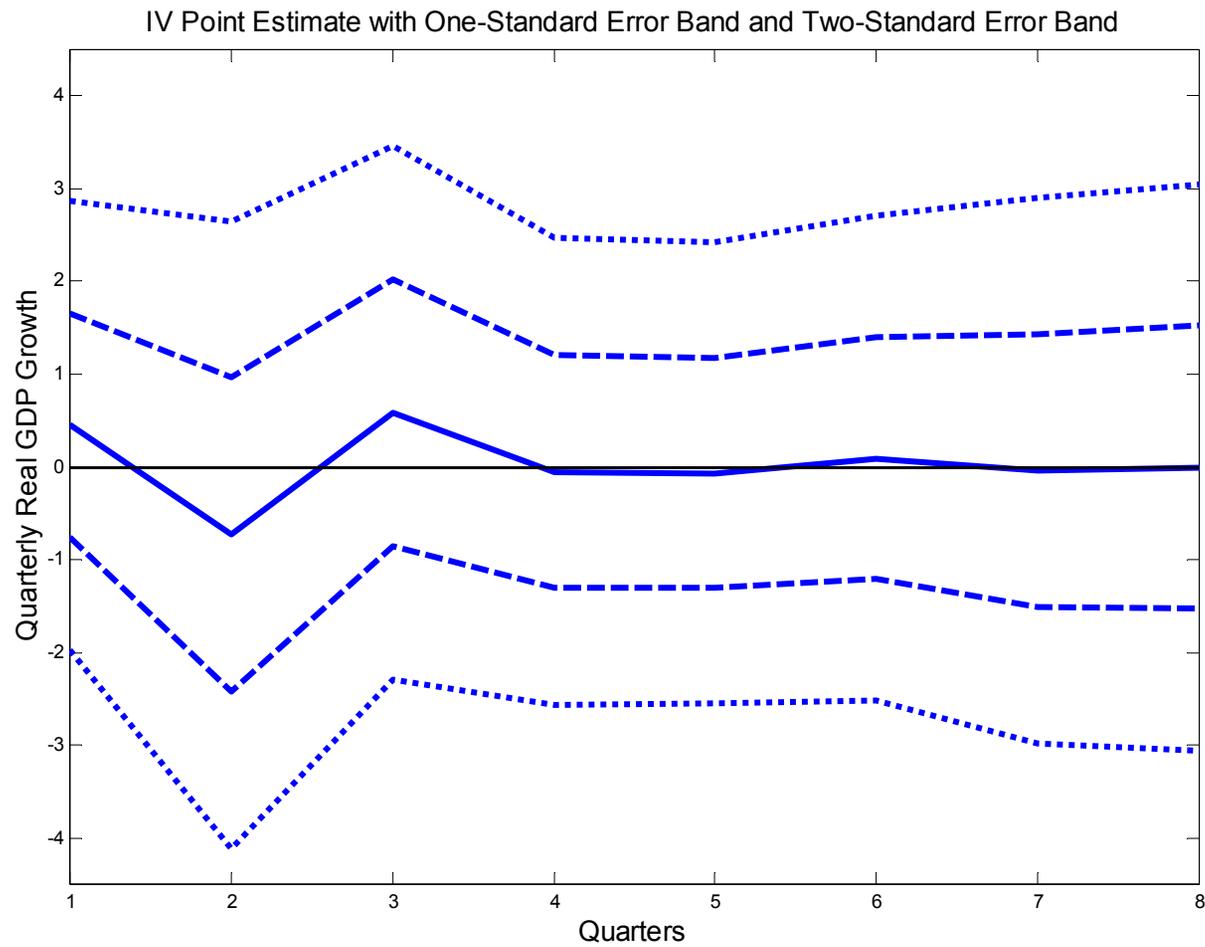
Weak Instrument Problems?

● Weak instruments produce biased IV estimators and hypothesis tests with large size distortions (see Stock, Wright and Yogo (2002) for a review).

● Stock and Yogo (2003) propose a test of the null of weak instruments against strong instruments.

Result:

All IV regressions in the previous table fail this weak instrument test!

Dynamic Effects of a 10% World Oil Supply Disruption on United States
Direct Estimate Based on Quantitative Dummies