Speculation in Oil Markets?

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Competing Views of the Global Market for Crude Oil

1. The price of oil is determined by shocks to the flow supply of oil and to the flow demand for oil.

2. The price of oil is determined by desired stocks. Shifts in the expectations of forward-looking traders are immediately reflected in changes in the price of oil through a shift in inventory demand.

Key Contributions of this Paper

1. We propose the first empirical model of the global market for crude oil that nests the stock demand and flow demand explanations of the determination of the real price of oil.
2. Using a new approach to identification, we show how the forward-looking element of the real price of oil can be identified with the help of data on crude oil inventories.
3. This allows us to shed light on the extent of speculation in oil markets since the late 1970s.
4. We provide for the first time a properly identified estimate of the short-run price elasticity of oil demand.

Limitations of Traditional Oil Market Models

- ⇨ Market expectations of future oil demand and oil supply conditions are equated with econometric expectations.

- ⇨ Problem:
  There is a potentially important forward-looking element in the real price of oil not captured by past data on global oil prices, oil production, or real activity.

Examples of Forward-Looking Elements in Expectations of Oil Demand and Supply Conditions

<u>Supply side</u>: New oil discoveries (Brazilian off-shore oil fields)

Anticipation of a War in the Middle East

Anticipation of "peak oil" effects

<u>Demand side</u>: Anticipation of a booming world economy

Anticipation of a major global recession

Anticipation of new energy-saving technologies

<u>Both sides:</u> Shifts in Uncertainty about Future Oil Supply Shortfalls

Key Insights

Shifts in expectations about future oil demand and/or oil supply conditions manifest themselves as shifts in the demand for oil inventories:

- ⇨ Expectation shifts cause a shift of the oil demand curve along the oil supply curve, conditional on past data
- ⇨ Raw data on inventories are not informative. We need to model all structural determinants of oil inventories simultaneously, if we want to capture the expectations-driven component in the inventories.

Expectations and Speculative Demand

● The most general economic definition of a speculator is anyone buying crude oil not for current consumption, but for future use (see Fattouh, Kilian and Mahadeva 2012).

● What is common to all speculative purchases of oil is that the buyer is anticipating rising oil prices.

● In other words speculation is driven by expectations of future oil supply shortfalls.

- ⇨ Expectations-driven inventory demand shocks are speculative demand shocks by construction.
- ⇨ Whether this speculation is normal or excessive or why speculators expect the oil market to tighten is left open by our approach.

Structural Model of the Global Crude Oil Market

Monthly data for 1973.2-2010.6:

1. Percent change in global crude oil production
2. Index of global real activity (in deviations from trend)
3. Real price of oil
4. Change in above-ground global crude oil inventories

- VAR(24) with seasonal dummies

Four Structural Shocks

1. Shock to the flow of crude oil production ("flow supply shock")
2. Shock to the demand for crude oil associated with the global business cycle ("flow demand shock")
3. Shock to the demand for above-ground oil inventories arising from forward-looking behavior ("speculative demand shock")
4. Residual demand shock that captures all structural shocks not otherwise accounted for and has no direct economic interpretation (e.g., weather shocks, shocks to inventory technology or preferences, idiosyncratic changes in SPR).

1. Identifying Assumptions on Sign of Impact Responses

	Flow Supply Shock	Flow Demand Shock	Speculative Demand Shock
Oil Production	-	+	+
Real Activity	-	+	-
Real Oil Price	+	+	+
Inventories			+

2. Bound on One-Month Price Elasticity of Supply

Consensus: The impact price elasticity of oil supply is near zero.

- Oil supply elasticity bound: $\eta^{Oil\ Supply} \leq 0.025$ (baseline)

- Our main results are robust to using a bound as high as 0.1.

3. Bound on One-Month Price Elasticity of Demand

- Standard demand elasticity measures equate the production of oil with the consumption of oil and ignore the role of inventory changes.

- We restrict the impact ***price elasticity of oil demand in use***, which accounts for changes in inventories:

$$-0.8 \leq \eta^{Oil\ Use} \leq 0$$

4. Dynamic Sign Restriction

- An unexpected flow supply disruption is associated with a positive response of the real price of oil and a negative response of oil production and global real activity for the first year.

This assumption helps rule out models that are inconsistent with conventional views of the effects of flow supply shocks.

Why do we not include the oil futures spread?

● Spot market and futures market are two distinct markets linked by an arbitrage condition (Alquist and Kilian 2010).

● Inventory data will capture spillover from oil futures market.

● Testable implication: Oil futures spread does not Granger-cause the variables included in the VAR model (Giannone & Reichlin JEEA 2006).

● In the absence of an oil futures market (or when arbitrage fails), our model would remain well-specified.

Implementation

• Reduced-form VAR model $A(L)y_t = e_t$, where e_t is the vector of white noise reduced-form innovations with variance-covariance matrix Σ_e such that $e_t = \tilde{B}\varepsilon_t$.

• B satisfies $\Sigma_e = BB'$. Then $\tilde{B} = BD$ also satisfies $\tilde{B}\tilde{B}' = \Sigma_e$ for any conformable orthogonal matrix D.

• Construct many candidate solutions $\tilde{B}$ by repeatedly drawing at random from the set of orthogonal matrices D. Discard all candidate solutions that do not satisfy the identifying restrictions and retain the set of admissible models.

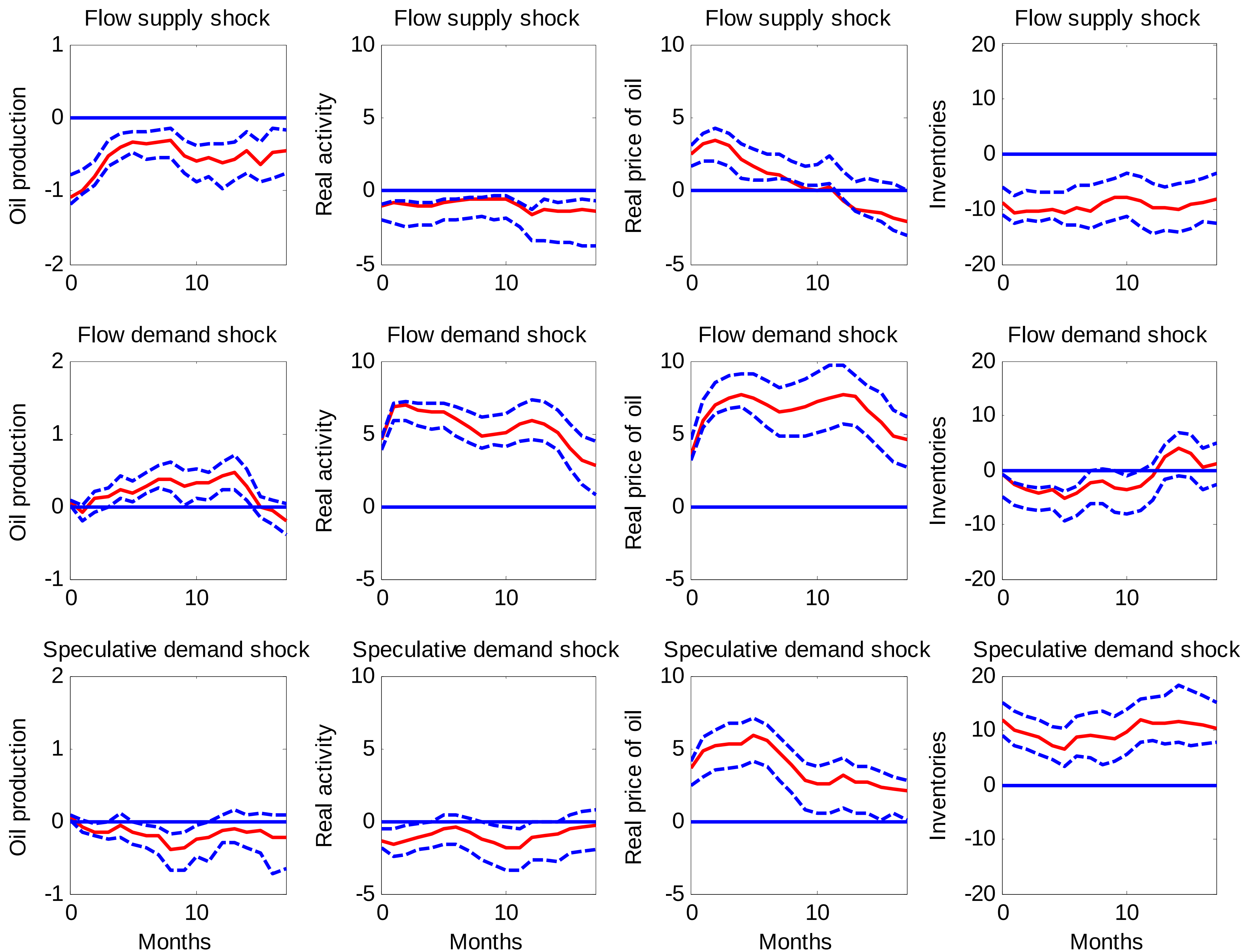
Benchmark Model

● Median response functions are invalid (Fry and Pagan JEL 2011; Kilian and Murphy, forthcoming: JEEA; Inoue and Kilian 2011).

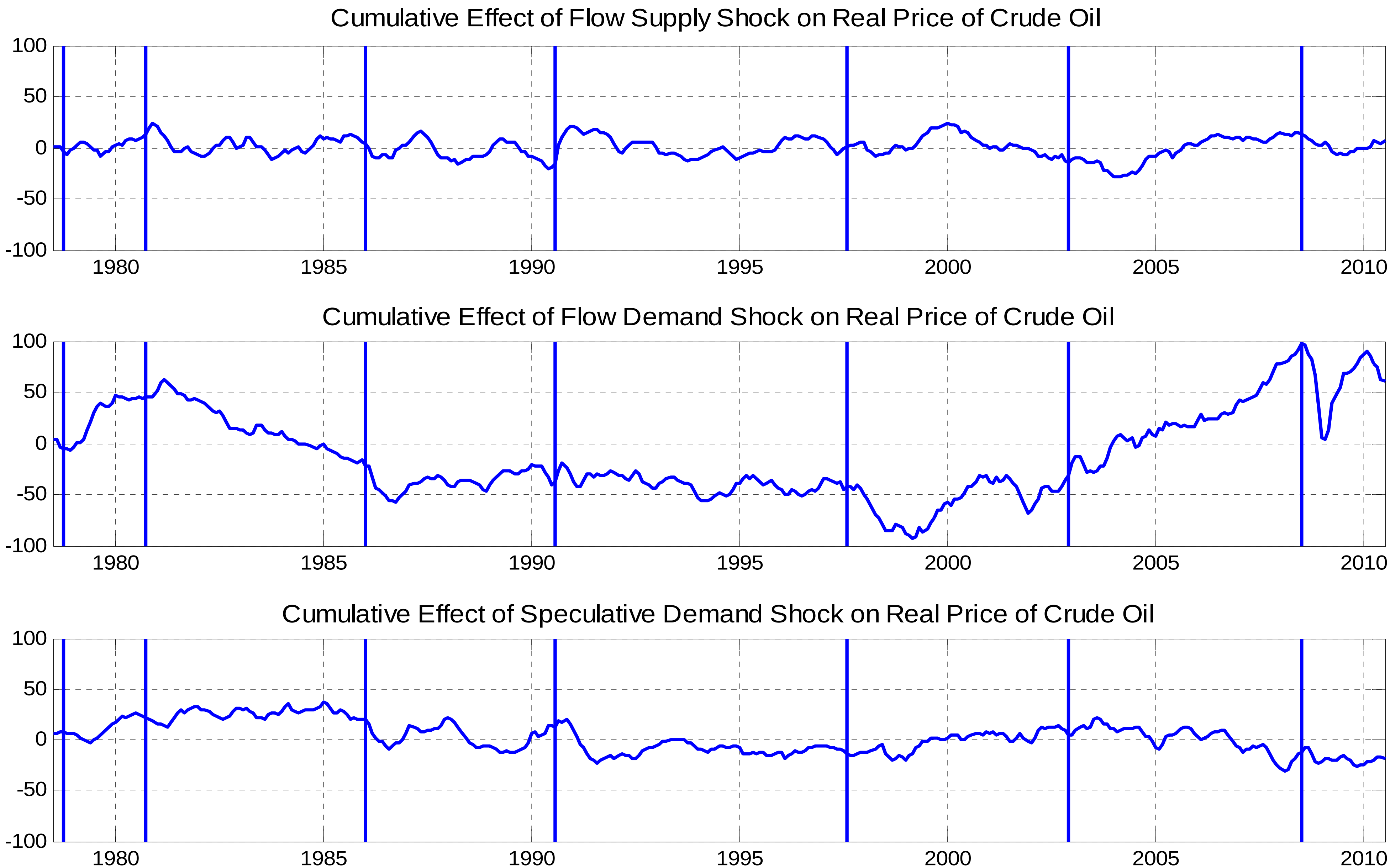
● All our admissible models have nearly observationally equivalent responses.

● We report one admissible model WLOG.

Structural Impulse Responses: 1973.2-2009.8



Historical Decompositions for 1978.6-2010.6



The Inventory Puzzle

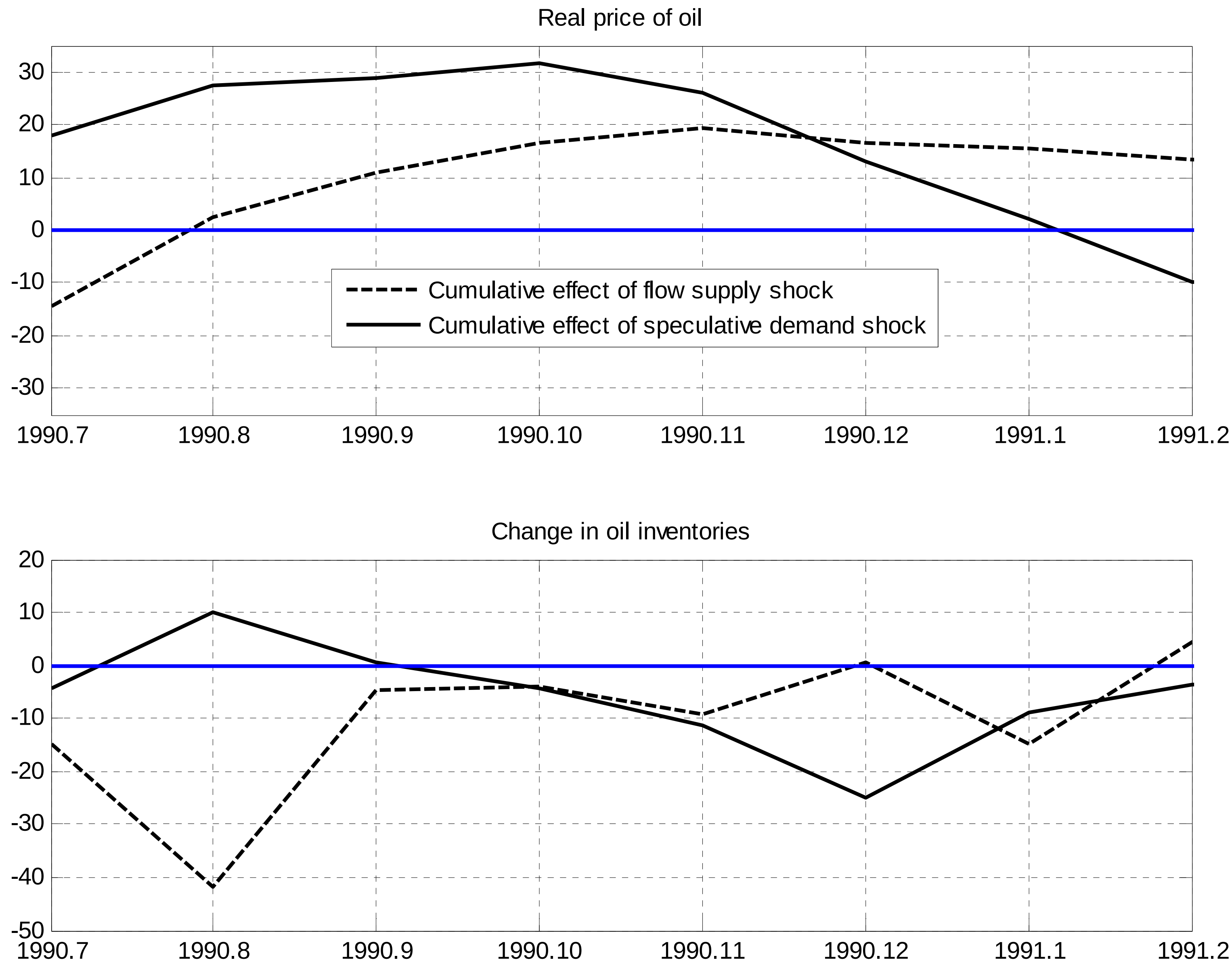
On August 2, 1990, Iraq invaded Kuwait and the real price of oil spiked. Starting in late 1990, the real price collapsed.

- Oil inventories did not increase in August of 1990 as one would have expected in response to a positive speculative demand shock (Hamilton, BPEA 2009).

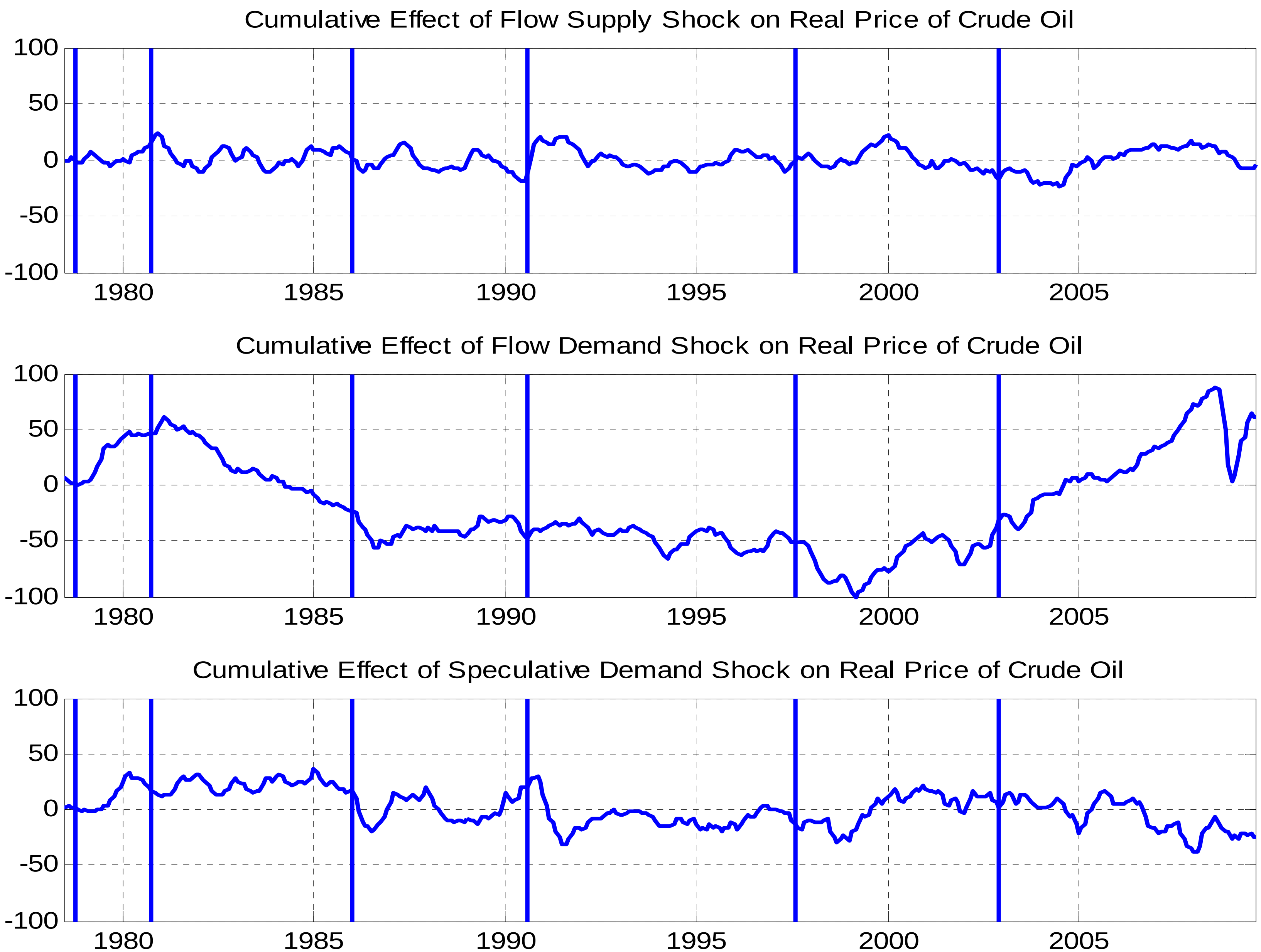
- The absence of a sharp decline in oil inventories in August of 1990 is inconsistent with the view that the price increase reflected a negative oil supply shock.

There was no positive supply shock in late 1990 that could explain the sharp decline in the real price (Kilian, REStat 2008).

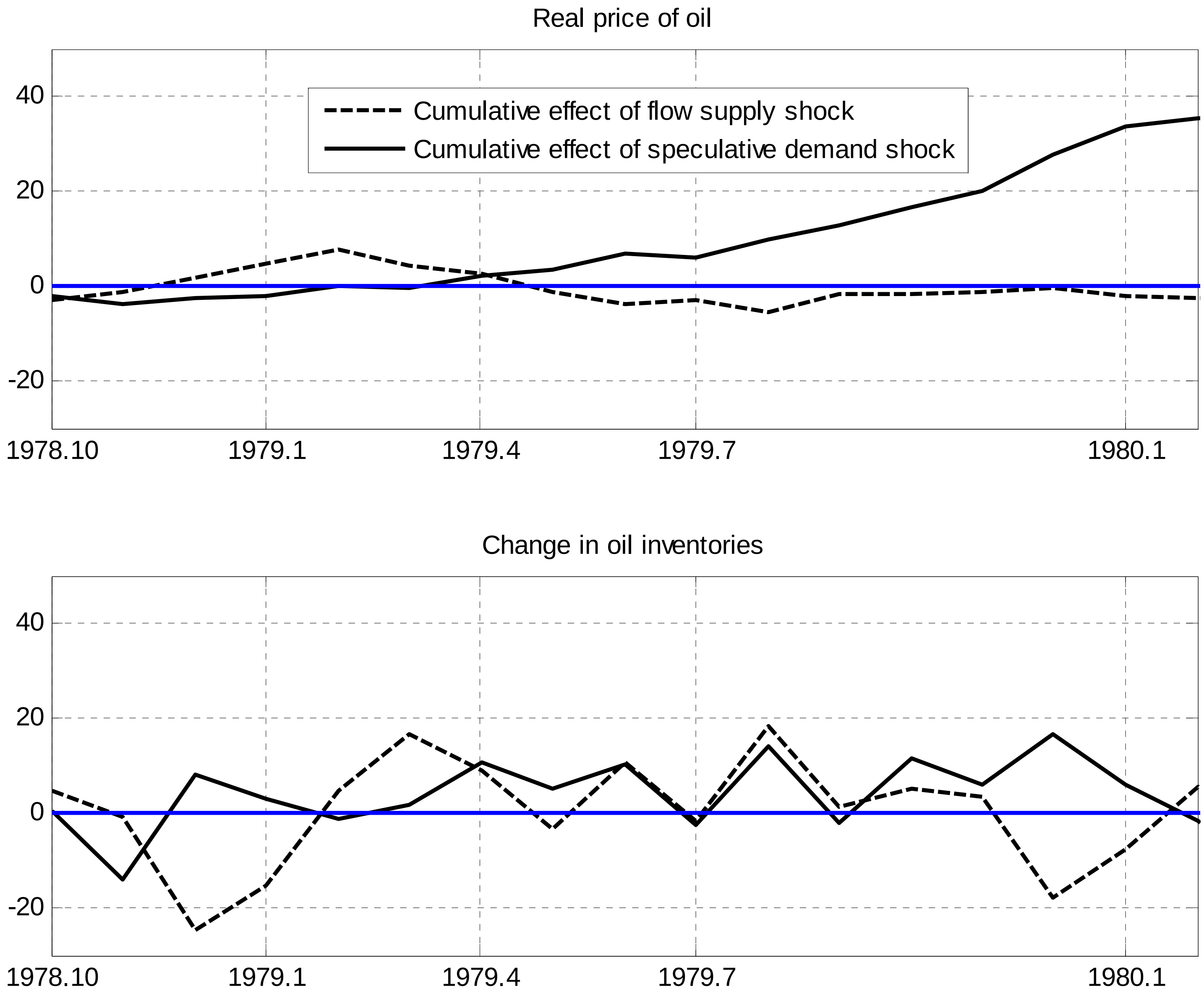
Historical Decompositions for the Persian Gulf War Episode



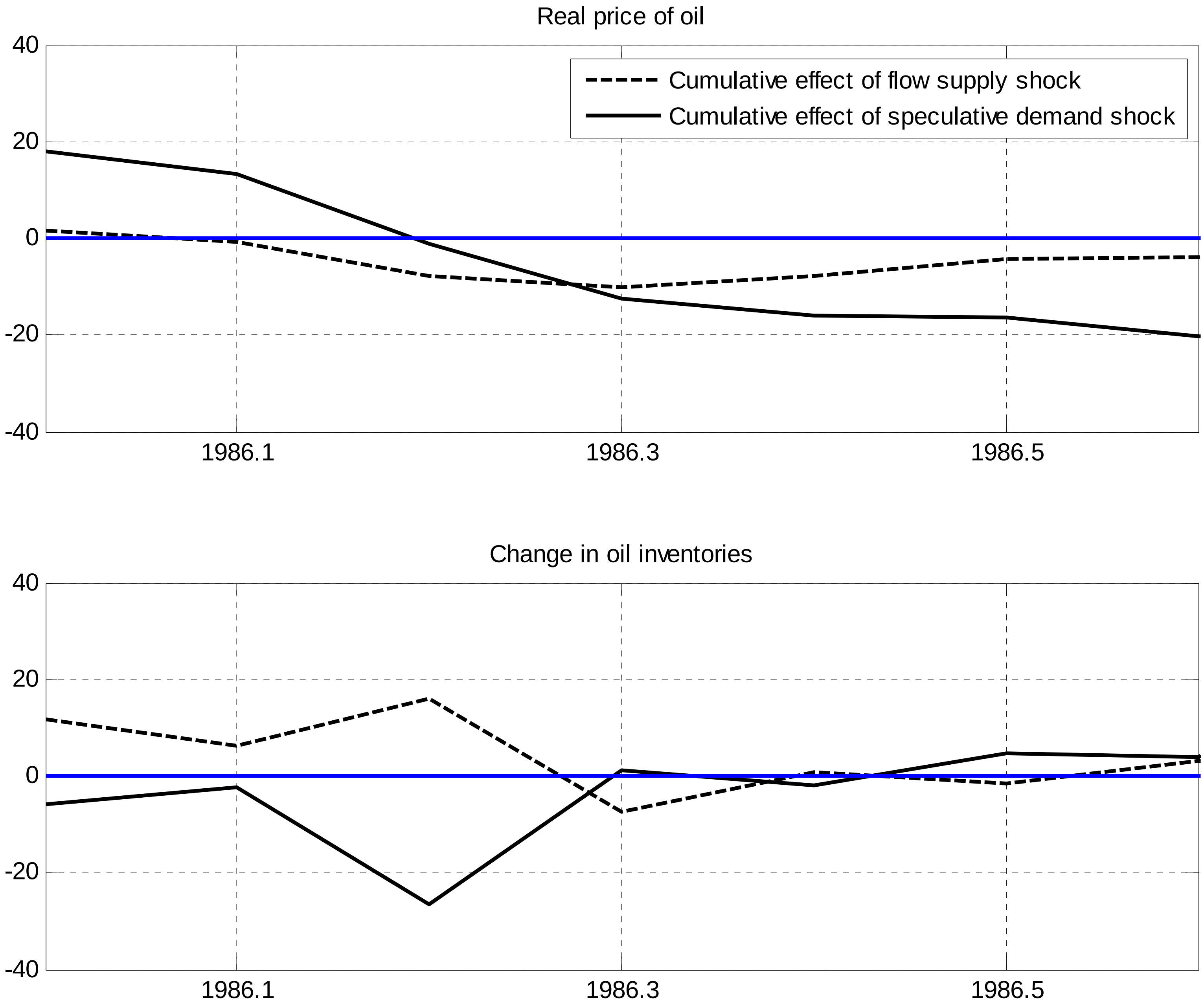
Historical Decompositions for 1978.6-2009.8



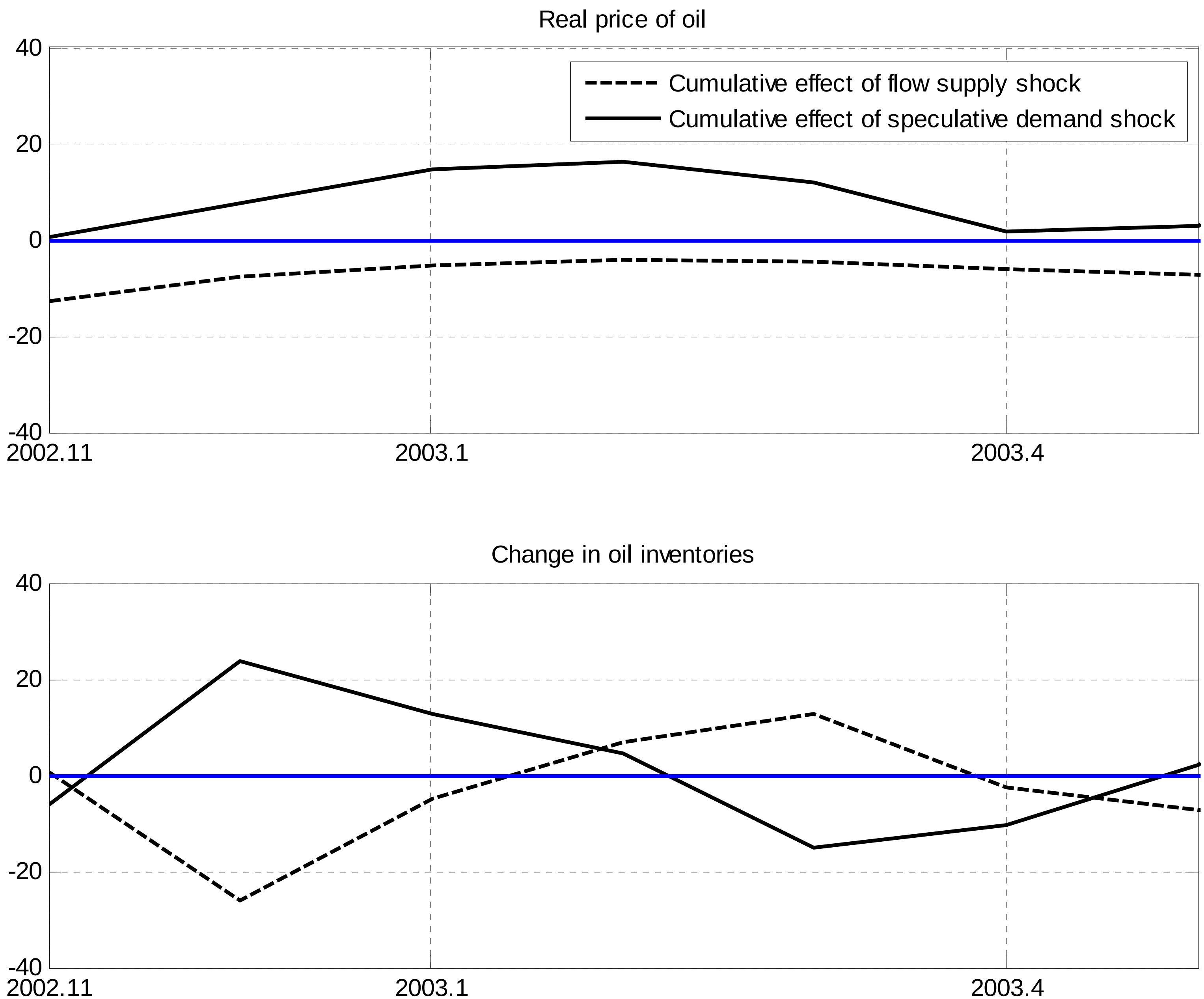
Historical Decompositions for the Iranian Revolution



Historical Decompositions for the Collapse of OPEC in 1986



Historical Decompositions for Venezuelan Crisis and Iraq War



What Explains the 2003-08 Oil Price Surge?

- No evidence that speculation by oil traders was responsible (so whether speculation is desirable or not is moot).
- No evidence that OPEC was behind the oil price increase.
- No evidence that "peak oil" has been the cause.
- Strong evidence that an unexpectedly booming world economy was the cause.

Related evidence in Kilian and Hicks (forthcoming):

$\Rightarrow$ Systematic errors by professional forecasters

$\Rightarrow$ Key role for emerging Asia

Three Policy Conclusions

1. Increased regulation of oil traders will not keep the real price of oil down.

2. Increased domestic oil production in the U.S. will not lower the real price of oil materially.

3. Efforts to revive the world economy will cause the real price of oil to recover, creating a policy dilemma.

Digression: Speculation without a Change in Oil Inventories?

● Hamilton (BPEA 2009): Possible if the short-run price elasticity of gasoline demand is zero.

● This elasticity is closely related to the short-run price elasticity of oil demand: $\eta^{Gasoline} \approx \eta^{Oil\ in\ Use}$

<u>Consensus view on short-run price elasticity of oil demand:</u>

Dahl (1993); Cooper (2003): -0.05, -0.07.

Problems with the Consensus on the Demand Elasticity

- The identification of this parameter requires an exogenous shift of the oil supply curve along the oil demand curve.

- Most of literature on estimating oil demand elasticities does not distinguish between oil demand and oil supply shocks.

- Standard reduced form approach suffers from downward bias. IV is infeasible, but our structural model provides an alternative.

Posterior Probability Distribution of the Short-Run Impact Price Elasticity of Demand for Crude Oil

	$\eta^{Oil\ Production}$	$\eta^{Oil\ Use}$
16th Percentile	-0.80	-0.54
50th Percentile	**-0.44**	**-0.26**
84th Percentile	-0.23	-0.09

Traditional reduced-from estimate on our data:

$$\eta^{Oil\ Production} = -0.02$$

Related structural estimates in literature:

Baumeister and Peersman (2009): $\eta^{Oil\ Production} = -0.38$ (median)

Serletis (2009): $\eta^{Oil\ Production} = -0.35$

Bodenstein and Guerrieri (2011): $\eta^{Oil\ Production} = -0.41$

U.S. Gasoline Consumption 1973.10-2008.10

Is Financial Speculation Different?

● A popular view is that the unprecedented surge in the spot price of oil during 2003-08 cannot be explained by changes in economic fundamentals, but was driven by the increased financialization of oil futures markets.

● It is well documented that, starting in 2003, there was an influx of financial investors such as index funds into oil futures markets.

● At about the same time, both spot and futures prices of crude oil began to surge, soon reaching unprecedented levels and peaking at a record high in mid-2008.

The Masters Hypothesis

- Non-academics such as Michael Masters and George Soros testified before the U.S. Congress that financial investors were taking speculative positions that resulted in rising oil futures prices, which in turn were responsible for a surge in the spot price of oil.

- The veracity of this view is not obvious at all and much of the academic debate centers on the evidence, if any, supporting this hypothesis.

A Stylized Model of Financial Speculation

1. Financial investors (e.g., index funds) after 2003 for exogenous reasons take long positions in the oil futures market.

2. Their demand for long positions drives up the oil futures price.

3. Higher futures prices signal expectations of rising spot prices and hence drive up demand for oil inventories above and/or below ground.

4. Higher inventory demand raises the spot price.

Why Do Policy Makers Pay So Much Attention?

● The Masters hypothesis seems to provide an obvious remedy to the problem of rising oil prices:

To the extent that financial speculation is the cause of the problem of rising oil prices, policies aimed at controlling trades in oil futures markets can be expected to prevent increases in the price of oil.

● This interpretation has informed recent policy efforts to regulate oil futures markets as part of a larger effort by the G20 governments to impose more control on financial markets.

While these policy reactions are perhaps understandable within the broader context of the global housing and banking crisis, they are not based on solid evidence.

Reminder: The Role of Speculation in Oil Markets

Speculation indeed is an important aspect of a functioning oil market and need not be morally reprehensible:

● For example, it seems entirely reasonable for oil companies to stock up on crude oil in anticipation of a disruption of oil supplies (or of rising oil demand) because these stocks help oil companies smooth the production of refined products such as gasoline.

● The resulting oil price response provides incentives for additional exploration, curbs current consumption, and helps alleviate future shortages. Hence, it would be ill-advised for policymakers to prevent such oil price increases.

Speculation versus Excessive Speculation

- The preceding discussion illustrates that speculation is a natural and essential component of the market for crude oil.

- In the public mind, however, speculation (and in particular financial speculation) has a negative connotation because it is viewed as excessive.

What is Excessive Speculation?

● Excessive speculation might be defined as speculation that is beneficial from a private point of view, but would not be beneficial from a social planner's point of view. It follows naturally that the public has an interest in preventing excessive speculation.

● The broad definition of speculation we discussed earlier makes no distinction between socially desirable and undesirable speculation. Indeed, that distinction does not matter for the results in Kilian and Murphy (2010) as long as overall speculation is negligible.

● Defining excessive speculative trading is difficult. The policy debate has focused on four definitions.

What is Excessive Speculation? Definition 1

Traditionally, traders in oil futures markets with a commercial interest in or a physical exposure to oil have been called hedgers, while those without a physical position to offset have been called speculators. This accounting definition is arbitrary, however:

1. The oil futures market cannot function without speculative traders providing liquidity and assisting in the price discovery. The presence of speculators defined as non-commercial traders tells us nothing about whether speculation is excessive.

2. In practice, commercial traders may take a stance on the price of a commodity or may not hedge in the futures market despite having an exposure to the commodity. Both positions could be considered speculative.

What is Excessive Speculation? Definition 2

Yet another argument has been based on the relative size of the oil futures market and the physical market for oil:

It is often asserted that the daily trading volume in oil futures markets is several times as high as daily physical oil production, fuelling the suspicion that speculators are dominating this market.

Academic research, however, shows that this ratio – after taking account of the number of days to delivery for the oil futures contract - is a fraction of about one half of daily U.S. oil usage rather than a multiple, invalidating this argument.

What is Excessive Speculation? Definition 3

An alternative approach has been to quantify speculation as an index measuring the percentage of speculation in excess of what is minimally necessary to meet short and long hedging demand (see Working 1960).

A high Working index number, however, does not necessarily indicate excessive speculation:

1. Index numbers for the oil market even at their peak remain in the midrange of historical experience for other commodity markets.

2. The correlation between the Working index of speculation and daily price changes is near zero.

3. No systematic co-movement between index and oil price.

What is Excessive Speculation? Definition 4

Sometimes excessive speculation is equated with market manipulation.

It has been asserted that financial traders are herding the market into positions from which they can profit, resulting in excessively high oil prices in the spot market.

<u>Problem:</u>

1. Market manipulation and speculation are economically distinct phenomena. The increased financialization of oil markets does not by itself mean that market manipulation is on the rise.

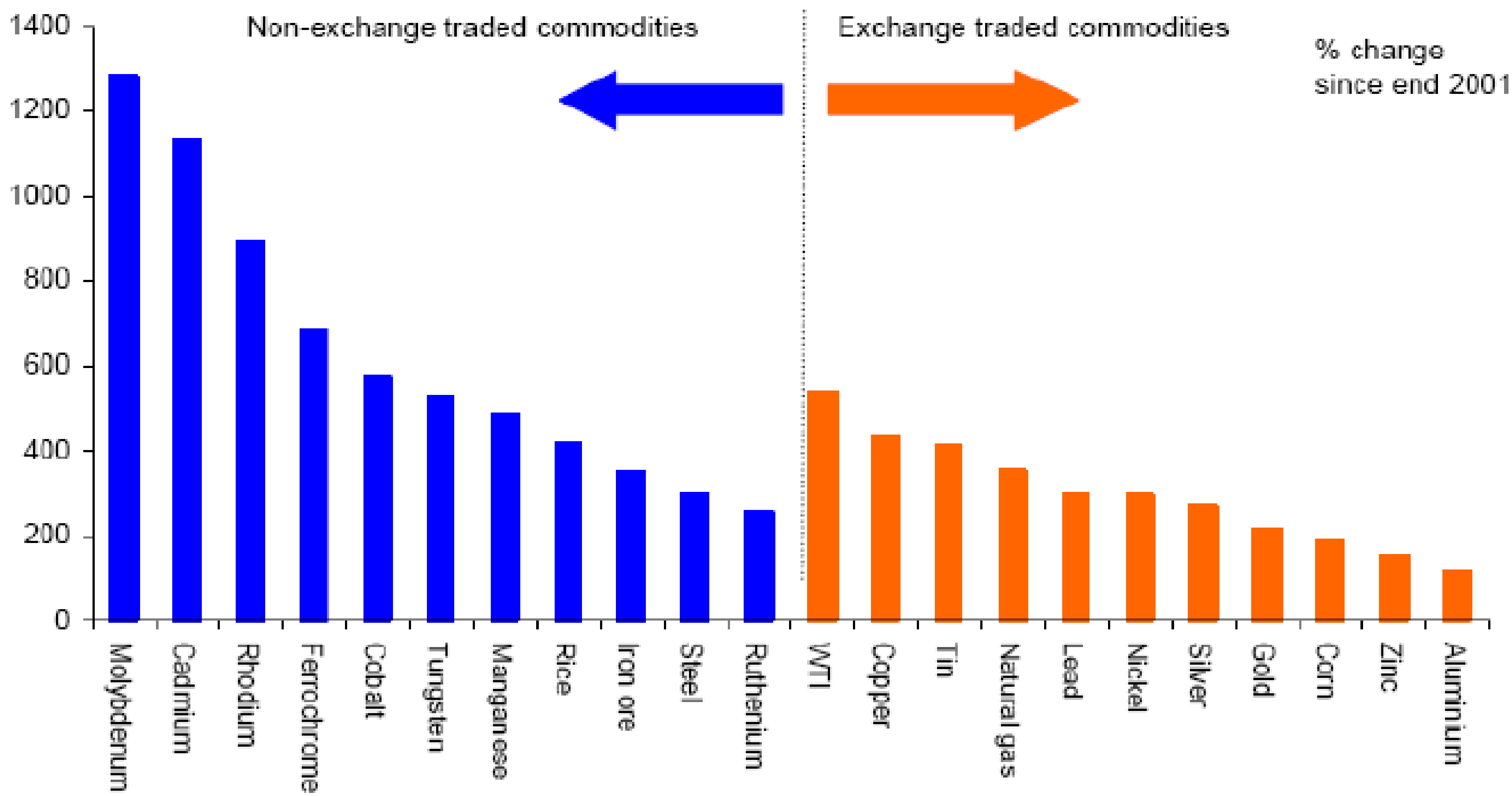
2. There is no widespread evidence of market manipulation in oil futures markets.

Conclusion

- There is no operational definition of excessive speculation.

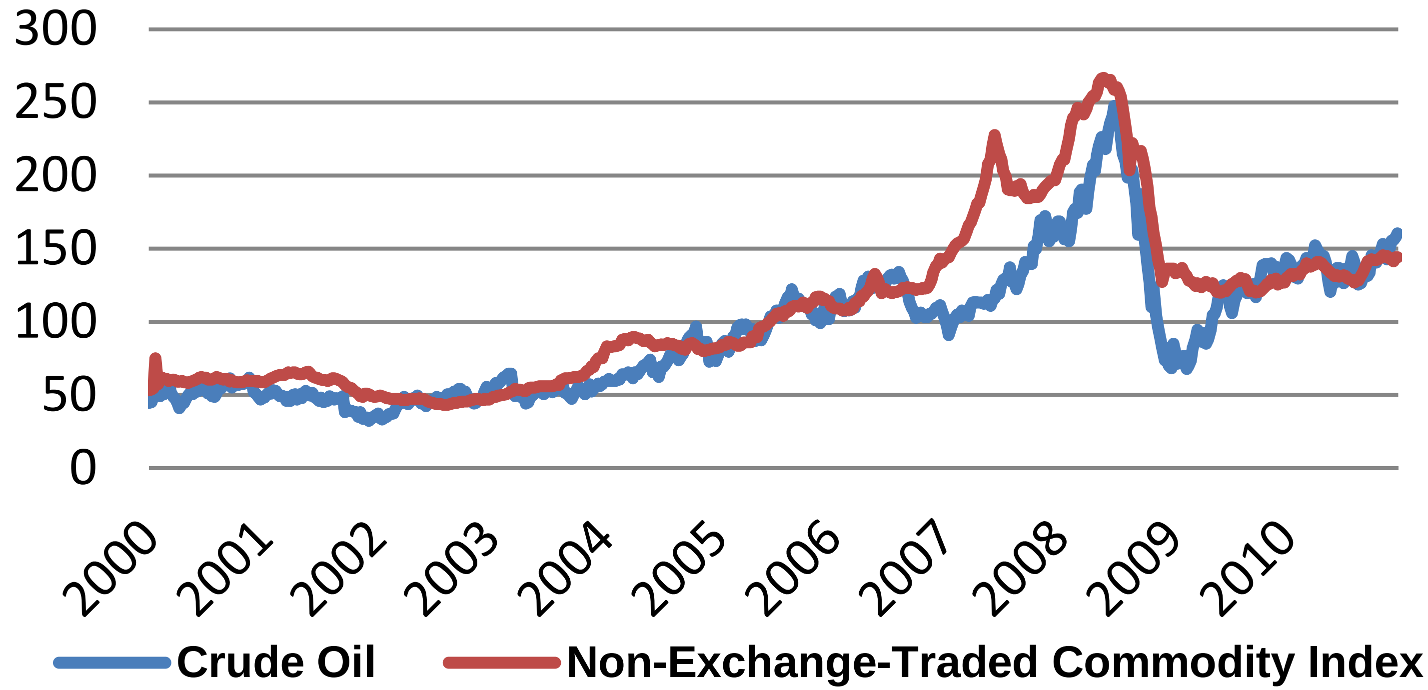
- Indeed, existing academic studies have focused on indirect evidence of excessive speculation rather than direct evidence.

1. Exchange vs. Non-Exchange Traded Commodities



Source: Deutsche Bank, Commodities Weekly, 14 August 2009, Figure 2.

Price of Non-Exchange Traded Commodities and Price of Crude Oil



Source: Computations of the authors based on data in the *IEA Oil Market Report*, March 15, 2011.

2. Do Index Funds Cause Oil Price Increases?

Where is the smoking gun?
Singleton (mimeo 2011) reports that index fund trading helps predict higher returns on oil futures contracts.

Is Masters right after all?

Problems:

- Dynamic correlation is not causation
- Very short sample
- Inappropriate Data

Problems with Singleton's Data

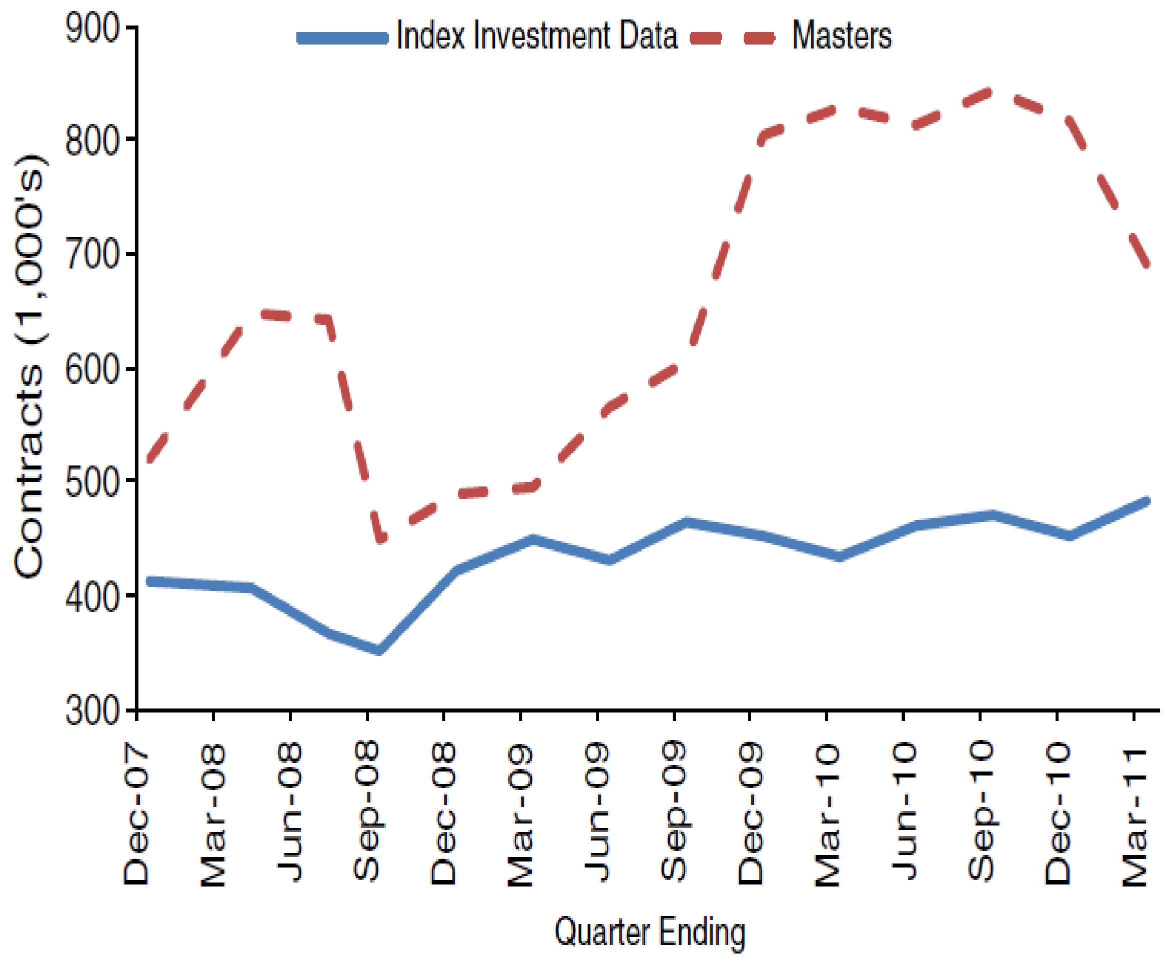
Irwin and Sanders (EnEc 2012):

1. Singleton's measure of index fund positions in oil futures is in fact inferred from CFTC data on agricultural futures, which subsequent research has shown to have little relation to the index funds' actual positions regarding oil.
2. The imputed data used by Singleton (and Masters) not only contain large absolute errors, but have near zero correlation with the best available estimates of actual positions taken by index funds in oil markets.

Büyükşahin and Harris (EnJ 2011):

Using appropriate data there is no evidence that the positions of hedge funds or other noncommercial investors predict changes in the futures price; rather prices predict positions.

Comparison of WTI Crude Oil Net Long Positions Index Investment Data vs. Masters' Estimates



Source: Irwin and Sanders (2012).

Additional Evidence in Hamilton and Wu (2012)

● Agricultural index fund positions predict futures price for oil more accurately than futures price of agricultural commodities.

● Singleton's predictive correlation breaks down when sample is extended by two years.

● Agricultural index fund positions also predict the U.S. stock market. That result is obviously spurious.

⇨ Singleton's results are driven by the 2008 recession.

Problems in Interpreting Predictive Correlations

● To the extent that any evidence of predictive power from index fund holdings to oil futures prices has been found, that evidence has not been based on rigorous real-time analysis and the extent of the *out-of-sample* gains has yet to be quantified.

● Evidence of predictability, if any, is not evidence of causation. This predictive power, if any, may arise simply from traders' positions responding to the underlying fundamentals of the oil market.

3. Shifts in Inventory Demand after 2003?

● Kilian and Murphy (2011) find no evidence of a shift in the demand for above-ground inventories driving up the real price of oil after 2003.

● Nor is there evidence of an unusual accumulation of below-ground oil inventories triggered by reductions in flow supply of crude oil.

<u>Fattouh, Kilian and Mahadeva (2012):</u>
Alternative studies that claim to have found evidence of financial speculation suffer from identification problems and are uninformative (e.g., Lombardi & Van Robays mimeo 2011; Juvenal and Petrella mimeo 2011).

4. Do Oil Futures Prices Predict Spot Prices?

● There is no evidence that oil futures prices significantly improve the out-of-sample accuracy of forecasts of the spot price of oil (Alquist, Kilian and Vigfusson, forthcoming: Hdbk. 2012).

This result holds whether one is forecasting the nominal price or the real price of oil.

● In contrast, there is evidence that models based on economic fundamentals help forecast the spot price of oil out of sample.

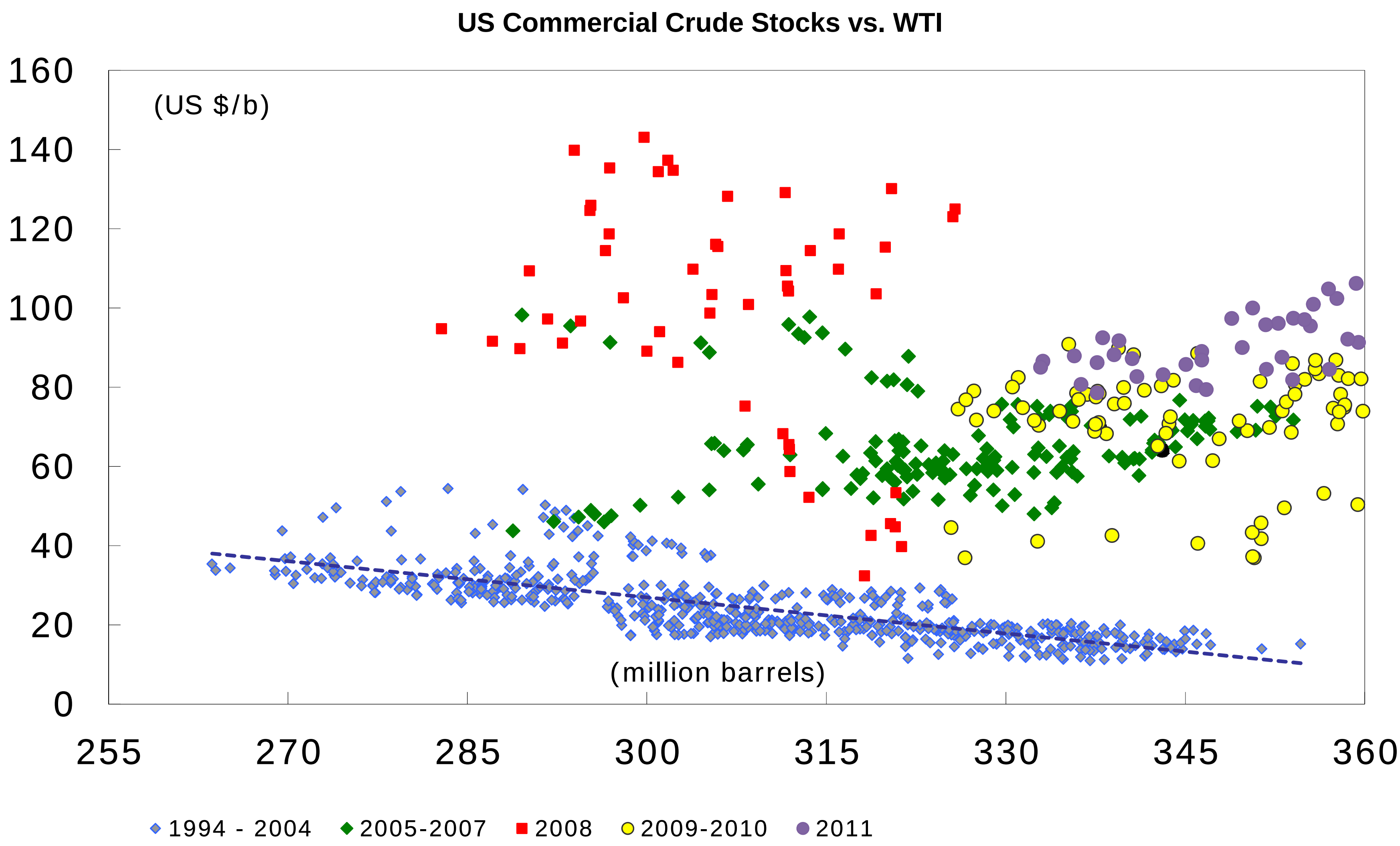
5. Did Index Funds Cause the Oil Price-Inventory Relationship to Collapse?

- The oil price-inventory relationship tells us nothing about the quantitative importance of speculation in oil markets.

- The absence or presence of speculative pressures in the oil market cannot be inferred from studying oil inventory data without a fully specified structural model (see Alquist and Kilian JAE 2010; Kilian and Murphy 2010).

- Evidence of a breakdown of this relationship is based on inappropriate data.

The Crude Oil Inventory-Oil Price Relationship



Source: Computations of the authors based on EIA data.

6. Is There A Role for Time-Varying Risk Premia?

Recently developed theoretical and empirical models of time-varying risk premia may help enhance our understanding of fluctuations in oil prices.

Problems:

1. It is not clear how representative the underlying theoretical models are for the global market for crude oil.

2. Their ability to explain fluctuations in the price of oil has yet to be explored.

3. There is no systematic change in the time-varying risk premium (e.g., Hamilton and Wu 2011).

7. Do Index Funds Cause Oil Price Volatility?

- High oil price volatility is not the problem for 2003 through mid-2008, but high oil prices.

- The literature has shown that the presence of index funds has, if anything, been associated with reduced oil price volatility.

- This view is also supported by historical analyses on the relationship between futures markets and price volatility.

What is the Consensus?

● It is sometimes suggested that academics have failed to adequately address the issue of speculation in oil markets and that more research is needed to establish what seems obvious to many policymakers. This is not the case.

Rather extensive research has produced a near-consensus among academic experts that speculation has not been a key driver of recent oil price fluctuations. This finding has important implication for on-going policy efforts to regulate oil futures markets.

● Policy makers have misdiagnosed the problem and are confused about the objective of regulating oil futures markets.

<u>Problem:</u>
Regulation is more politically opportune than conservation.

Real-Time Out-of-Sample Forecast Accuracy

Baumeister and Kilian (forthcoming: JBES):
The Kilian and Murphy oil market VAR model also is a better predictor of the real price of oil than the random walk (or oil futures prices for that matter):

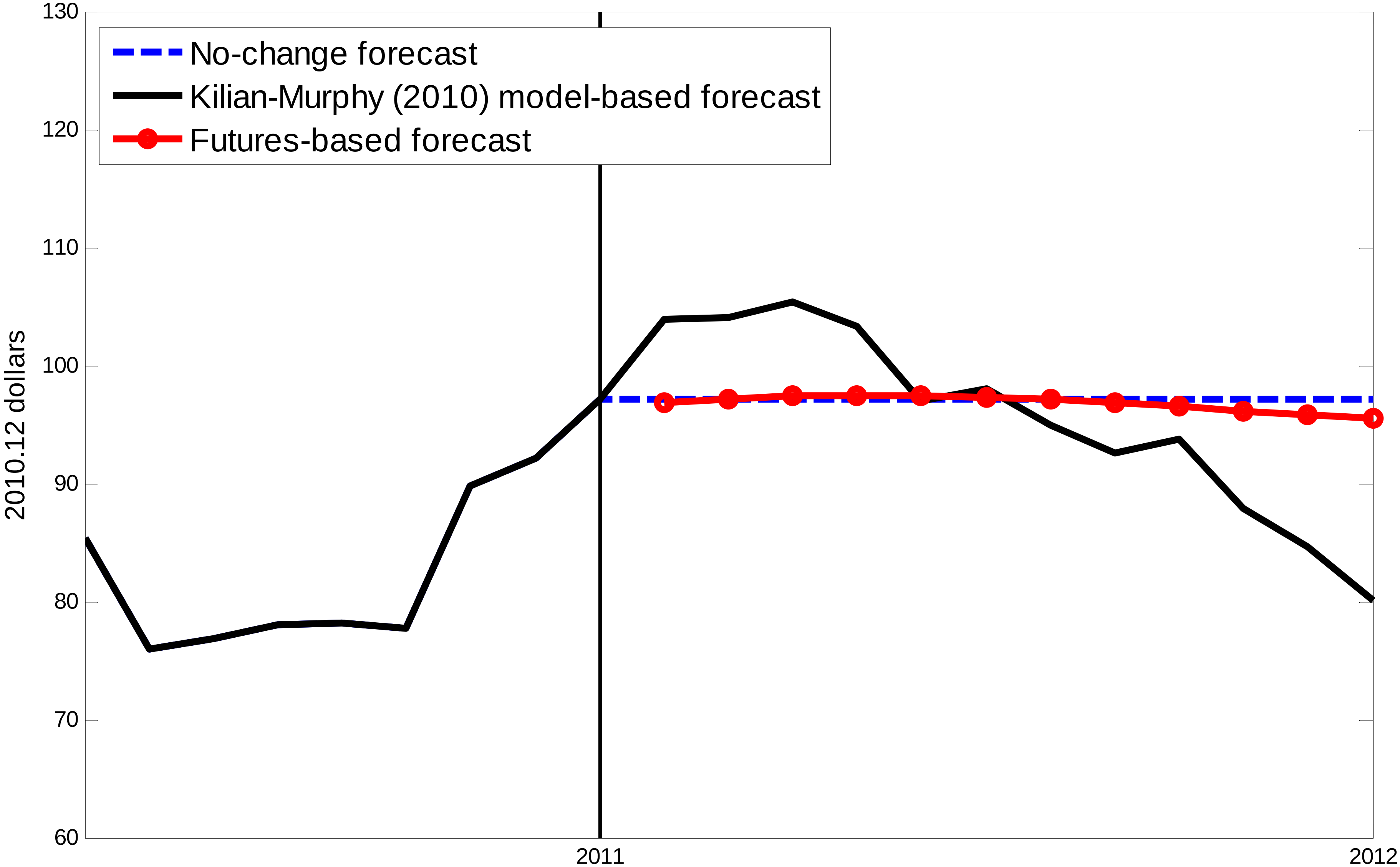
● Large out-of-sample MSPE reductions relative to no-change forecast up to six months (up to 25% in real time); smaller reductions up to one year.

● High and statistically significant real-time directional accuracy for horizons up to one year (as high as to 65%).

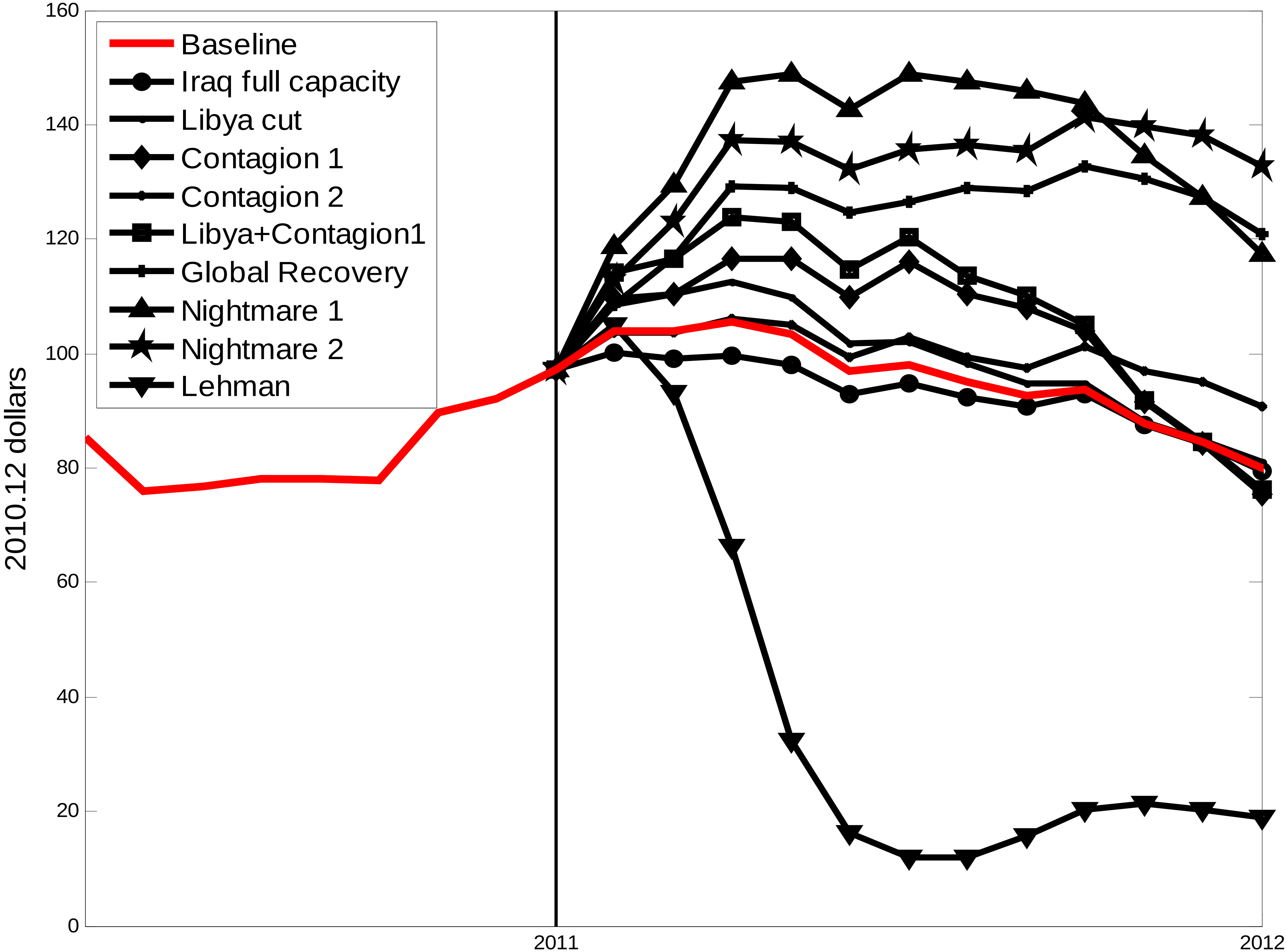
● Model works especially well during financial crisis.

● Model allows construction of forecast scenarios and risk analysis.

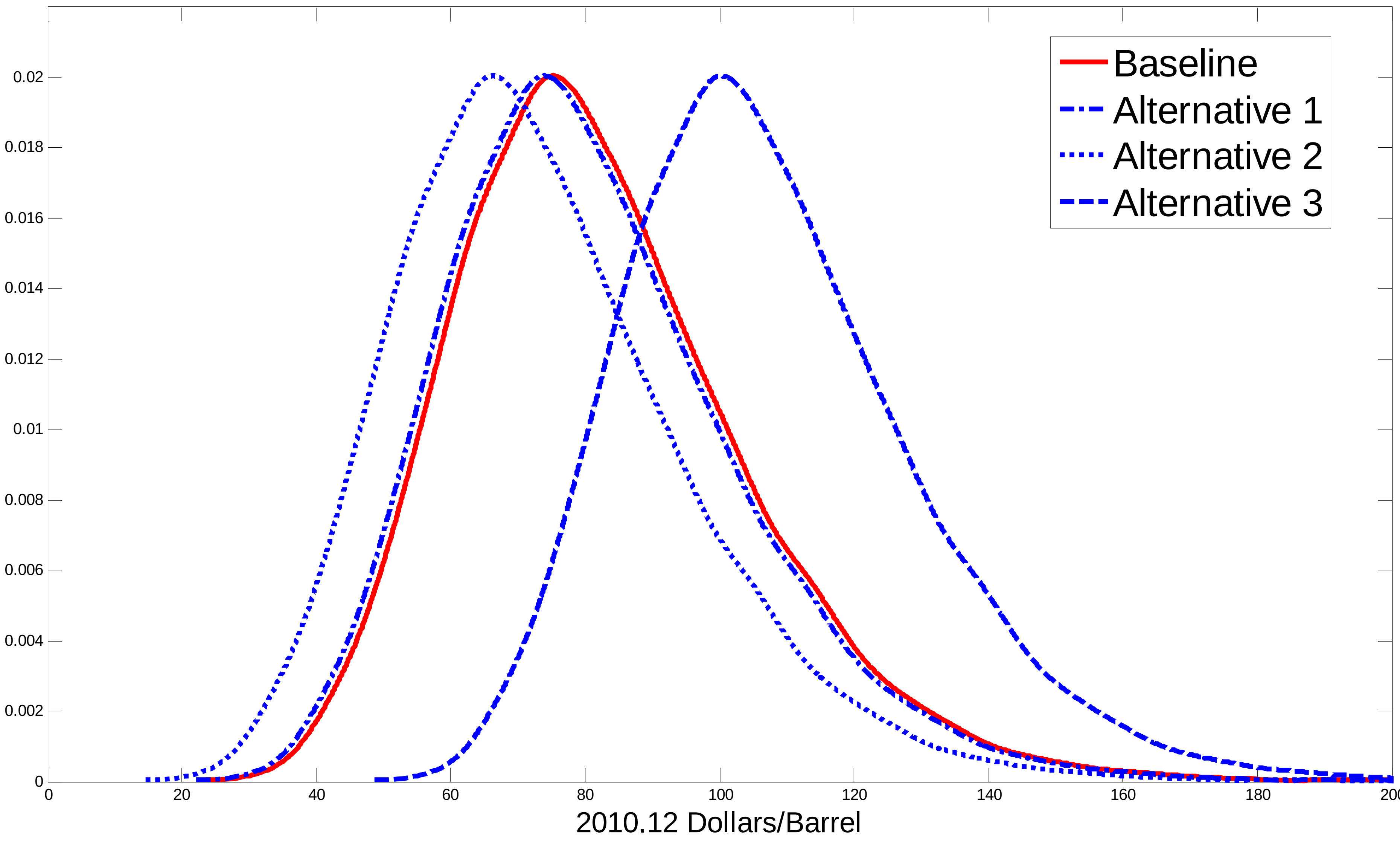
Real-Time Forecasts of Real U.S. Refiners' Acquisition Cost as of 2010.12



Forecast Scenario Analysis as of 2010.12



Real-Time Probability-Weighted 1-Year Ahead Predictive Densities for the Real Price of Oil as of 2010.12: An Illustrative Example



Risk Measures for Probability Weighted Forecast Scenarios
Upside Risks

Scenario	h	$P(R_{t+h} > 100)$	$E(R_{t+h} - 100 \mid R_{t+h} > 100)$	$E(R_{t+h} - 100 \mid R_{t+h} > 100) \times \Pr(R_{t+h} > 100)$
Baseline	3	0.67	13.53	9.06
	6	0.46	17.09	7.93
	12	0.20	16.70	3.27
	24	0.23	23.13	5.37
1	3	0.72	14.25	10.19
	6	0.41	16.63	6.79
	12	0.18	16.50	3.02
	24	0.21	22.93	4.82
2	3	0.61	12.72	7.72
	6	0.26	15.10	3.89
	12	0.12	15.81	1.88
	24	0.16	22.40	3.60
3	3	0.93	21.01	19.54
	6	0.74	21.82	16.15
	12	0.60	21.16	12.64
	24	0.47	25.56	11.92

The presentation touched mainly on four papers with various coauthors:

http://www-personal.umich.edu/~lkilian/km040312.pdf (a revision of this paper will be posted later this week)

http://www-personal.umich.edu/~lkilian/milan030612.pdf

http://www-personal.umich.edu/~lkilian/JBES11183final.pdf

http://www-personal.umich.edu/~lkilian/bk120511new.pdf

More related papers are on my homepage.