

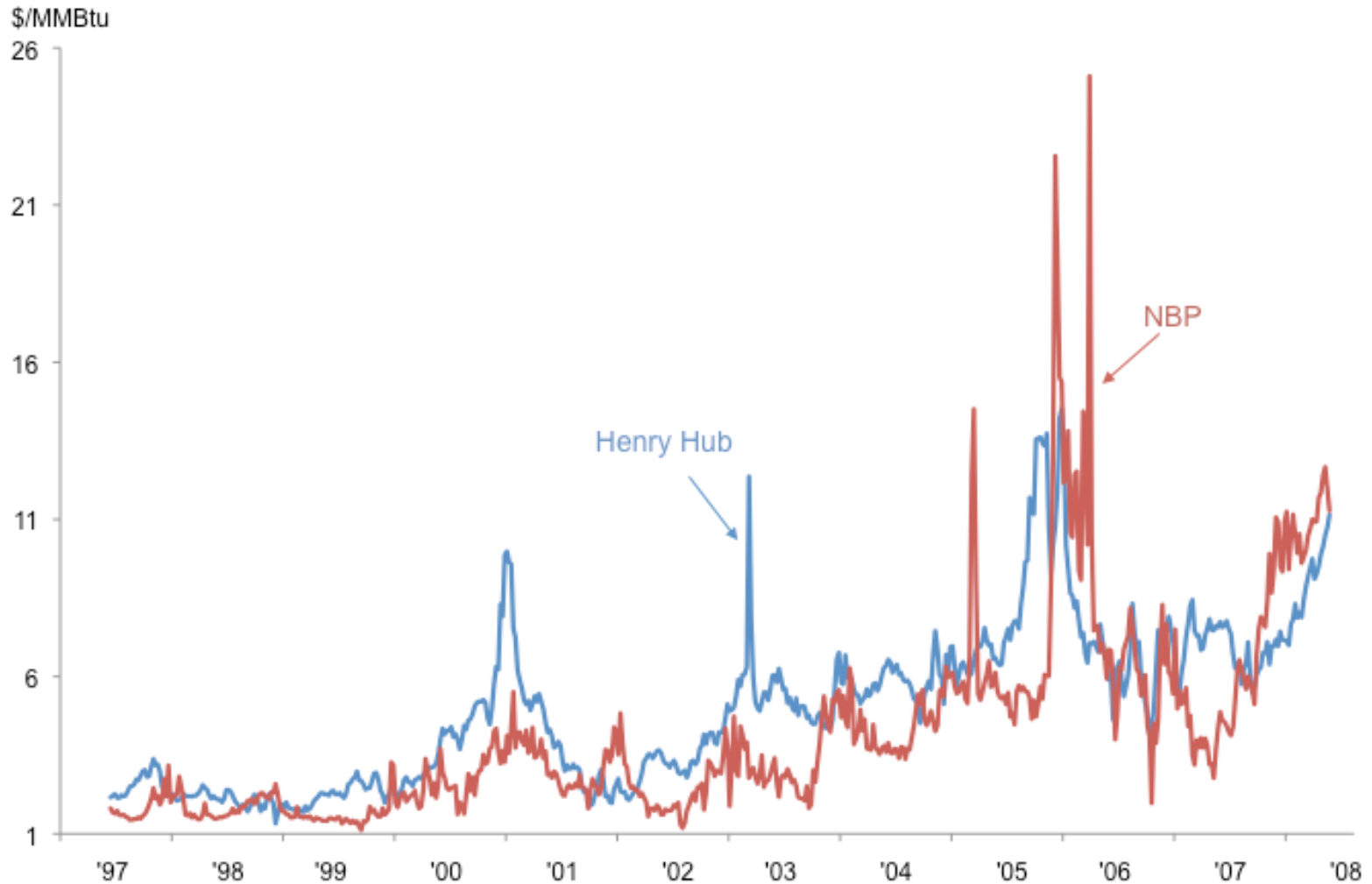
Market Arbitrage: European and North American Natural Gas Prices

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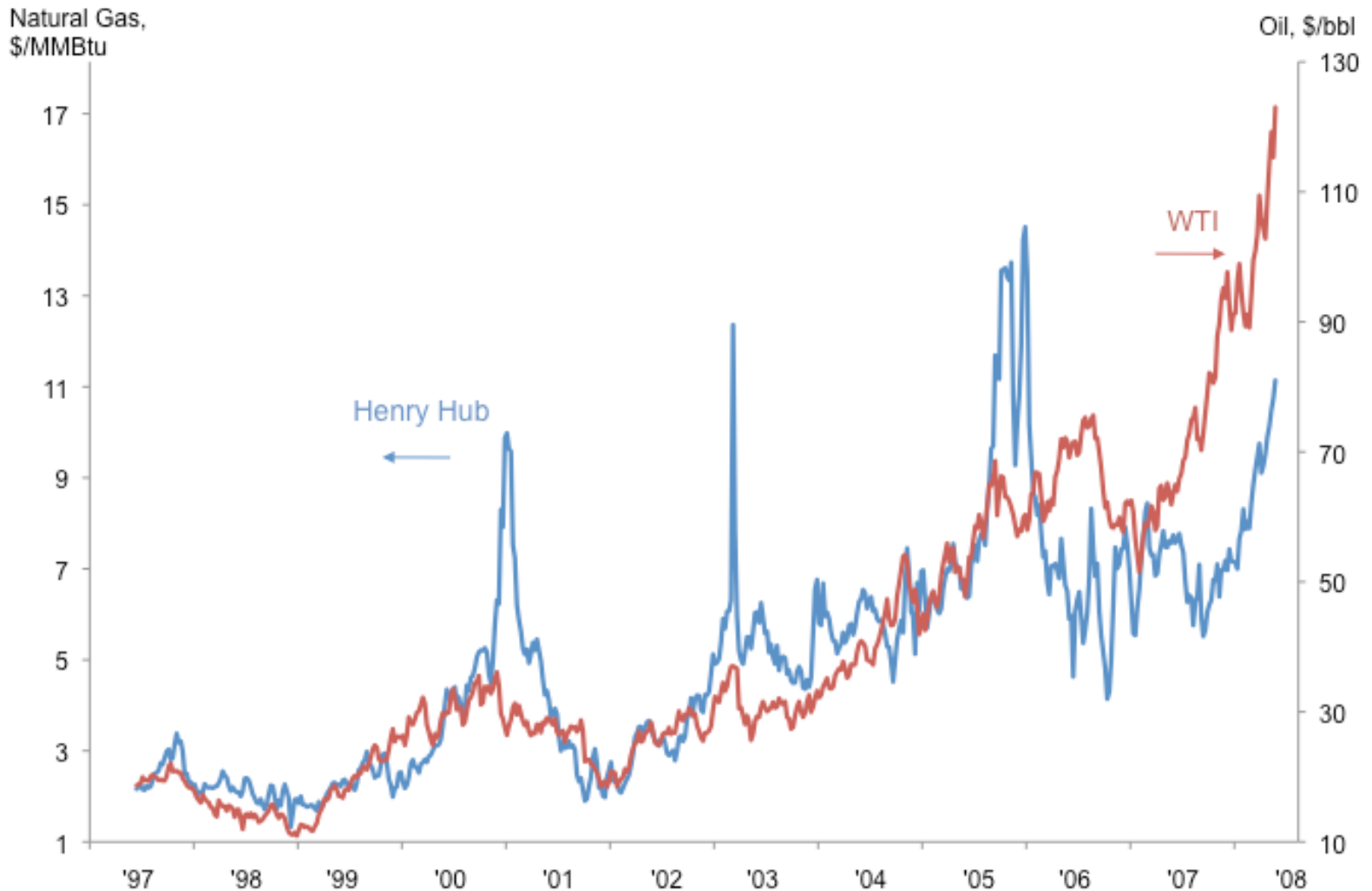
Mine Yücel

Federal Reserve Bank of Dallas

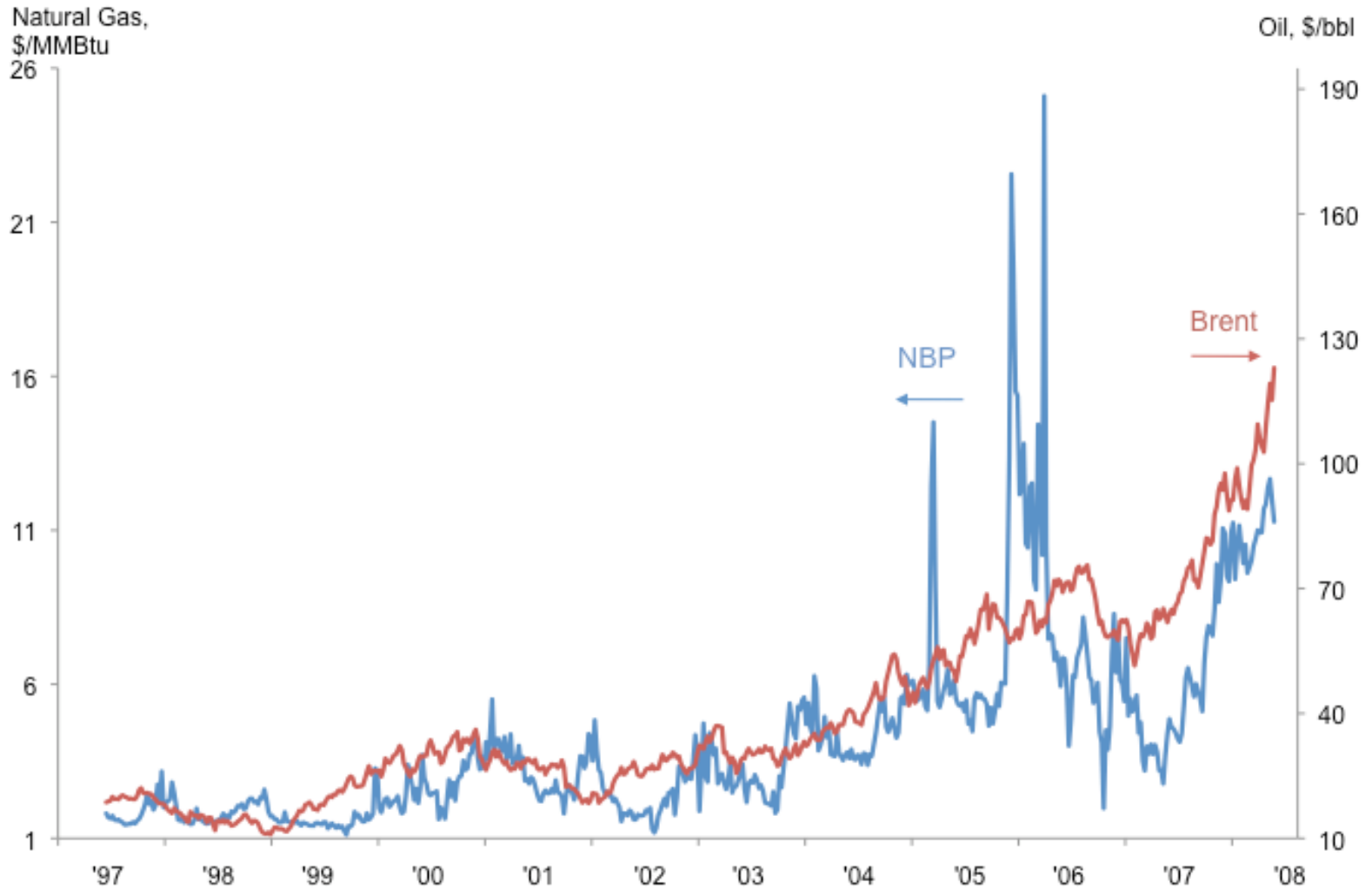
Henry Hub and NBP Prices



Henry Hub and WTI Prices



NBP and Brent Prices



Does LNG facilitate arbitrage across the Atlantic?

- Movements of natural gas prices in Europe and North America are linked to each other
- Movements of natural gas prices on both sides of the Atlantic are linked to those for crude oil
- Our econometric tests: is co-movement of natural gas prices is mediated through crude oil prices?

The Data

- **Weekly data:** June 13, 1997 - May 9, 2008
- **Natural Gas:** Henry Hub (United States) and National Balancing Point (United Kingdom)
- **Crude Oil:** WTI (United States) and Brent (Northern Europe)

- All four price series are difference stationary.
- HH is cointegrated with NBP, WTI and Brent.
- NBP is cointegrated with HH, Brent and WTI.

Bivariate Causality Testing (error-correction models)

HH ↔ NBP

HH ← WTI

HH ← BRENT

NBP ↔ HH

NBP ← WTI

NBP ← BRENT

Multivariate Causality Testing

- Henry Hub
 - WTI and NBP as explanatory variables
 - Brent and NBP as explanatory variables
- NBP
 - WTI and HH as explanatory variables
 - Brent and HH as explanatory variables

Multivariate Causality Testing

	Dependent Variable Henry Hub	
explanatory variables	Significance of Joint F-tests [‡]	Significance of Joint F-tests [‡]
HH lags	0.0533	0.1284
NBP lags & $CI_{HH,NBP}$	0.0723	0.1284
WTI lags & $CI_{HH, WTI}$	0.0207	
Brent lags & $CI_{HH,Brent}$		0.2151
Optimal Lags	4	4
	$R^2=.07$ Adj $R^2=.04$ Significance of Overall F-Statistic: 0.0005 [‡]	$R^2=.05$ Adj $R^2=.03$ Significance of Overall F-Statistic: 0.0166 [‡]

Multivariate Causality Testing

	Dependent Variable National Balancing Point	
explanatory variables	Significance of Joint F-tests [‡]	Significance of Joint F-tests [‡]
NBP lags	0.0029	0.0083
HH lags & $CI_{HH, NBP}$	0.7015	0.7009
WTI lags & $CI_{NBP, WTI}$	0.0708	
Brent lags & $CI_{NBP, Brent}$		0.2430
Optimal Lags	4	4
	$R^2=.11$ Adj $R^2=.09$ Significance of Overall F-Statistic: 0.0000 [‡]	$R^2=.10$ Adj $R^2=.08$ Significance of Overall F-Statistic: 0.0000 [‡]

Multivariate Causality Testing

- Henry Hub
 - with WTI in the model, NBP is marginally significant
 - with Brent in the model, NBP is insignificant
- NBP
 - with WTI in the model, HH is insignificant
 - with Brent in the model, HH is insignificant

Exogenous Variables Affecting Henry Hub

- Heating degree days
- Deviations from normal heating degree days
- Cooling degree days
- Deviations from normal cooling degree days
- U.S. natural gas storage
- Shut-in production in the Gulf of Mexico.

Multivariate Causality Testing with exogenous variables

explanatory variables	Dependent Variable	
	HH Significance of Joint F-tests [‡]	NBP Significance of Joint F-tests [‡]
NBP lags		0.0653
HH lags	0.1597	
HH lags & $CI_{HH,NBP}$		0.3158
NBP lags & $CI_{HH,NBP}$	0.1597	
WTI lags & $CI_{HH,WTI}$	0.0000	
WTI lags & $CI_{NBP,WTI}$		0.0376
Exogenous Variables	0.0000	0.0564
Exogenous Variables, HH lags & $CI_{HH,NBP}$		0.1450
Optimal Lags	4	4
	$R^2=.18$ Adj $R^2=.15$ Significance of Overall F-Statistic: 0.0000 [‡]	$R^2=.13$ Adj $R^2=.10$ Significance of Overall F-Statistic: 0.0000 [‡]

Multivariate Causality Testing with exogenous variables

- Henry Hub
 - With WTI and the exogenous variables in the model, NBP is insignificant
- NBP
 - With WTI and the exogenous variables in the model, HH is insignificant

Conclusions

- Bivariate testing shows coordinated movement of HH and NBP
- Natural gas prices on both sides of the Atlantic adjust to crude oil prices in an error-correction process
- Multivariate testing shows coordinated movement of HH and NBP may be mediated through crude oil prices
- The extensive pricing of LNG against crude oil in Europe could statistically reinforce the relationship between crude oil and natural gas prices

