

LNG and the Relationship between UK and NW European Natural Gas Markets.

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Main Question:

Has the relationship between UK NBP and AGIP changed since the opening of the UK to global LNG trade?

If it did, how...?

- (i) Prices have *permanently* broken away from the old long-term relationship and have entered a new one.
- (ii) Prices broke away from the old relationship and no longer maintain a long-term relationship with each other at all.

Key Results:

- (i) *Evidence of a price decoupling from old to new, much weaker, long-run relationship from middle of 2006.*
- (ii) *From November 2008, the date when UK LNG imports picked up, the long-run relationship appears to break down altogether.*

Contributions

The contributions of this study are threefold:

- (i) First study to take account of important UK spot gas market drivers: seasonality, temperature and gas storage injection/withdrawal behaviour.
- (ii) The effect of pipeline and LNG import capacity extensions on the long-term relationship between UK NBP and oil-indexed gas prices will be analyzed. Use measure of oil-indexed gas prices in the NW European market, the *Average German Import Price*, rather than price for crude oil.
- (iii) Larger dataset compared to previous research, which covered data up until and including 2005, hence import UK gas market events.

Why prices might have decoupled...

Key:

Through LNG the UK natural gas market has opened to international arbitrage for the marginal unit of supply.

Relative *global natural gas prices matter.*

UK NBP and AGIP can reconnect if:

- (i) Spot LNG prices are above AGIP.
- (ii) High UK demand exceeds available spot LNG - NW European imports balance UK market.

...and why it is important.

Key:

Decoupling of UK NBP and oil-indexed gas increases the friction between the two pricing systems.

The dynamic properties of the AGIP-UK NBP price differential is important for:

- (i) Large-scale gas consumers in NW Europe, positioned in long-term oil-indexed supply contracts.

Key: high degree of integration between UK and NW European spot markets.

- (ii) Exporters of natural gas into NW Europe - decoupling increases pressure to move away from oil-indexation.
- (iii) UK consumers - exposure of UK NBP to oil-price shocks.

- 1 Previous research
- 2 Data
 - Natural gas prices
 - Gas market fundamentals
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 - Cointegration
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Previous research produces conflicting results...

- Commonly held view: arbitrage across the IUK connects UK NBP and oil-indexed prices in the NW European market; Barton and Vermeire (1999), ILEX(2001).
- *Contradicting empirical evidence:*
 - (i) Significant cointegration relationship between UK NBP and Brent for period of physical market isolation (1995-98), cointegration rejected from 1998-2002; Asche et al. (2006).
 - (ii) Cointegration holds between UK NBP and Brent over the entire sample between 1996-2003, *before* opening of the IUK; Panagiotidis and Rutledge (2007).
- **Key:** No empirical work on long-term relationship using data post 2005.



Natural gas prices

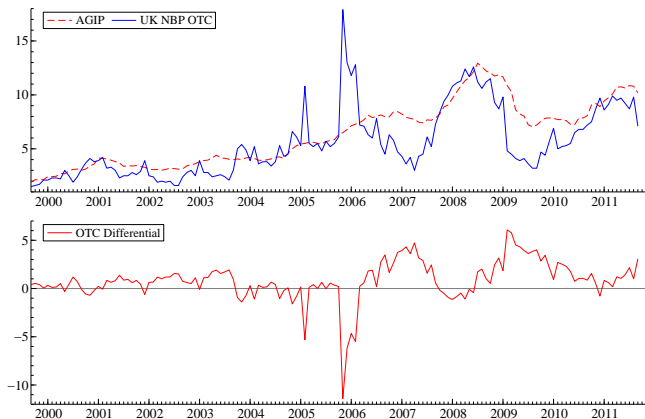


Figure: AGIP, NBP OTC and Differential (in USD/mmbtu): September 1999 to November 2011



Gas market fundamentals

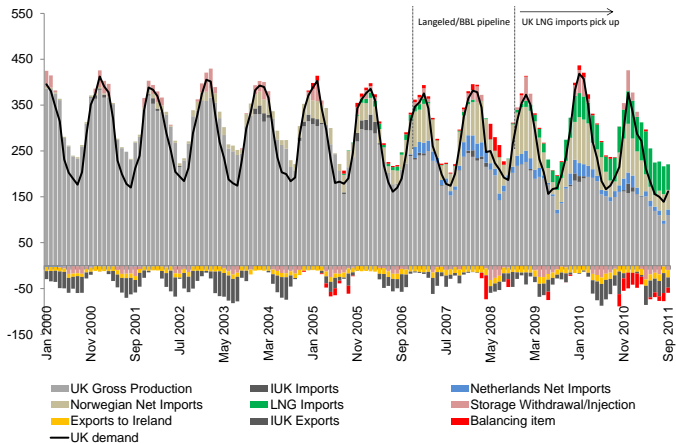


Figure: UK Natural Gas Balance (mcm/day) Jan 2000 - Sep 2011,
Source: DECC, National Grid, author's calculation



Gas market fundamentals

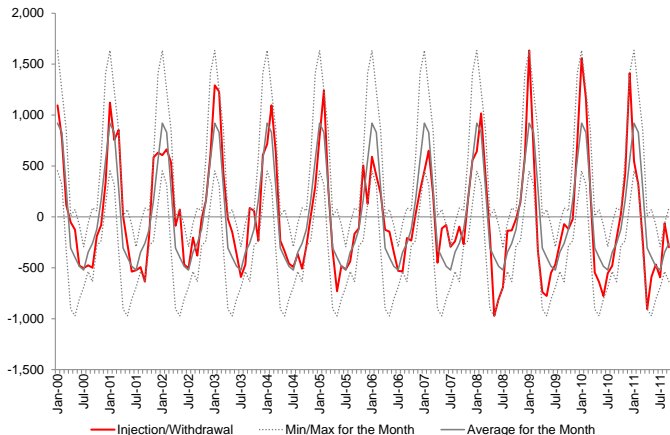


Figure: UK natural gas storage injections (-) and withdrawals (+) (in mcm) - Source: National Grid, author's calculation.



Gas market fundamentals

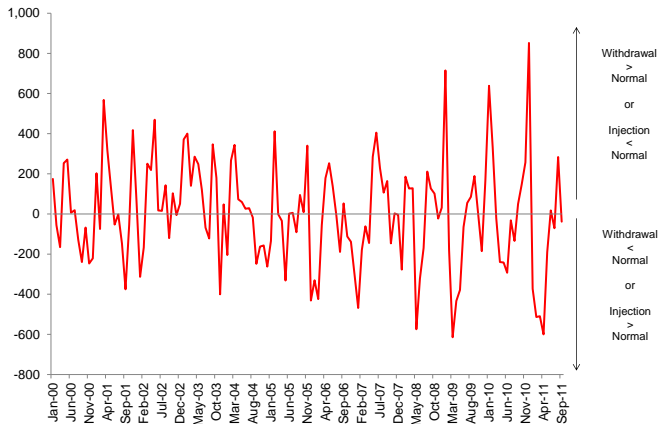


Figure: UK natural gas storage deviations from Normal inj./withdr. (in mcm) - Source: author's calculation.



Gas market fundamentals

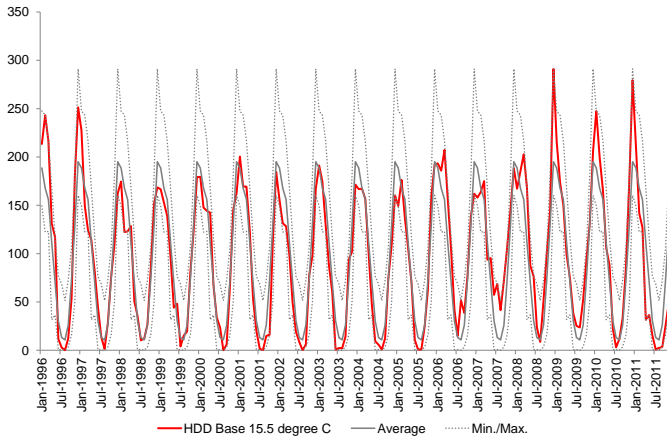


Figure: UK Heating Degree Days (HDD), monthly aggregates - Source: Bloomberg



Gas market fundamentals

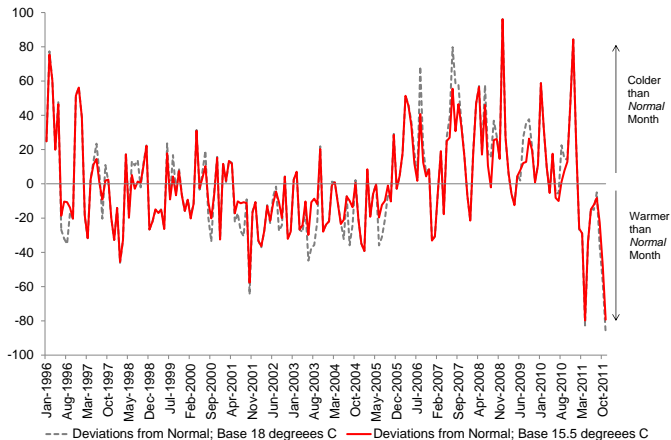


Figure: UK Heating Degree Days (HDD), deviations from normal, monthly aggregates - Source: author's calculation

Is there a break in the cointegrating relationship and have prices decoupled? If so, how?

Following Ramberg and Parsons (2012):

- (i) Prices have *permanently* broken away from the old long-term relationship and have entered a new long-term relationship.

Implies: a regime shift in the cointegrating relationship.

- (ii) Prices broke away from the old relationship and no longer maintain a long-term relationship with each other at all.

Implies: prices are no longer cointegrated.



Following long-run model between UK NBP and AGIP is proposed:

$$\log(nbpt_t^m) = \alpha + \beta \log(agipt_t) + \phi_1 Winter_t^{05/06} + \phi_2 DS_t + \phi_3 DHDD_t + \epsilon_t$$

To test for structural breaks, Gregory and Hansen (1996):

- (i) Test for *coupling* while allowing for single break in both constant α and sensitivity β .
- (ii) Obtain estimated break-date τ .
- (iii) Estimate model on each side of τ separately.



Partition the variation in the AGIP-UK NBP price differential (y_t) into several components:

$$y_t = \mu_t + \gamma_t + \phi_1 \text{Winter}_t^{05/06} + \phi_2 \text{DS}_t + \phi_3 \text{DHDD}_t + \epsilon_t$$

- μ_t stochastic trend component, follows RW.
- γ_t stochastic seasonal, time variant.
- Temperature, storage and winter 05/06 controls.

Test for *structural break* in stochastic trend at two **known** dates: BBL pipeline (December 2006) and the pick-up of UK LNG imports (November 2008).



Table: Cointegration Regressions and Endogenous Breaks

	Dependent: $\log(nbp^{otc})$			Dependent: $\log(nbp^{front})$		
	$m = otc$			$m = front$		
Break†	No	$\tau = 2006(5)$	$\tau = 2006(5)$	No	$\tau = 2006(8)$	$\tau = 2006(8)$
Model		C	C/S		C	C/S
$\log(agip)$	0.9584*** (0.1040)	1.5587*** (0.1336)	1.5293*** (0.1473)	0.9828*** (0.1053)	1.4912*** (0.1367)	1.4443*** (0.1487)
$\log(agip) * \delta_{\tau}^m$	-	-	0.1283 (0.2775)	-	-	0.2208 (0.3053)
Dev. Storage	-0.0001 (0.0002)	-0.0001 (0.0001)	-0.0002 (0.0001)	-0.0002 (0.0002)	-0.0002 (0.0001)	-0.0002* (0.0001)
Dev. HDD(b=15.5)	0.0011 (0.0020)	0.0027* (0.0015)	0.0029** (0.0014)	0.0004 (0.0020)	0.0011 (0.0016)	0.0014 (0.0015)
Constant	-0.1684 (0.1874)	-0.9029*** (0.1950)	-0.8338*** (0.2135)	-0.1361 (0.1896)	-0.7703*** (0.2040)	-0.6768*** (0.2203)
Constant* δ_{τ}^m	-	-0.6711*** (0.1189)	-0.9661* (0.5627)	-	-0.5743*** (0.1214)	-1.0607* (0.6311)
R^2	0.6575	0.7611	0.7657	0.6556	0.7332	0.7389
adj.- R^2	0.6499	0.7541	0.7569	0.6480	0.7253	0.7291
N	140	140	140	140	140	140

* = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level.

(...) Standard errors in parentheses. † break dates estimated using Gregory and Hansen (1996).

Model: (C) break only in level, (C/S) break in both level and slope parameter.



Cointegration

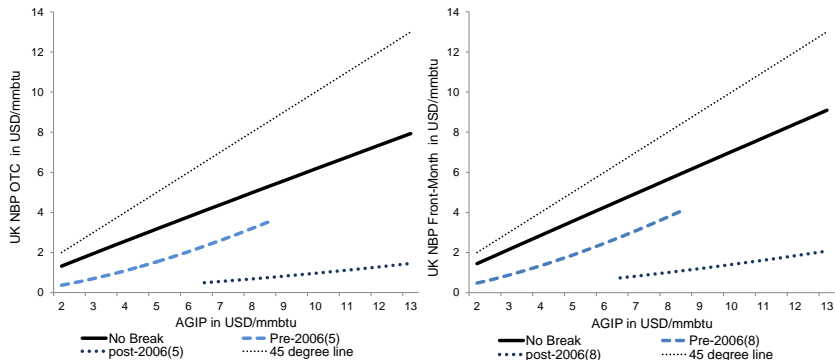


Figure: UK NBP and AGIP Cointegrating Relationships



Unobserved components model

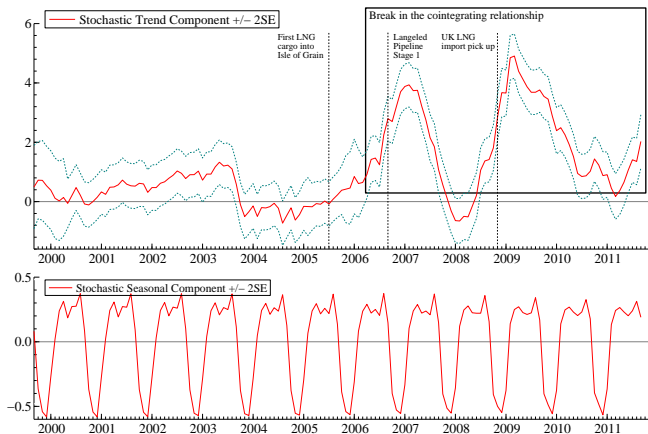


Figure: UC Model 5 (OTC): stochastic trend and break in co-integrating vector

Unobserved components model

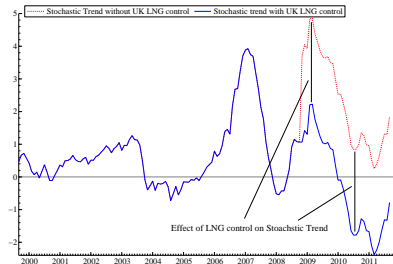
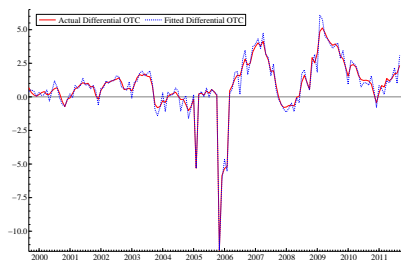


Figure: Final Model: actual and fitted differential, the effect of LNG on the stochastic trend (USD/mmbtu)



Table: Split Cointegration Regressions UK NBP OTC and AGIP

Dependent Variable: $\log(NBP - OTC)$							
<i>Full sample</i>	N	Constant	$\log(AGIP)$	R^2	Engle-Granger τ	Phillips-Ouliaris τ	Hansen [‡]
1999M10:2011M09	144	-0.2747* (0.1489)	1.0174*** (0.0825)	0.6793	-4.6463 [0.0011]	-4.65315 [0.0011]	> 0.2
<i>Break 2006(12)</i>	N	Constant	$\log(AGIP)$	R^2	Engle-Granger τ	Phillips-Ouliaris τ	Hansen [‡]
1999M10:2006M11	86	-0.4961** (0.2006)	1.2335*** (0.1368)	0.6655	-4.4270 [0.0030]	-4.4915 [0.0025]	> 0.2
2006M12:2011M09	58	-1.7975*** (0.4169)	1.6743*** (0.1883)	0.5890	-2.6023 [0.2505]	-2.5196 [0.2838]	[0.1707]
<i>Break 2008(11)</i>	N	Constant	$\log(AGIP)$	R^2	Engle-Granger τ	Phillips-Ouliaris τ	Hansen [‡]
1999M10:2008M10	109	-0.3108* 0.175077	1.0680*** (0.1054)	0.7058	-4.4115 [0.0028]	-4.4578 [0.0024]	> 0.2
2008M11:2011M09	35	-1.5206** (0.6063)	1.5541*** (0.2767)	0.4738	-1.9869 [0.5418]	-1.8954 [0.5873]	[0.1343]

(...) Standard errors in parentheses. [...] MacKinnon (1996) p-values in parentheses.

‡ Hansen (1992) p-values in parentheses.

* = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level.

The null-hypothesis of both Engle-Granger and Phillips-Ouliaris tests is: *no cointegration*.

The null-hypothesis of the Hansen test is: *cointegration*.



Table: Split Cointegration Regressions UK NBP Front-Month and AGIP

Dependent Variable: $\log(NBP - Front)$							
<i>Full sample</i>	N	Constant	$\log(AGIP)$	R^2	Engle-Granger τ	Phillips-Ouliaris τ	Hansen [‡]
1999M10:2011M09	144	-0.2312 (0.1563)	1.0364*** (0.0866)	0.6798	-4.3488 [0.0031]	-3.9463 [0.0109]	[0.1379]
<i>Break 2006(12)</i>	N	Constant	$\log(AGIP)$	R^2	Engle-Granger τ	Phillips-Ouliaris τ	Hansen [‡]
1999M10:2006M11	86	-0.6111*** (0.1953)	1.3796*** (0.1332)	0.7349	-4.4787 [0.0026]	-3.8342 [0.0171]	[> 0.2]
2006M12:2011M09	58	-1.8862*** (0.4079)	1.7390*** (0.1842)	0.5975	-2.5399 [0.2754]	-2.6611 [0.2285]	[> 0.2]
<i>Break 2008(11)</i>	N	Constant	$\log(AGIP)$	R^2	Engle-Granger τ	Phillips-Ouliaris τ	Hansen [‡]
1999M10:2008M10	109	-0.3239* (0.1797)	1.1352*** (0.1081)	0.7310	-4.3516 [0.0034]	-3.7310 [0.0212]	[> 0.2]
2008M11:2011M09	35	-1.3049*** (0.4646)	1.4708*** (0.2120)	0.4664	-1.9270 [0.5716]	-1.8517 [0.6087]	[< 0.01]

(...) Standard errors in parentheses. [...] MacKinnon (1996) p-values in parentheses.

‡ Hansen (1992) p-values in parentheses.

* = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level.

The null-hypothesis of both Engle-Granger and Phillips-Ouliaris tests is: *no cointegration*.

The null-hypothesis of the Hansen test is: *cointegration*.

Conclusion...

- (a) Conventional cointegration analysis:
 - (i) Estimated over the entire sample, AGIP and UK NBP are cointegrated, close to unit elasticity.
 - (ii) Endogenous break estimation suggest level and constant change in the middle of 2006.
 - (iii) Split estimation provides better fit, explaining between 8-10% more of UK NBP vol.
 - (iv) Substantial drop in constant indicates drastically weakened long-run relationship.
 - (v) Evidence of a price *decoupling* from old to new, much weaker, long-run relationship from middle of 2006.



...continued.

(b) Unobserved components modelling:

- (i) Continuous decline in seasonal pattern confirms reduced influence of seasonal arbitrage on price differential.
- (ii) Trend departure from zero in middle of 2006 - break in cointegrating relationship.
- (iii) Evidence of a price *decoupling* from old to new, much weaker, long-run relationship from the end of 2006.
- (iv) From 2008(11) LNG, long-run relationship appears to break down altogether. **Key:** despite tight Asian LNG market!

Problem: low post-break sample size.

Going forward...

- (a) Repeat analysis as more data on post-break sample becomes available. Possible results:
 - (i) Reject CI in post-break sample. Parameters meaningless. Price no longer maintain long-run relationship.
 - (ii) Accept CI in post-break sample and confirm new, much weaker, long-run relationship.

Both cases suggest the relationship between UK NBP and AGIP is broken.

- (b) Include (Asian) spot LNG price. Determine whether the price of spot LNG has taken over from AGIP in setting the UK NBP in periods of peak UK demand.

Thank you!

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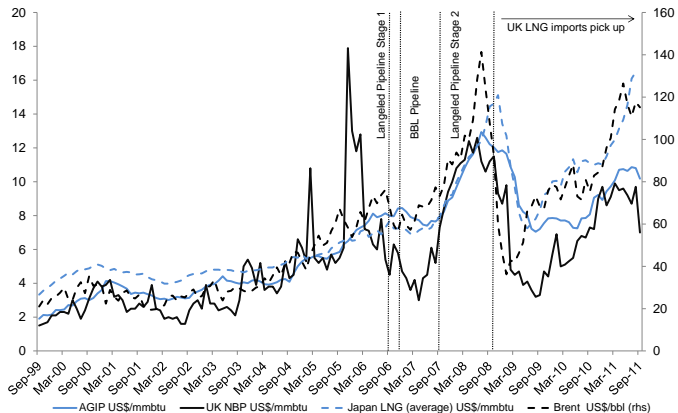


Figure: UK NBP day-ahead, AGIP and Japan LNG import price in USD/mmbtu (lhs), Brent crude oil in USD/bbl (rhs) September 1999-2011, Source: Bloomberg, BAFA

Table: UK LNG Regasification Capacity

Terminal Name	Operator/Developer	Commissioning Date	Landfall in the UK	Capacity in <i>bcma</i>
Isle of Grain 1/2	National Grid	2005	Isle of Grain	13.5
Gasport	Excelerate	2007	Teesside	≈ 4
Dragon	BG/Petronas	2009	Milford Haven	6
South Hook 1	QP/ExxonMobil	2009	Milford Haven	10.5
South Hook 2	QP/EconMobil	2010	Milford Haven	10.5
Isle of Grain 3	National Grid	2010	Isle of Grain	7
			Total existing	≈ 51.5
Isle of Grain 4	National Grid	?	River Medway	?

Source: Heather (2010) and National Grid (2010). QP Qatar Petroleum. BG British Gas (Centrica).

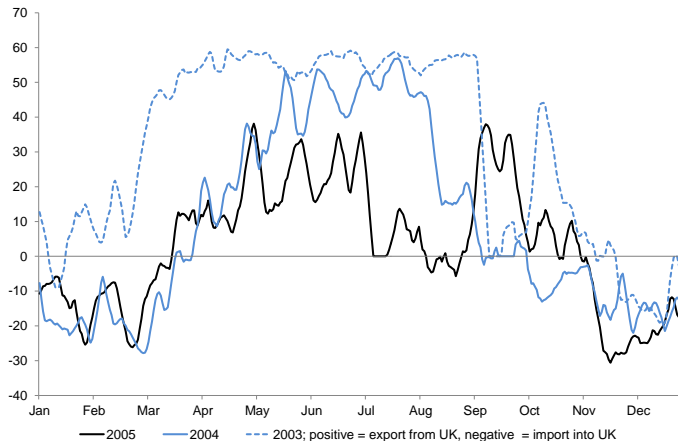


Figure: Interconnector Daily Pipeline Flows pre LNG (Weekly average in mcm/day) 2003-2005, Source: Interconnector

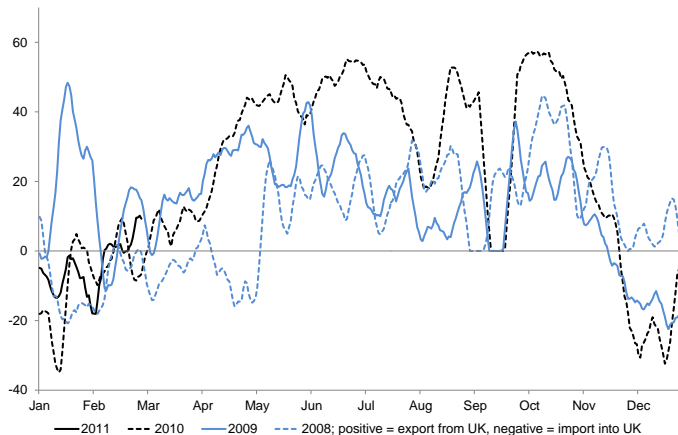


Figure: Interconnector Daily Pipeline Flows post LNG (Weekly average in mcm/day) 2008-2011, Source: Interconnector

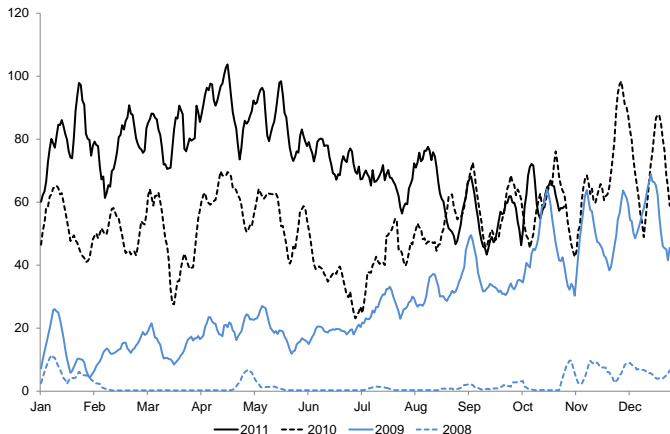


Figure: UK LNG imports (Weekly average in mcm/day) 2011-08, Source: Bloomberg/NationalGrid

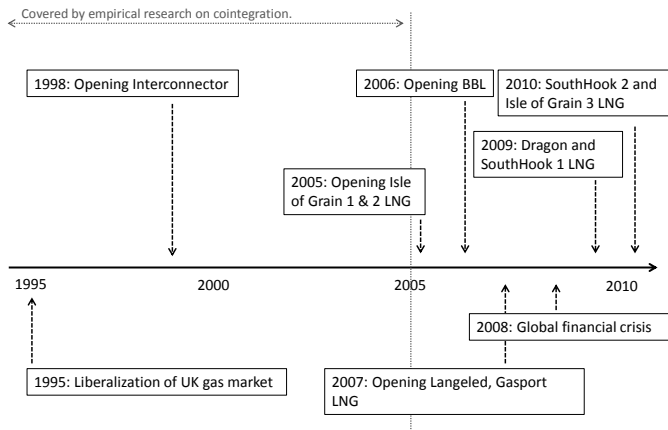


Figure: Major Events in the UK Gas Market, 1995-2010

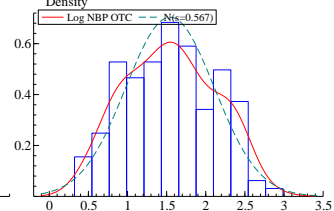
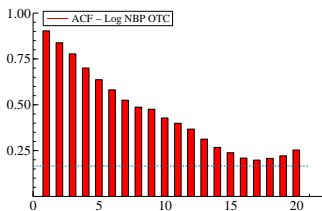
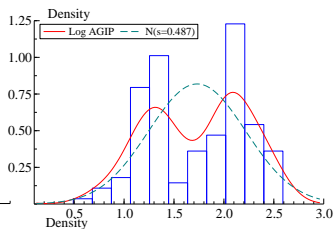
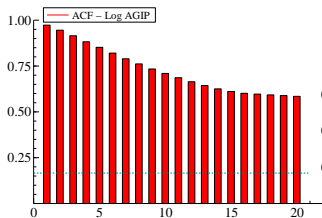


Figure: Distribution and ACF: Log Prices

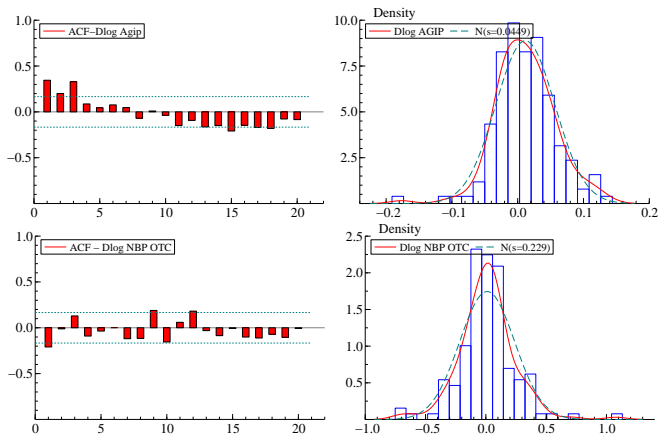


Figure: Distribution and ACF: 1-month difference - Log Prices

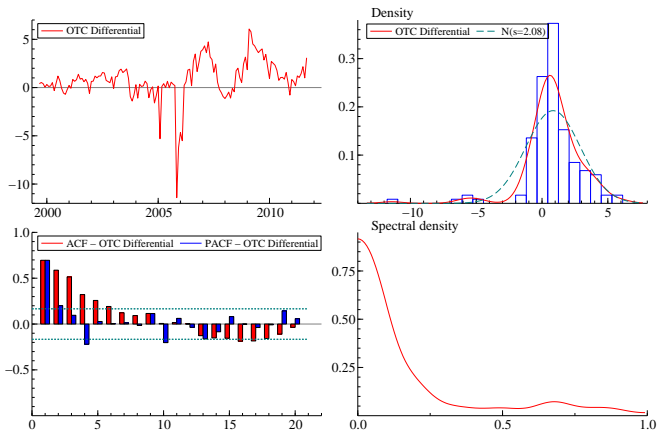


Figure: AGIP-NBP OTC differential, ACF (PACF), distribution and spectral density

Table: UK Natural Gas Storage Injection/Withdrawal, deviations from normal

Deviation	Storage Injection	or	Storage Withdrawal	Count	Hypothesized Effect on UK NBP spot price
$DS_t > 0$:	<i>< Normal</i>	or	<i>> Normal</i>	71	<i>Upward pressure</i>
$DS_t < 0$:	<i>> Normal</i>	or	<i>< Normal</i>	70	<i>Downward pressure</i>

$DS = \text{Actual Injection (Withdrawal)} - \text{Normal Injection (Withdrawal)}$

Table: UK Heating Degree Days (HDD), deviation from normal

HDD Deviation	Count Baseline 18C	Count Baseline 15.5C	Hypothesized Effect on UK NBP spot price
$DHDD_t > 0$:	67	65	<i>Upward pressure</i>
$DHDD_t < 0$:	74	76	<i>Downward pressure</i>

$DHDD = \text{ActualHDD for the month} - \text{Normal (Average) for the month.}$

Table: Descriptive Statistics

	AGIP	UK NBP Front	UK NBP OTC	Log Differential OTC	Log Differential Front	Dev. Storage	Dev. HDD <i>base=15.5</i>	Dev. HDD <i>base=18</i>
Observations	141	141	141	141	141	141	141	141
Mean	6.4501	6.0416	5.5943	0.1885	0.1136	-0.9854	0.6733	0.6491
Median	6.4910	5.2880	4.8000	0.1450	0.1028	1.5406	-2.8933	-4.3750
Maximum	12.9362	18.6203	17.9000	0.9471	0.8154	852.0697	96.1067	96.1067
Minimum	2.4154	1.7814	1.6000	-1.0144	-1.0538	-614.3223	-79.7375	-82.7062
Std. Dev.	2.8585	3.3898	3.1503	0.3160	0.3189	260.8423	25.8353	29.9141
Skewness	0.4013	1.0001	1.0546	-0.3037	-0.2354	0.2011	0.6392	0.5510
Kurtosis	2.0250	3.6163	3.7256	4.2352	3.6911	3.4694	4.4921	3.5140
JB (p-value)	0.0092	0.0000	0.0000	0.0038	0.1283	0.3256	0.0000	0.0130

JB is the Jarque-Bera test for normality (null hypothesis: normally distributed). The sample covers September 1999 - September 2011.

Log Differential OTC = $\ln(\text{AGIP}) - \ln(\text{NBP OTC})$; *Log Differential Front* = $\ln(\text{AGIP}) - \ln(\text{NBP Front})$

Table: Unit Root Tests

		Levels		First Differences	
		t-Statistic	Prob.*	t-Statistic	Prob.*
Log AGIP	ADF	-1.5847	0.4878	-8.3079	0.0000
	PP	-1.8995	0.3318	-8.6210	0.0000
Log NBP OTC	ADF	-2.8369	0.0557	-14.6156	0.0000
	PP	-2.6473	0.0860	-14.6339	0.0000
Log NBP Front	ADF	-2.5214	0.1125	-9.3982	0.0000
	PP	-1.9917	0.2903	-9.3026	0.0000
Log Differential OTC	ADF	-4.6208	0.0002	-	-
	PP	-4.6237	0.0002	-	-
Log Differential Front	ADF	-4.3322	0.0006	-	-
	PP	-3.9740	0.0021	-	-
Differential OTC	ADF	-3.7060	0.0049	-	-
	PP	-4.9030	0.0001	-	-
Differential Front	ADF	-4.4254	0.0004	-	-
	PP	-4.1584	0.0011	-	-

*MacKinnon (1996) one-sided p-values, including constant. Lag-length selection based on Schwartz information criterion (min-lag=0, max-lag=13)

Null-hypothesis: the series is integrated of order one, $I(1)$.

ADF= Augmented Dickey-Fuller; PP = Phillips-Perron



Table: Cointegration Tests

Johansen System Cointegration Test				
Series: $\log(agip)$, $\log(nbp^{OTC})$				
Sample (adjusted): 2000M02 2011M09				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.1336	22.2187	15.4947	[0.0042]
At most 1	0.0152	2.1398	3.8415	[0.1435]
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.1336	20.0789	14.2646	[0.0054]
At most 1	0.0152	2.1398	3.8415	[0.1435]
1 Cointegrating Equation:		Log likelihood		288.93
Normalized cointegrating coefficients			$\log(nbp^{OTC})$	$\log(agip)$
			1.0000	-0.9719 (-0.1008)
Adjustment coefficients			$D\log(nbp^{OTC})$	$D\log(agip)$
			-0.3306 (-0.0882)	0.0219 (-0.0156)

(...) Standard errors in parentheses. Both Trace and Max-Eigen tests indicate

1 cointegrating equation at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level.

**MacKinnon-Haug-Michelis (1999) p-values

Table: Cointegration Tests

Single-Equation Cointegration Tests				
Series: $\log(AGIP)$, $\log(NBP - OTC)$				
Sample: 1999M09 2011M09				
<i>Engle-Granger</i> [†]				
Dependent	τ -statistic	Prob.*	z-statistic	Prob.*
$\log(UKNBPOTC)$	-4.6463	0.0011	-37.8681	0.0006
$\log(AGIP)$	-2.9623	0.1260	-17.9166	0.0746
<i>Phillips-Ouliaris</i>				
Dependent	τ -statistic	Prob.*	z-statistic	Prob.*
$\log(NBP - OTC)$	-4.6531	0.0011	-37.9991	0.0006
$\log(AGIP)$	-3.6469	0.0252	-24.0454	0.0189
Null-hypothesis: Series are not cointegrated. † automatic lags specification based on Schwarz criterion (maxlag=13). *MacKinnon (1996) p-values.				

Table: UC Estimation Output - Dependent variable: Differential OTC

<i>Model</i>	1	2	3	4	5	6	7 [†]
<i>Final State</i>							
Level	1.8898	2.2061	2.2508	2.1121	2.0282	-2.1644	-0.7802
(p-value)	(0.0151)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0700)	(0.3912)
Seasonality	<i>Fixed</i>	<i>Fixed</i>	<i>Stochastic</i>	<i>Stochastic</i>	<i>Stochastic</i>	<i>Stochastic</i>	<i>Stochastic</i>
<i>Controls</i>							
Outlier 2005(2)	-	-5.4397*** [0.7613]	-5.0587*** [0.7579]	-4.9687*** [0.7550]	-5.1346*** [0.7494]	-5.0903*** [0.7333]	-5.0826*** [0.7349]
Outlier 2005(11)	-	-5.6266*** [0.8377]	-4.9945*** [0.8527]	-4.9311*** [0.8481]	-5.2699*** [0.8263]	-5.3041*** [0.8095]	-5.1776*** [0.8085]
Winter 05/06	-	-5.6565*** [0.6633]	-5.9881*** [0.6734]	-5.9742*** [0.6679]	-5.7795*** [0.6486]	-5.6249*** [0.6057]	-5.6895*** [0.6125]
Dev. Storage	-	-	-0.0007** [0.0003]	-0.0005 [0.0003]	-	-	-
Dev. HDD(b=15.5)	-	-	-	-0.0058 [0.0037]	-0.0084** [0.0032]	-0.0083*** [0.0031]	-0.0091*** [0.0031]
<i>Structural Breaks</i>							
BBL/Langeled (December 2006)	-	-	-	-	-	1.31318 [0.7627]	-
LNG (November 2008)	-	-	-	-	-	2.6647*** [0.7570]	2.6280*** [0.7689]

[..] Standard errors in parentheses. The sample period for the model analysis is January 2000 through September 2011.

† break model that minimizes Bayesian Schwartz Criterion.

* = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level

Table: UC Estimation Output - Dependent variable: Differential Front

<i>Model</i>	1	2	3	4 [†]	5
<i>Final State</i>					
Level	0.9160	1.0348	1.0073	-5.9681	-4.5338
(p-value)	(0.0473)	(0.0073)	(0.0038)	(0.0000)	(0.0013)
Seasonality	<i>Fixed</i>	<i>Stochastic</i>	<i>Stochastic</i>	<i>Fixed</i>	<i>Stochastic</i>
<i>Controls</i>					
Outlier 2005(11)	-	-4.7233*** [0.8400]	-3.9156*** [0.8492]	-4.7983*** [0.8634]	-4.4283*** [0.8424]
Outlier 2006(2)	-	3.0367*** [0.8400]	2.8976*** [0.8165]	3.1720*** [0.8283]	2.9215*** [0.8073]
Winter 05/06	-	-3.6697*** [0.9039]	-3.9341*** [0.9258]	-3.8325*** [0.7630]	-3.7126*** [0.8609]
Dev. Storage	-	-	-0.0006** [0.0003]	-0.0003 [0.0003]	-0.0006** [0.0003]
Dev. HDD(b=15.5)	-	-	-0.00417 [0.0036]	-0.0033 [0.0036]	-
<i>Structural Breaks</i>					
BBL/Langeled (December 2006)	-	-	-	3.1660*** [0.8411]	2.8381*** 0.90554
LNG (November 2008)	-	-	-	3.4558*** [0.8324]	2.5803*** [0.9063]

[..] Standard errors in parentheses. The sample period for the model analysis is January 2000 through September 2011. † *break* model that minimizes Bayesian Schwartz Criterion. * = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level

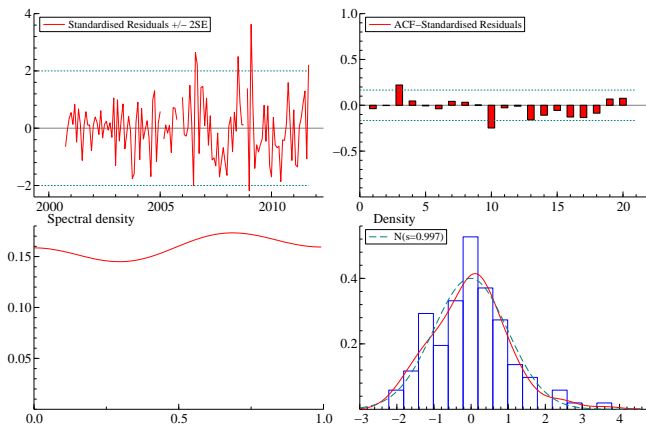


Figure: UC Model 7 (OTC): residual diagnostics

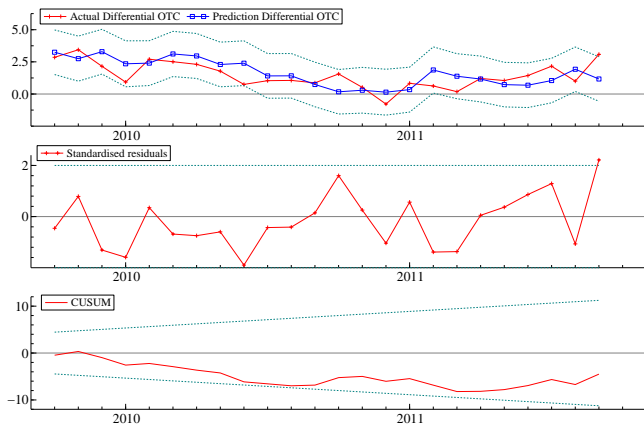


Figure: UC Model 7 (OTC): in-sample predictions