Forecasting International Oil Price Using an ECM Model

Wu Haiying and Shengchu Pan

Central University of Finance & Economics, Beijing China

Presenting at the 19th INFORUM World Conference

South Africa, August 2011

Introduction

- The rapid increment of China's oil demand is thought to be one of the main reasons for the rising of international oil price in recent years.

- Our model intends to empirically answer if and how China's oil demand influences NYMEX crude oil future price (WTI), and forecasting of the WTI price is also made.

Main Contents

- The model's characteristics

- WTI equation

- WTI forecasts in 2011

- Conclusions

The Model's Characteristics

- Exams the significance of China's oil demand on global oil price based on world oil import and export markets.
- Explanatory variables:
  - Growth changes in oil exports (supply side)
  - Growth changes in major countries' oil imports (demand side)
  - Other factors (US dollar index and US crude oil stocks)
- Dynamic modeling techniques and error correction model (ECM) are adopted. The software used is PcGive10.0.
- Quarterly model based on data from 1995 to 2010.

Variables of WTI Equation

	Description	Units	Source
WTI	WTI crude oil future price	$/barrel	Wind Database
UsIm	US crude oil & petroleum product imports	Million barrels	CEIC Database
ChnIm	China crude oil & petroleum product imports	Million barrels	Wind Database
OPEC	OPEC crude oil production capacity	Million barrels	Wind Database
UsInv	US crude oil stocks	Million barrels	CEIC Database
USD	Nominal major currencies dollar index	March 1973 = 100	www.federalreserve.gov

Note: WTI and USD are quarterly average data.

Figure 1: Oil Imports[1] - US & China (% of World Exports of Oil[2])
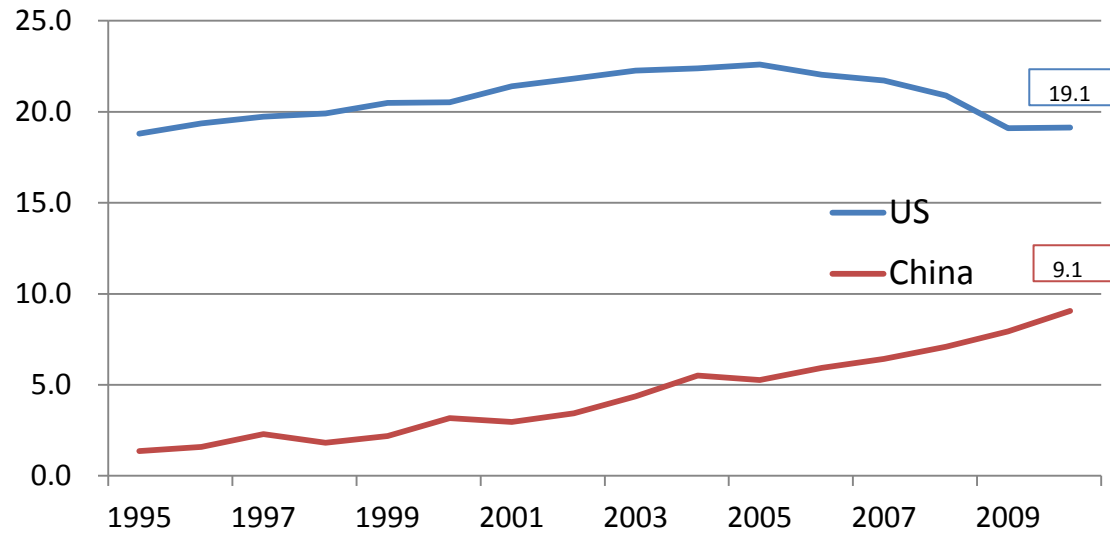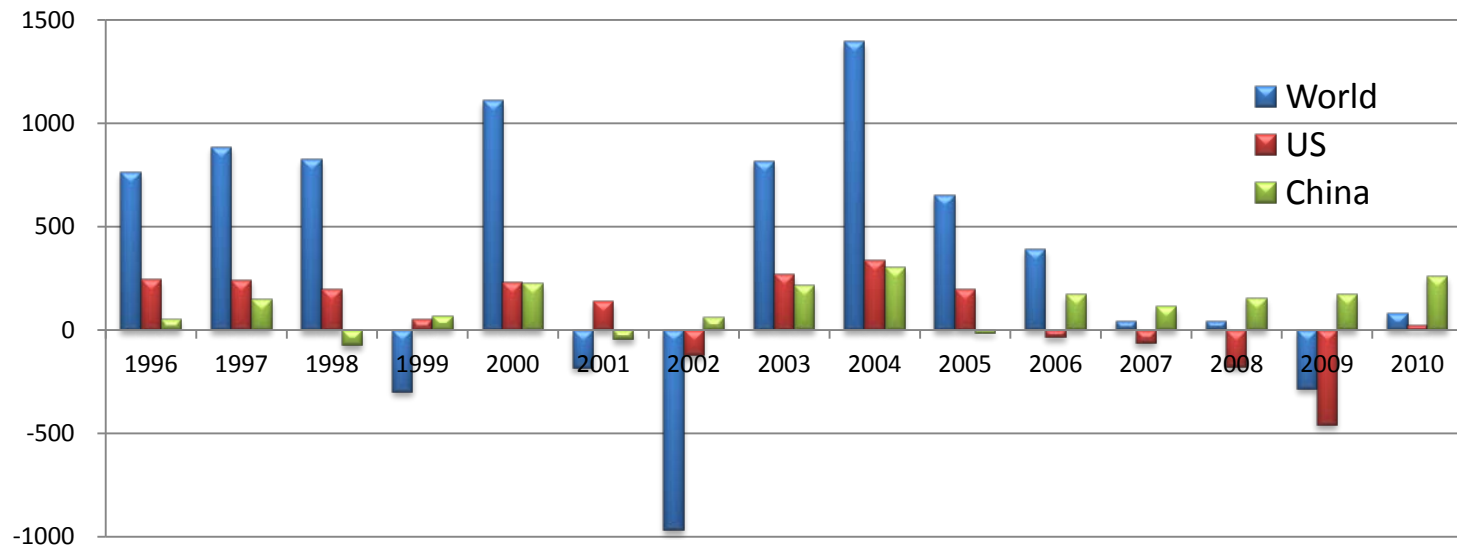

[1]US & China oil imports include imports of crude oil and petroleum products;

[2]World exports of crude oil and refined products.

Source: Calculations based on Wind database and OPEC Annual Statistical Bulletin.

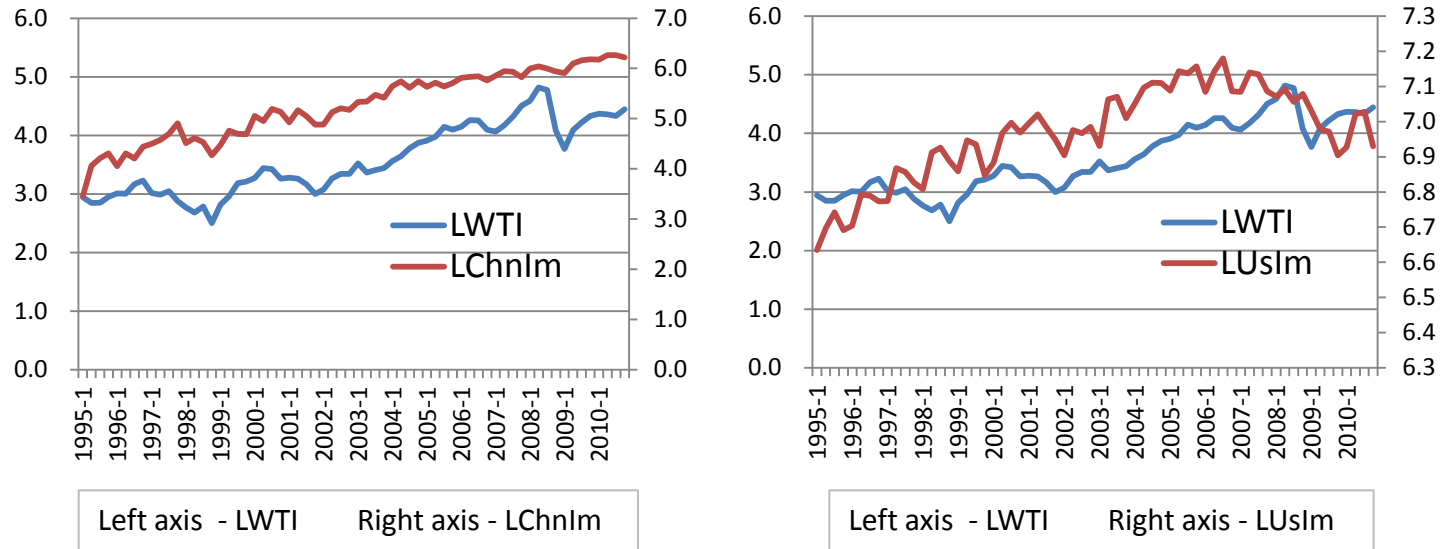# Figure 2: Change in Oil Imports – World[1], US and China (Million Barrels)

[1]World here refers to world exports of crude oil and refined products.

Source: Calculations based on Wind database and OPEC Annual Statistical Bulletin.

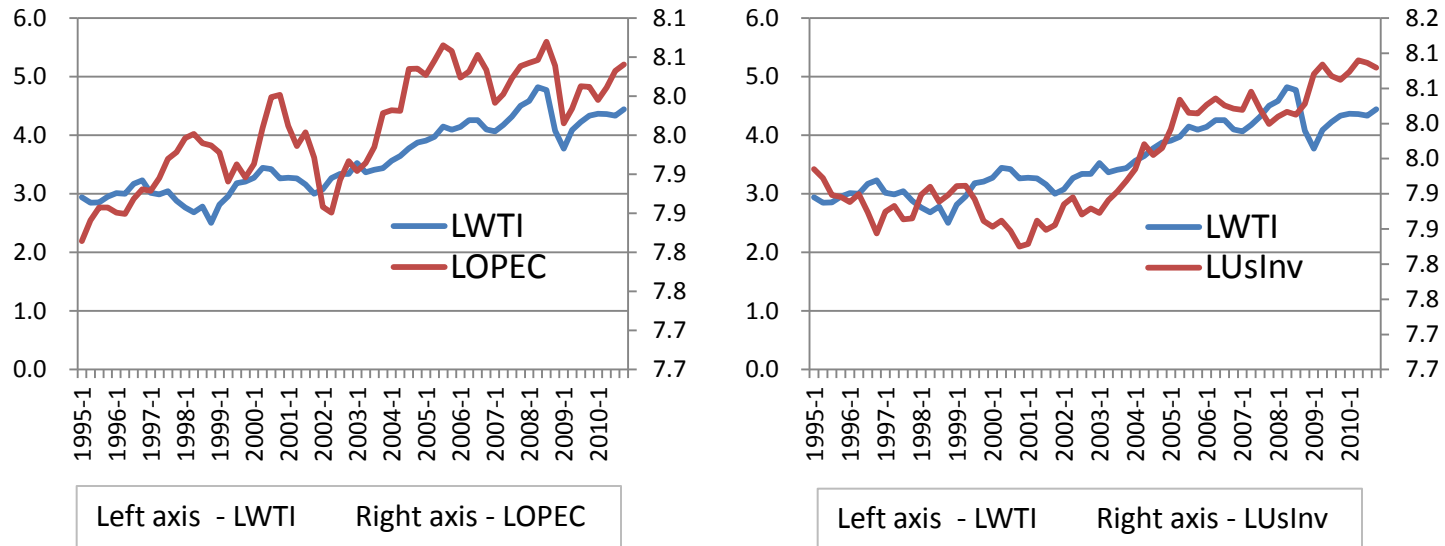# Figure 3: US, China Oil Imports VS WTI Future Price

Note: Lx means logarithm of x.
Source: Calculations based on Wind and CEIC database.

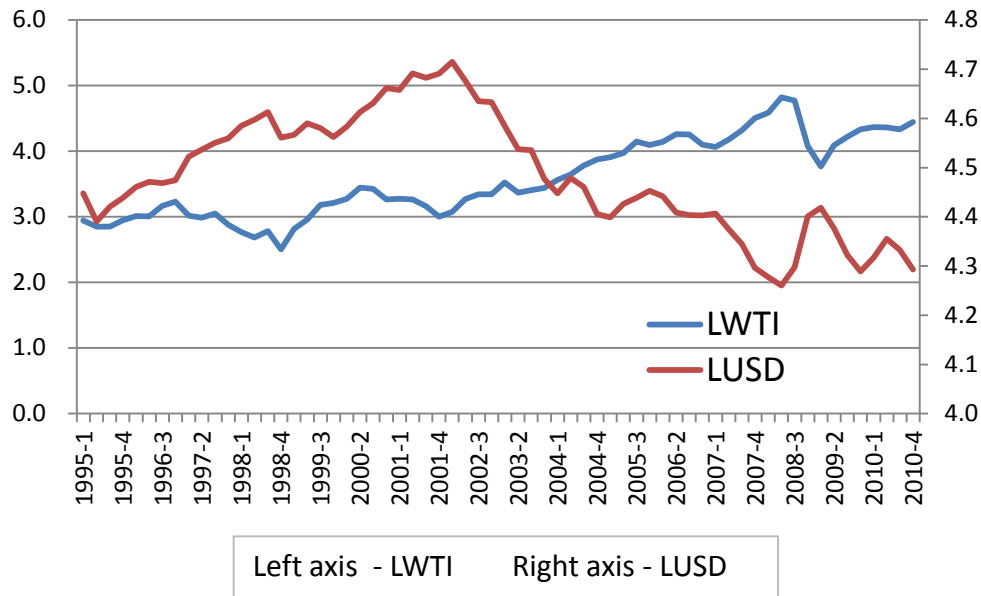# Figure 4: OPEC Capacity and US Crude Oil Stocks VS WTI Future Price

Left axis - LWTI   Right axis - LOPEC

Left axis - LWTI   Right axis - LUsInv

Note: Lx means logarithm of x.
Source: Calculations based on Wind and CEIC database.

Figure 5: US Dollar Index VS WTI Future Price

Left axis - LWTI   Right axis - LUSD

Note: Lx means logarithm of x.
Source: Calculations based on Wind and CEIC database.

Unit-root Tests

LWTI	LUsIm	LChnIm	LOPEC	LUsInv	LUSD
-3.26	-0.92	-3.73*	-2.89	-1.98	-2.68
DLWTI	DLUsIm	DLChnIm	DLOPEC	DLUsInv	DLUSD
-6.25**	-9.88**	-7.97**	-7.50**	-7.65**	-5.67**

Note: [1]Data are quarterly from 1995-2010;
    [2]LX represents logarithm of X, DLX means the first-order difference of LX;
    [3]LX ADF tests use constant, trend and seasonal dummies, while DLX tests just include constant. ** for 1% significance level, * for 5% significance level.

Econometric Techniques Adopted

- ECM can be generated by rewriting autoregressive distributed-lags model (AD). For a simple example, the AD model in (1) is equivalent to the ECM model given by (2).

$$y_t = \beta_0 + \beta_1 z_t + \beta_2 y_{t-1} + \beta_3 z_{t-1} + \varepsilon_t \tag{1}$$

$$\Delta y_t = \beta_0 + \beta_1 \Delta z_t + (\beta_2 - 1)(y - K_1 z)_{t-1} + \varepsilon_t \qquad K_1 = \frac{\beta_1 + \beta_3}{1 - \beta_2} \tag{2}$$

Where : Δ is the first-order difference;

$(y - K_1 z)_{t-1}$ is lagged equilibrium error (ECM variable);

$(\beta_2 - 1)$ is the adjustment factor which is expected to be negative and greater than -1.

Estimation Process

- First, we set up an ADL model with LWTI as dependent variable:

  - $LWTI_t = f(LUsIm_t, LChnIm_t, LOPEC_t, LUsInv_t, LUSD_t, Seasonal)+\varepsilon_t,$ (3)
  - Adequately long lags were used to ensure that ε_t is a white noise process.

- Then, adopting the "general to specific" dynamic approach, we gradually reduced the model (3) and derived its ECM equation as the format expressed in model (2).

- The final estimated equation is as follows:

- DLWTI = 4.979 + 0.1724*DLWTI(-1) + 1.218*DLOPEC

  $\quad$ - 5.776*DLUsInv - 0.948*DLUsIm + 0.2018*DLChnIm

  $\quad$ + 0.2325*Seasonal + 0.3139*Seasonal_1

  $\quad$ - 0.4405*WTI_ECM(-1) $\hspace{4cm}$ (4)

  Where, DLWTI = LWTI − LWTI(-1) and so on;

- At the same time, we got the ECM term:

  WTI_ECM = LWTI - 0.51*LChnIm - 1.97*LUsIm + 2.1*LUSD+1.88*LOPEC

- From the ECM term, In the long run , we have

  LWTI = 0.51*LChnIm + 1.97*LUsIm -1.88*LOPEC - 2.1*LUSD

Estimation Results

	Coefficient	Std. Error	t-value	t-prob
Constant	4.98	0.8022	6.21	0.000
DLWTI (-1)	0.17	0.0889	1.94	0.058
DLOPEC	1.22	0.6347	1.92	0.060
DLUsInv	-5.78	0.9386	-6.15	0.000
DLUsIm	-0.95	0.3456	-2.74	0.008
DLChnIm	0.20	0.0878	2.30	0.026
Seasonal	0.23	0.0390	5.96	0.000
Seasonal_1	0.31	0.0493	6.37	0.000
WTI_ECM (-1)	-0.44	0.0695	-6.34	0.000

R^2 = 0.702153   DW = 2.08

AR 1-4 test: $F(4,49)$ = 0.46567 [0.7606]

ARCH 1-4 test: $F(4,45)$ = 0.32070 [0.8626]

Normality test: $Chi^2(2)$ = 0.65040 [0.7224]

hetero test: $F(14,38)$ = 1.9549 [0.0509]

China's Influence on WTI Price

- China's oil imports do have effects on global oil price both in the long run and short run.
  - In the long run , its elasticity to WTI is 0.51.
  - In the short run, change in China's oil imports also have a positive influence on WTI price.

- Although China affects oil price, its strength is the weakest among other three long determinants, which are US dollar index, US oil imports and OPEC crude oil production capacity. The elasticity of oil price with respect to them is -2.1, 1.97 and -1.88 respectively.

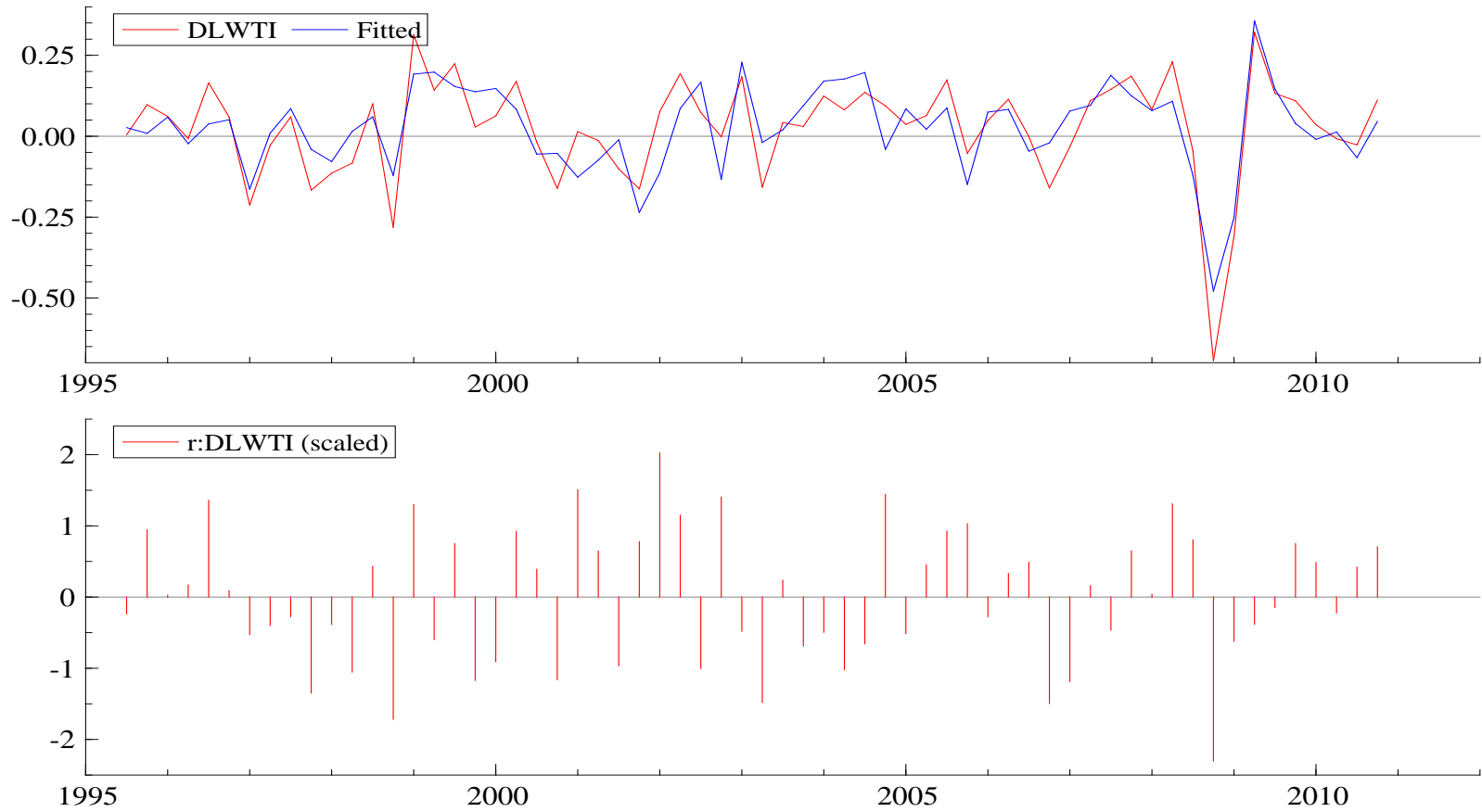# Figure 6: Fitness of DLWTI and its Residual Distribution

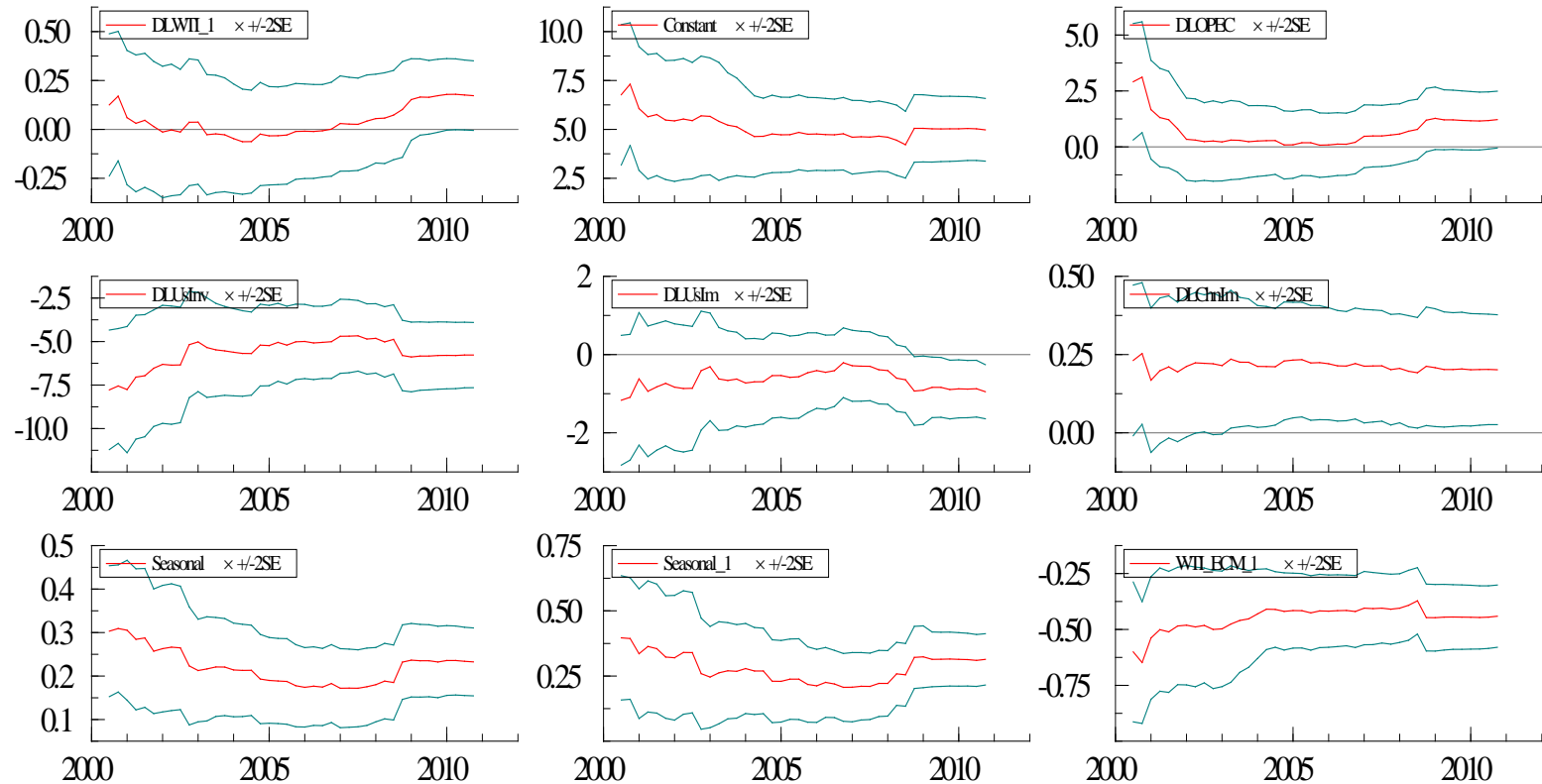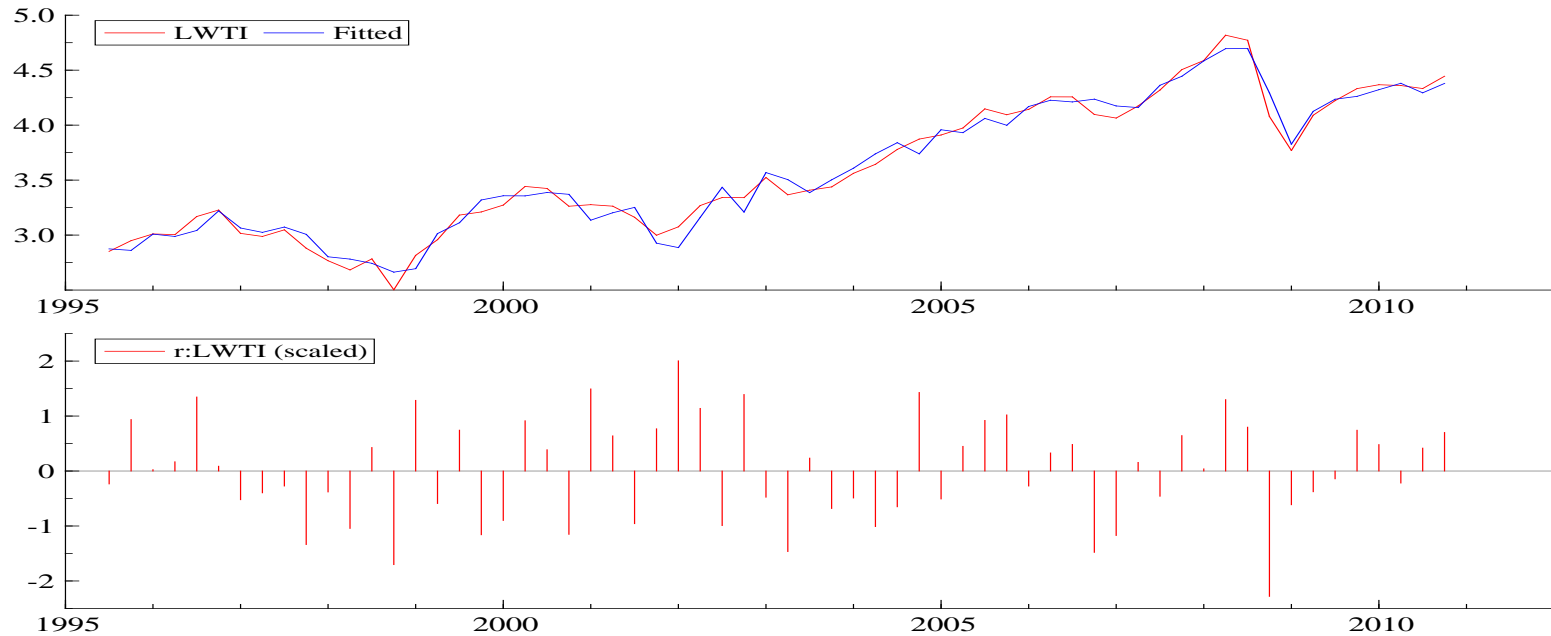# Figure 7: Recursive Analysis of Coefficients in DLWTI Equation (95% confidence interval)

Figure 8: Fitness of LWTI and its Residual Distribution   (R²=0.9789)

Note: LWTI equation is simply derived from DLWTI equation (4) with LWTI = DLWTI + LWTI (-1).

Assumptions for Explanatory Variables

- **OPEC**: According to *Short-term Energy Outlook, August 2011* from Energy Information Association(EIA). EIA expects OPEC crude oil production capacity will decline from 33.76 in 2010 to 32.86 million barrels per day in 2011, in large part due to the supply disruption in Libya.

- **USD**：2011 Q1 and Q2 data are actual observations. For the next two quarters in 2011, we assume US dollar will keep a slight appreciation with 70 and 71, largely due to Europe debt crisis.

- **UsInv**: Based on quarterly growth rates from EIA short-term energy outlook, August 2011.

- **UsIm & Chnim**: From their own autoregressive models.

Exogenous Variables (Million barrels)

	US oil imports	China oil imports	OPEC crude oil production capacity	US crude oil stocks	US Dollar index March 1973=100
2011 Q1	1024	548	3051	3240	72.1
2011 Q2	1103	536	2959	3282	69.8
2011 Q3	1099	549	2991	3272	70.0
2011 Q4	1061	554	2991	3302	71.0

Note : Data in red color is forecasted based on the assumption listed.
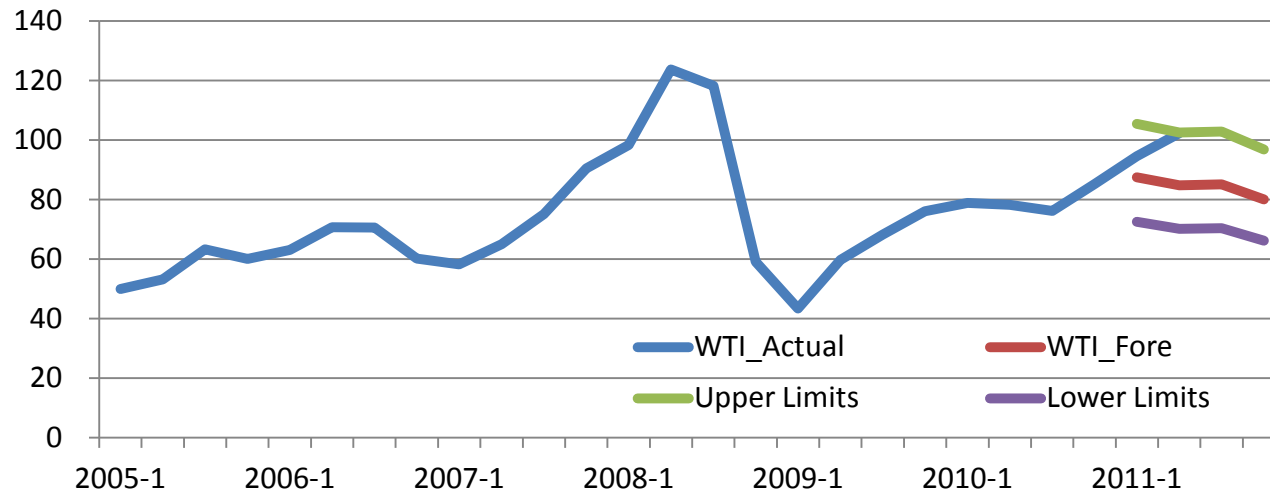
Oil Price Forecasts

	Actual price	Point forecasts[1]	Confidence intervals[2]
2011 Q1	94.60	87.4	72.5 - 105.4
2011 Q2	102.34	84.9	70.2 - 102.6
2011 Q3	NA	85.1	70.4 - 102.9
2011 Q4	NA	80.1	66.2 - 96.8

[1] Dynamic (ex ante) forecasts.
[2] The standard error based on error variance only.

Figure 9: Oil price forecasts ($/Barrel)

Conclusions

- The rapid growth of China's oil imports has already influenced the global oil price, while the extent is much lower than that of US and OPEC factors.

- WTI oil future price will hold around 84 dollar per barrel through 2011.

Thank   you!