Independent Statistics & Analysis
U.S. Energy Information Administration

Petroleum Products Supply Module
Short-Term Energy Outlook Model

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Contents

1. Overview

The petroleum products supply module of the *Short-Term Energy Outlook* (*STEO*) model provides forecasts of petroleum refinery inputs (crude oil, unfinished oils, pentanes plus, liquefied petroleum gas, motor gasoline blending components, and aviation gasoline blending components) and refinery outputs (motor gasoline, jet fuel, distillate fuel, residual fuel, liquefied petroleum gas, and other petroleum products). Table 1 shows the top four product yields from U.S. refineries for the last 5 years. U.S. refineries have historically been optimized to produce motor gasoline.

Table 1. Top 4 refinery product yields on a percentage basis

Product	2007	2008	2009	2010	2011
Finished motor gasoline	45.5	44.2	46.1	45.7	44.9
Distillate fuel oil	26.1	27.8	26.9	27.5	28.9
Kerosene-type jet fuel	9.1	9.7	9.3	9.3	9.4
Petroleum coke	5.3	5.2	5.3	5.3	5.5

Source: EIA *Petroleum Supply Monthly*.

Note: Refinery yield represents the percent of finished product produced from input of crude oil and net input of unfinished oils. It is calculated by dividing individual net production of finished products into the sum of crude oil and net unfinished input. Before calculating the yield for finished motor gasoline, the input of natural gas liquids, other hydrocarbons and oxygenates, and net input of motor gasoline blending components are subtracted.

The *STEO* model contains over 2,000 equations, of which about 450 are estimated regression equations. The regression equations are estimated and the forecast models are solved using Eviews Econometric Software (Quantitative Micro Software, LLC). The frequency of the *STEO* model is monthly and the model equations are used to produce monthly forecasts over a 13-to-24 month horizon (every January the *STEO* forecast is extended through December of the following year).

The petroleum products supply module, which is documented in this report, contains 28 equations, of which 14 are estimated regression equations. Some input variables to the petroleum products supply module are exogenous, coming from other modules in the *STEO* model (e.g., crude oil and petroleum product prices) or forecasts produced by other organizations (e.g., weather forecasts from the National Oceanic and Atmospheric Administration).

2. Data Sources

The sources for monthly U.S. refinery inputs and outputs are:

- EIA *Weekly Petroleum Status Report* (WPSR) for estimated monthly-from-weekly volumes for the 2 most recent months

- EIA *Petroleum Supply Monthly* (PSM) for preliminary monthly data;
- EIA *Petroleum Supply Annual* (PSA) for revised final monthly data

The *STEO* model uses macroeconomic variables such as population, gross domestic product (GDP), income, employment, and industrial production as explanatory variables in the generation of the forecast. The macroeconomic forecasts are generated by models developed by IHS/Global Insight Inc. (GI). GI updates its national macroeconomic forecasts monthly using its model of the U.S. economy. EIA re-runs the GI model to produce macroeconomic forecasts that are consistent with the *STEO* energy price forecasts.

Heating degree day history and projections are obtained from the National Oceanic and Atmospheric Administration (NOAA). NOAA also publishes forecasts of population-weighted regional heating degree days up to 14 months out. Where the *STEO* forecast horizon goes beyond the NOAA forecast period, "normal" heating degree days may be used. The *STEO* model uses a corrected normal that accounts for population migration (*Change in STEO Regional and U.S. Degree Day Calculations*).

3. Variable Naming Convention

Over 2,000 variables are used in the *STEO* model for estimation, simulation, and report writing. Most of these variables follow a similar naming convention. Table 2 shows an example of this convention using total crude oil refinery inputs:

Table 2. Variable naming convention

Variable name: CORIPUSX

Characters	CO	RI	P	US	X
Positions	1 and 2	3 and 4	5	6 and 7	8 +
Identity	Type of energy: crude oil	Energy activity or end-use sector: refinery inputs	Type of data: physical units	Geographic area of special equation factor: United States	Data treatment: temporary value

In this example, CORIPUSX is the identifying code for crude oil (CO) refinery inputs (RI) physical units (P) in the United States (US). The variable holds a temporary value (X) that may be adjusted before it is stored to the final CORIPUS data series.

Some examples of the identifiers used in this naming convention are:

Type of energy categories:

AB = aviation gasoline blending components
CO = crude oil
DF = distillate fuel, including diesel fuel and heating oil

DS = diesel fuel
EO = fuel ethanol
JF = jet fuel
JK = jet fuel, kerosene-type
LG = liquefied petroleum gas
MB = motor gasoline blending components
MG = finished motor gasoline
OH = other hydrocarbons and oxygenates
OR = operable refining
PA = total liquid fuels
PP = pentanes plus
PS = other petroleum products
RA = refiner average (crude oil acquisition cost)
RF = residual fuel oil
UO = unfinished oils
ZW = weather

Energy activity or end-use sector:

DI = Distillation inputs
HD = heating degree days
HN = heating degree days normal
PS = petroleum stocks
RI = Refinery input
RO = Refinery output
TC = total consumption
WH = wholesale sales

Type of data:

P = data in physical units (e.g., barrels or barrels per day)
X = share or ratio expressed as a fraction
U = price per physical unit, excluding taxes

Geographic identification or special equation factor:

US = United States

Data treatment:

SA = seasonally adjusted series from Census X-11 method
SF = seasonal factors derived from Census X-11 method
X = temporary value

Many equations include monthly dummy variables to capture the normal seasonality in the data series. For example, JAN equals 1 for every January in the time series and is equal to 0 in every other month.

Dummy variables for specific months may also be included in regression equations where the observed data may be outliers because of infrequent and unpredictable events such as hurricanes, survey error, or other factors. Generally, dummy variables are introduced when the absolute value of the estimated regression error is more than 2 times the standard error of the regression (the standard error of the regression is a summary measure based on the estimated variance of the residuals). No attempt was made to identify the market or survey factors that may have contributed to the identified outliers.

Dummy variables for specific months are generally designated Dyymm, where yy = the last two digits of the year and mm = the number of the month (from "01" for January to "12" for December). Thus, a monthly dummy variable for March 2002 would be D0203 (i.e., D0203 = 1 if March 2002, = 0 otherwise).

Dummy variables for specific years are designated Dyy, where yy = the last two digits of the year. Thus, a dummy variable for all months of 2002 would be D02 (i.e., D02= 1 if January 2002 through December 2002, 0 otherwise). A dummy variable might also be included in an equation to show a structural shift in the relationship between two time periods. Generally, these type of shifts are modeled using dummy variables designated DxxON, where xx = the last two digits of the year at the beginning of the shift period. For example, D03ON = 1 for January 2003 and all months after that date, and D03ON = 0 for all months prior to 2003.

4. Refinery Inputs

A. Introduction

The refinery inputs section of the petroleum products supply module contains 6 estimated regression equations and one identity. The estimated regression equations for refinery inputs are for crude oil, unfinished oils, pentanes plus, liquefied petroleum gas, motor gasoline blending components, aviation gasoline blending components, and other petroleum products.

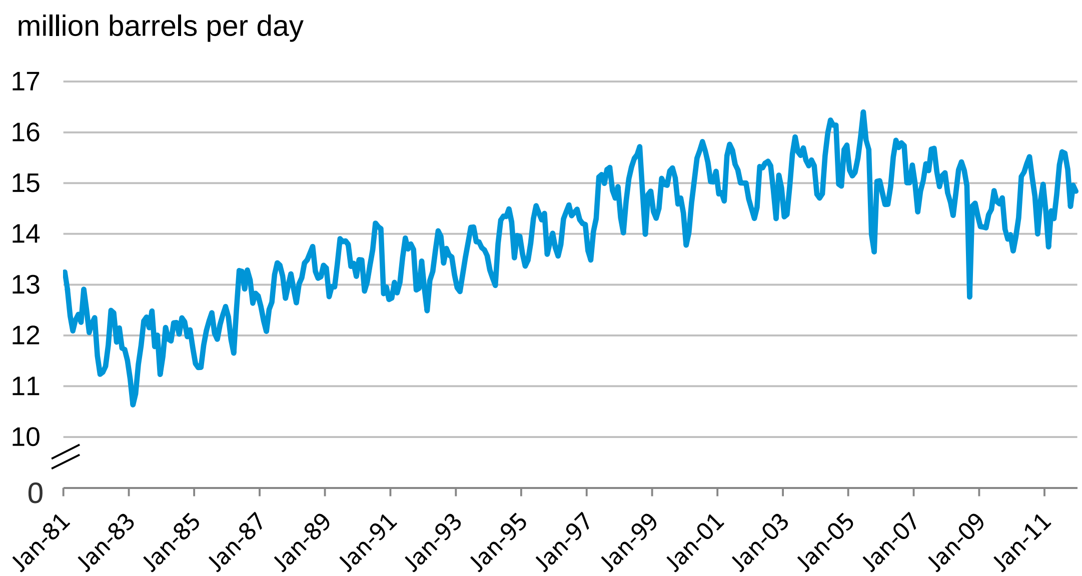
The refinery input section of the module produces forecasts of temporary values for refinery inputs of crude oil and unfinished oil (each equation's dependent variable ID ends with an "X"). The crude oil and unfinished oils refinery inputs are then adjusted upwards or downwards so that total refinery inputs plus refinery processing gain equal total refinery outputs (see "Crude Oil Balance" section).

B. Refinery Input Equations

1. Crude Oil

U.S. refinery inputs of crude oil are driven primarily by domestic consumption of gasoline, distillate fuel, and jet fuel. Refinery inputs of crude oil are seasonal, reflecting the seasonality in product consumption (Figure 1). Over the last 5 years (2007 – 2011) refinery crude oil inputs have ranged from an average low of 14.2 million barrels per day in February to an average high of 15.3 million barrels per day in July.

Figure 1. U.S. refinery inputs of crude oil, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

Refinery inputs of crude oil are expected to be a positive function of current and prior month consumption of the primary petroleum products: motor gasoline (less fuel ethanol), distillate fuel oil, and jet fuel (equation 1). Crude oil inputs are also expected to be a negative function of other refinery inputs that may be considered substitutes in production such as unfinished oils and liquefied petroleum gas. Refinery profitability and the incentive to process crude oil is often measured by refining margins, or the difference between product wholesale or spot prices and the cost of crude oil. A commonly used measure of refining margins that is included in the crude oil refinery inputs equation is the "3-2-1 crack spread," which assumes 3 gallons of crude oil is processed to make 2 gallons of gasoline and 1 gallon of distillate fuel. The 3-2-1 crack spread in this model is calculated as 2/3 times the refiner price of gasoline for resale plus 1/3 times the refiner price of diesel fuel for resale less the price of the refiner average acquisition cost of crude oil, all expressed in cents per gallon.

The regression equation also includes a trend variable, which covers the period January 2008 through December 2011, to capture the increase in liquid fuel exports over this period. U.S. liquid fuel exports rose as falling demand in Europe contributed to the closing of refining capacity in that region. Exports from Europe to Central and South America declined and U.S. exports to those regions rose. The trend variable equals 0 for every month before January 2008, then rises by 1 every month until December 2011 after which it remain constant. The *STEO* model does not include a module of foreign trade and equation 1 implicitly assumes that the rising export trend does not continue after 2011.

CORIPUSX = a0 + a1 * (MGTCPUSX – EOTCPUS + DFTCPUS + JFTCPUS) (1)
+ a2 * (MGTCPUSX(-1) – EOTCPUS(-1) + DFTCPUS(-1) + JFTCPUS(-1))
+ a3 * UORIPUSX
+ a4 * (LGRIPUS – LGROPUS)
+ a5 * (2* MGWHUUS + DSWHUUS)- 3*(RACPUUS*100/42) / 3
+ a6 * (D08on*@trend(2007:12)-D12on*@trend(2011:12))
+ a7 * CORIPUSX(-1)
+ monthly dummy variables

where,

CORIPUSX = crude oil refinery input (initial value), million barrels per day
CORIPUSX(-1) = prior month crude oil refinery input (initial value), million barrels per day
DFTCPUS = distillate fuel total consumption, million barrels per day
DSWHUUS = diesel fuel refiner price for resale, cents per gallon
EOTCPUS = ethanol total consumption, million barrels per day
JFTCPUS = jet fuel total consumption, million barrels per day
LGRIPUS = liquefied petroleum gas refinery inputs, million barrels per day
LGROPUS = liquefied petroleum gas refinery outputs, million barrels per day
MGTCPUSX = motor gasoline total consumption, million barrels per day
MGWHUUS = motor gasoline refiner price for resale, cents per gallon
RACPUUS = refiner acquisition cost of crude oil, dollars per barrel
UORIPUSX = unfinished oils refinery input (initial value), million barrels per day

2. Unfinished Oils

Unfinished oils are all oils requiring further processing, except those requiring only mechanical blending into liquid fuel products. Unfinished oils are produced by partial refining of crude oil and include naphthas and lighter oils, kerosene and light gas oils, heavy gas oils, and residuum. Heavy gas oils and residuum represent most of the refinery inputs of unfinished oils (Table 3).

Table 3. Refinery inputs of unfinished oils, annual average thousands of barrels per day

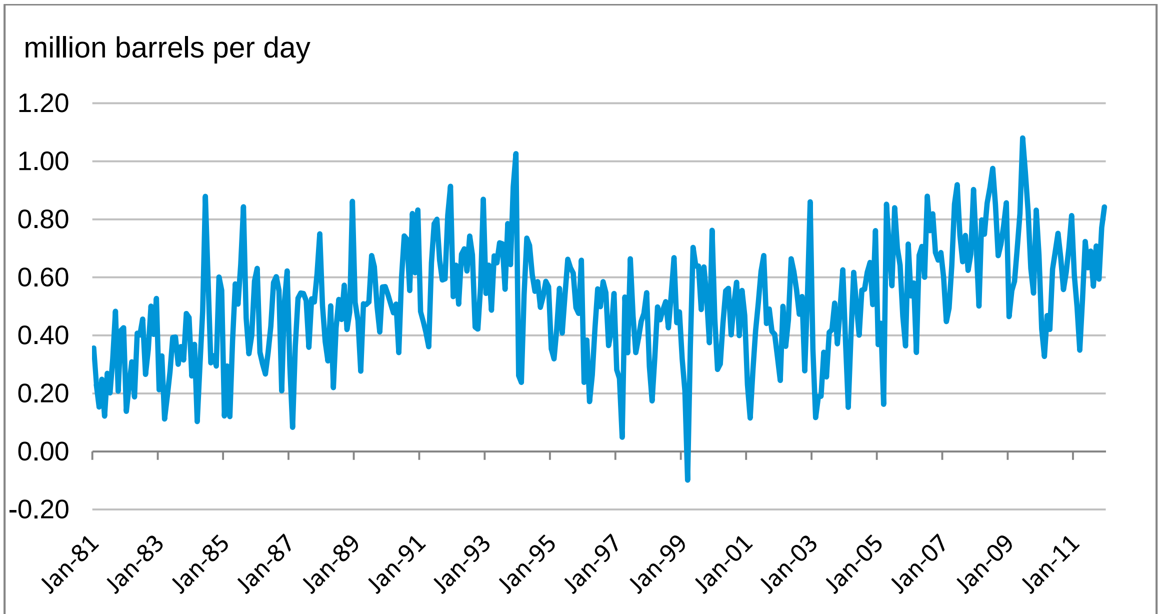
	Naphthas and lighter	Kerosene and light oils	Heavy gas oils	Residuum	Total unfinished oils
2005	75	-11	383	122	569
2006	116	-53	442	157	661
2007	57	-34	526	145	693

2008	94	14	519	155	782
2009	109	47	440	128	723
2010	27	42	419	104	591
2011	22	-17	475	150	666

Source: EIA Petroleum Supply Monthly, Table 28.

Refinery inputs of unfinished oils are seasonal, highest during the summer and winter months, but are also highly variable as refiners may purchase and process unfinished oils as they become available (Figure 2).

Figure 2. U.S. refinery inputs of unfinished oils, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

The regression equation for unfinished oils refinery inputs assumes that unfinished oils are mean-reverting with seasonality. The equation is estimated over the sample period 2001 through 2011. A trend variable is included for the increase in unfinished oils refinery inputs between 2004 and 2007 (equation 2).

UORIPUSX = a0 + a1 * (D04ON*@TREND(2003:12)-D08ON*@TREND(2007:12)) (2)
+ a2 * UORIPUS(-1)
+ monthly dummy variables

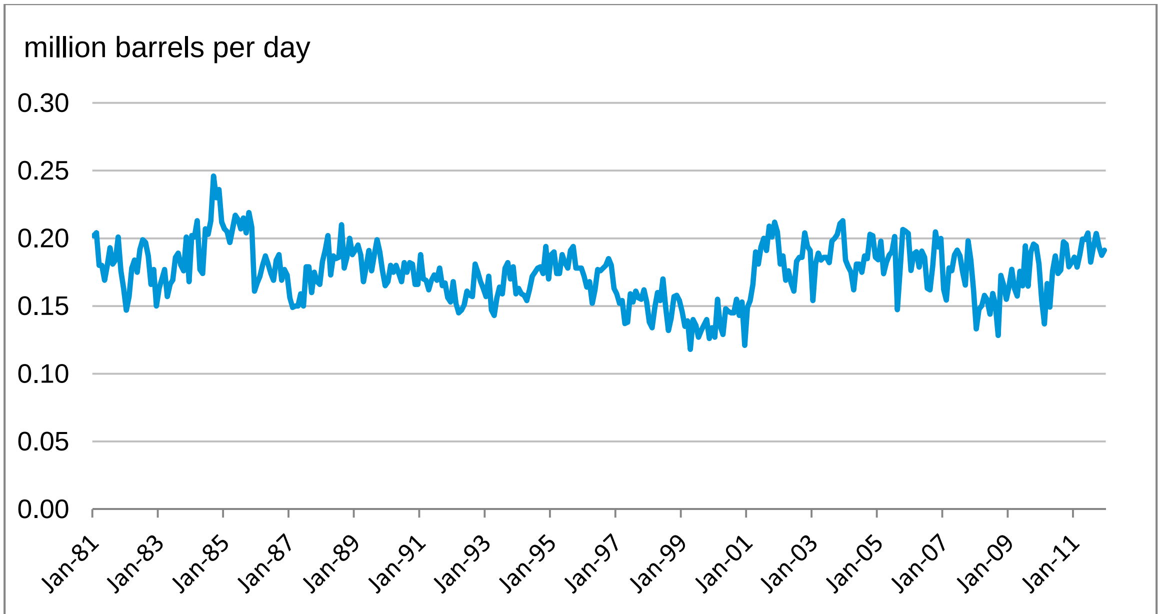
where,

UORIPUSX = unfinished oils refinery input (initial value), million barrels per day
UORIPUS(-1) = prior month unfinished oils refinery inputs , million barrels per day

3. Pentanes Plus

Pentanes plus are a mixture of hydrocarbons, mostly pentanes and heavier hydrocarbons (such as isopentane, natural gasoline, and plant condensate), extracted from natural gas. Pentanes plus may be blended directly into gasoline (reported in the *PSM* as "refinery and blender net input") or may be blended into fuel ethanol as a denaturant (reported in the *PSM* as "renewable fuel and oxygenate plant net production"). Pentanes plus blended into ethanol as a denaturant are reported in the *PSM* as a negative value for renewable fuel and oxygenate net production. Consequently, the total volume of pentanes plus blended into gasoline is calculated as refinery and blender net input (PPRIPUS) minus renewable fuel and oxygenate plant net production (PPPRPUS). Pentanes plus blended into gasoline have remained fairly steady, averaging about 170,000 barrels per day over the last 30 years (Figure 3). Pentanes plus renewable plant production is estimated as a fixed fraction (0.02) of ethanol production.

Figure 3. Pentanes plus blended into gasoline, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

Pentanes plus blended into gasoline are estimated as a function of the gasoline yield from crude oil and monthly dummy variables and a lagged dependent variable (equation 3). We assume pentanes plus gasoline blending to be inversely related to gasoline yields. Increasing the share of gasoline produced from crude oil generally requires operating downstream processing units such as cat crackers at higher rates and severities. This increases production of lighter by-products such as pentanes plus, which reduces the demand for refinery inputs of pentanes plus from other sources.

$$\text{PPRIPUS} - \text{PPPRPUS} = a0 + a1 * \text{MGYLD} + a2 * (\text{PPRIPUS}(-1) - \text{PPPRPUS}(-1)) + \text{monthly dummy variables} \quad (3)$$

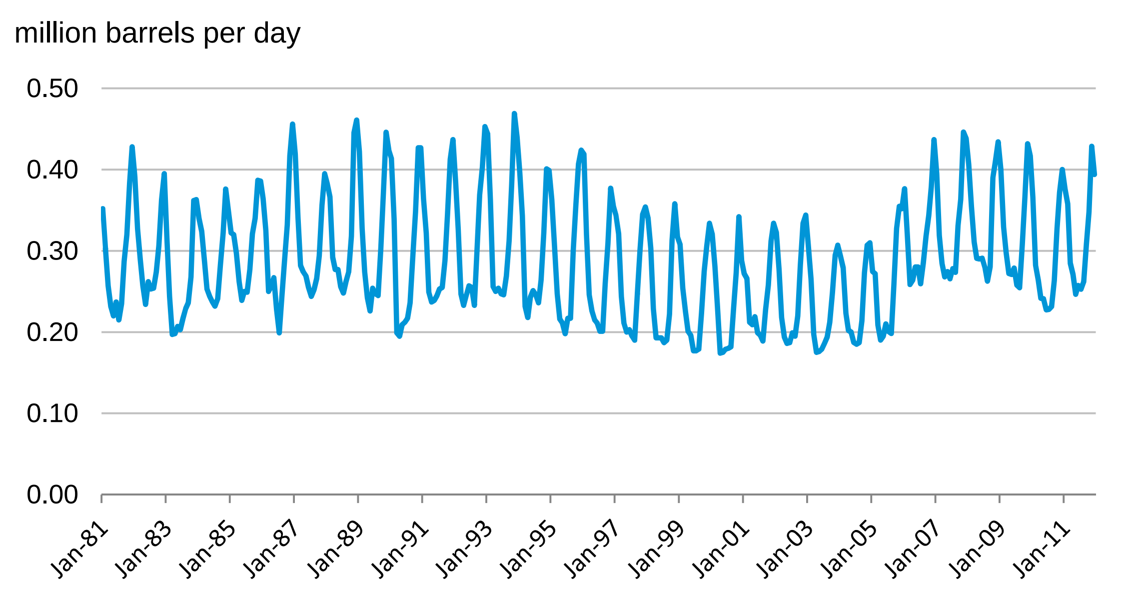
where,

MGYLD = motor gasoline refinery yield from crude and unfinished oils
PPPRPUS = pentanes plus renewable plant production, million barrels per day
PPPRPUS(-1) = prior month pentanes plus renewable plant production, million barrels per day
PPRIPUS = pentanes plus refinery input, million barrels per day
PPRIPUS (-1) = prior month pentanes plus refinery inputs, million barrels per day

4. Liquefied Petroleum Gas (LPG)

LPG is a group of hydrocarbon-based gases derived from crude oil refining or natural gas fractionation. They include ethane, ethylene, propane, propylene, normal butane, butylene, isobutane, and isobutylene. For convenience of transportation, these gases are liquefied through pressurization. LPGs are primarily used for gasoline blending, either directly or by first processing such as in alkylation units and then blending. LPGs generally increase the vapor pressure of motor gasoline when blended. Consequently, because finished motor gasoline has a higher allowable vapor pressure during the winter months than the summer months, refinery inputs of LPGs are highest during the winter (Figure 4).

Figure 4. U.S. refinery inputs of liquefied petroleum gas, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

The regression equation for liquefied petroleum gas (LPG) refinery input is shown in equation 4. We expect LPG refinery input to be negatively correlated with the number of heating degree days above normal, which serves as a proxy for the consumption of LPGs for space heating and the price of LPG relative to motor gasoline. Heating degree days measures how cold a location is over a period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. The measure is computed for each day by subtracting the average of the day's high and low temperatures from the base temperature (65 degrees), with negative values set equal to zero. Each day's heating degree days are summed to create a heating-degree-day measure for a specified reference period. We also expect LPG refinery inputs are positively related to refinery output of motor gasoline (after controlling for seasonality).

$$LGRIPUS = a0 + a1 *((ZWHDPUS – ZWHNPUS)/ ZSAJQUS) + a2 * MGROPUS + a3 * LGRIPUS(-1) + \text{monthly dummy variables} \quad (4)$$

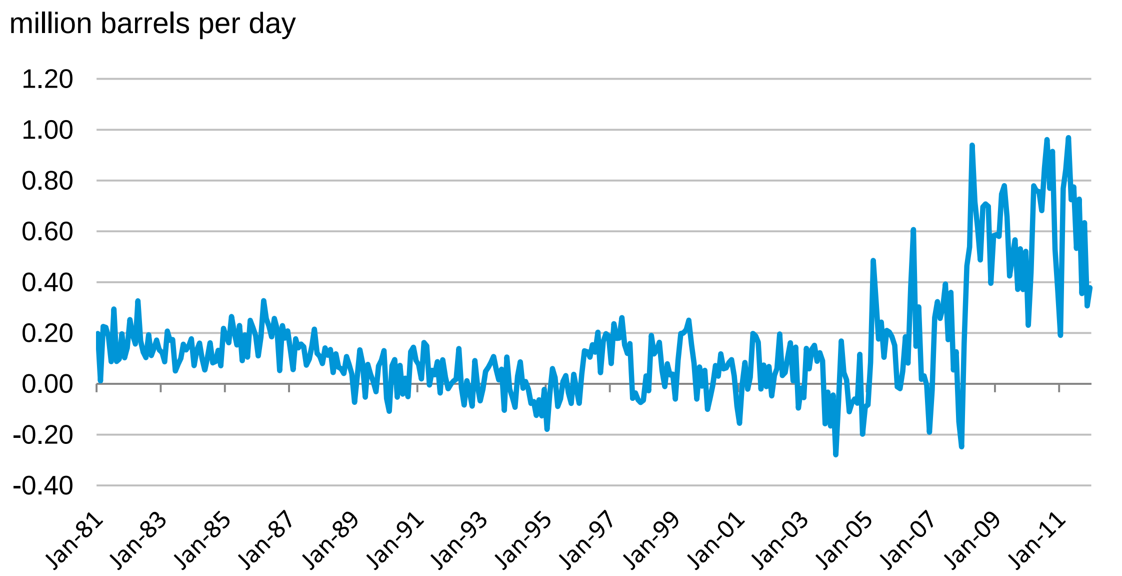
where,

LGRIPUS = liquefied petroleum gas refinery input, million barrels per day
LGRIPUS(-1) = prior month liquefied petroleum gas refinery inputs, million barrels per day
MGROPUS = motor gasoline refinery output, million barrels per day
ZSAJQUS = number of days in a month
ZWHDPUS = U.S. heating degree days
ZWHNPUS = U.S. heating degree days normal

5. Motor Gasoline Blending Components

Motor gasoline blending components (e.g., straight-run gasoline, alkylate, reformate, benzene, toluene, xylene) are used for blending or compounding into finished motor gasoline. These components include reformulated gasoline blend stock for oxygenate blending (RBOB) but exclude oxygenates (alcohols, ethers), butane, and pentanes plus. Refinery inputs of motor gasoline blending components have been rising since 2005 as ethanol production in the United States has grown (Figure 5).

Figure 5. U.S. refinery inputs of motor gasoline blending components, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

The regression equation for motor gasoline blending components refinery input is shown in equation 5. The estimation period of the regression equation begins in January 2008 to avoid the biasing effects of the non-stationarity in the growth of ethanol blending. The motor gasoline blending components adjustment represents the unaccounted-for supply volume in the balance of blending components total supply (imports) and disposition (refinery inputs, stock build, and exports). Motor gasoline blending component refinery inputs is expected to be a positive function of unaccounted-for motor gasoline blending components, i.e., additional unaccounted-for supply).

MBRIPUS = a0 + a1 * MBFPPUS (5)
+ a2 * MBRIPUS(-1)
+ monthly dummy variables

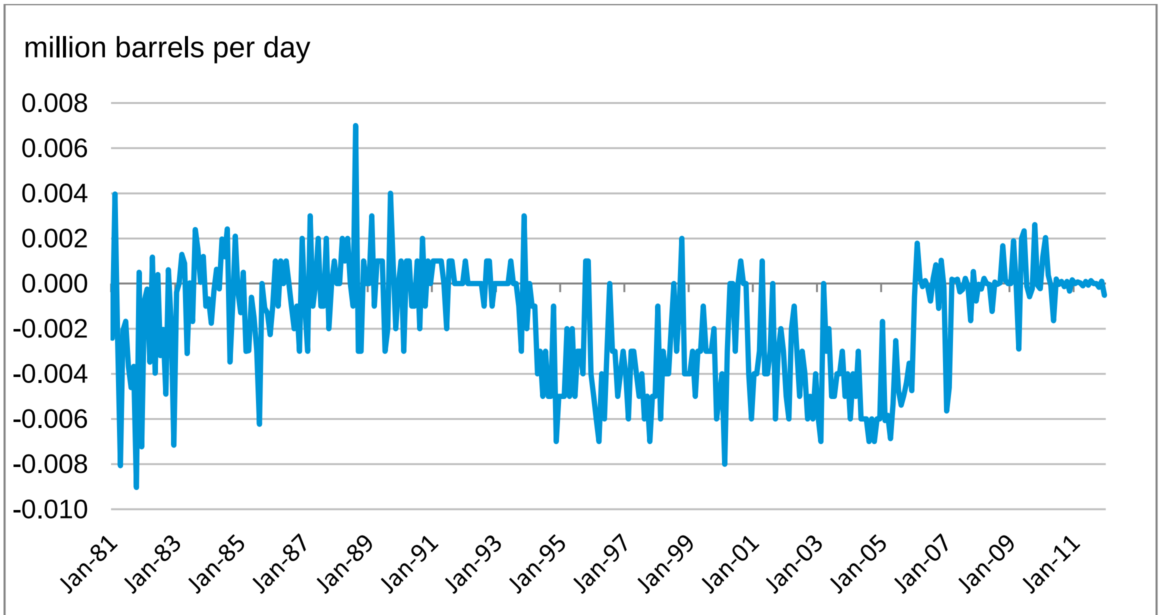
where,

MBRIPUS = motor gasoline blending components refinery inputs, million barrels per day
MBRIPUS (-1) = prior month motor gasoline blending components refinery inputs, million barrels per day
MBFPPUS = motor gasoline blending components supply adjustment, million barrels per day

6. Aviation Gasoline Blending Components

Aviation gasoline blending components are naphthas that will be used for blending into finished aviation gasoline (e.g., straight run gasoline, alkylate, reformate, benzene, toluene, and xylene). Net refinery inputs of aviation gasoline components are generally close to zero (Figure 6).

Figure 6. U.S. refinery inputs of aviation gasoline blending components, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

The regression equation for aviation gasoline blending components refinery inputs is assumed to be mean-reverting with seasonality (equation 6).

ABRIPUS = a0 + a1 * ABRIPUS(-1) (6)
+ monthly dummy variables

where,

ABRIPUS = aviation gasoline blending components refinery input, million barrels per day
ABRIPUS (-1) = prior month aviation gasoline blending components refinery inputs, million barrels per day

7. Other Hydrocarbons and Oxygenates

Refineries' inputs also include ethanol, other oxygenates (e.g., methyl tertiary butyl ether), other renewable fuels (e.g., biodiesel), and hydrogen and other hydrocarbons (equation 7). These inputs are derived in other STEO modules.

OHRIPUS = EORIPUS + OXRIPUS + RNRIPUS + HORIPUS (7)

where,

EORIPUS = fuel ethanol refinery input, million barrels per day
HORIPUS = hydrogen and other hydrocarbons refinery input, million barrels per day
OHRIPUS = other hydrocarbons and oxygenates refinery input, million barrels per day
OXRIPUS = oxygenates (excluding fuel ethanol) refinery input, million barrels per day
RNRIPUS = renewable fuels except fuel ethanol refinery input, million barrels per day

8. Total Refinery Input

Total refinery input is the sum of the individual refinery inputs (equation 8).

PARIPUSX = CORIPUSX (8)
+ UORIPUSX
+ PPRIPUS
+ LGRIPUS
+ MBRIPUS
+ ABRIPUS
+ OHRIPUS

where,

ABRIPUS = aviation gasoline blending components refinery input, million barrels per day
CORIPUSX = crude oil refinery input (initial value), million barrels per day
LGRIPUS = liquefied petroleum gas refinery input, million barrels per day
MBRIPUS = motor gasoline blending components refinery inputs, million barrels per day
OHRIPUS = other hydrocarbons and oxygenates refinery input, million barrels per day
PARIPUSX = total refinery input (initial value), million barrels per day
PPRIPUS = pentanes plus refinery input, million barrels per day
UORIPUSX = unfinished oils refinery input (initial value), million barrels per day

5. Refinery Output

A. Introduction

The refinery outputs section of the model contains 6 estimated regression equations and one identity. The refinery output equations are for motor gasoline, distillate, jet fuel, residual fuel, LPG, and other petroleum products.

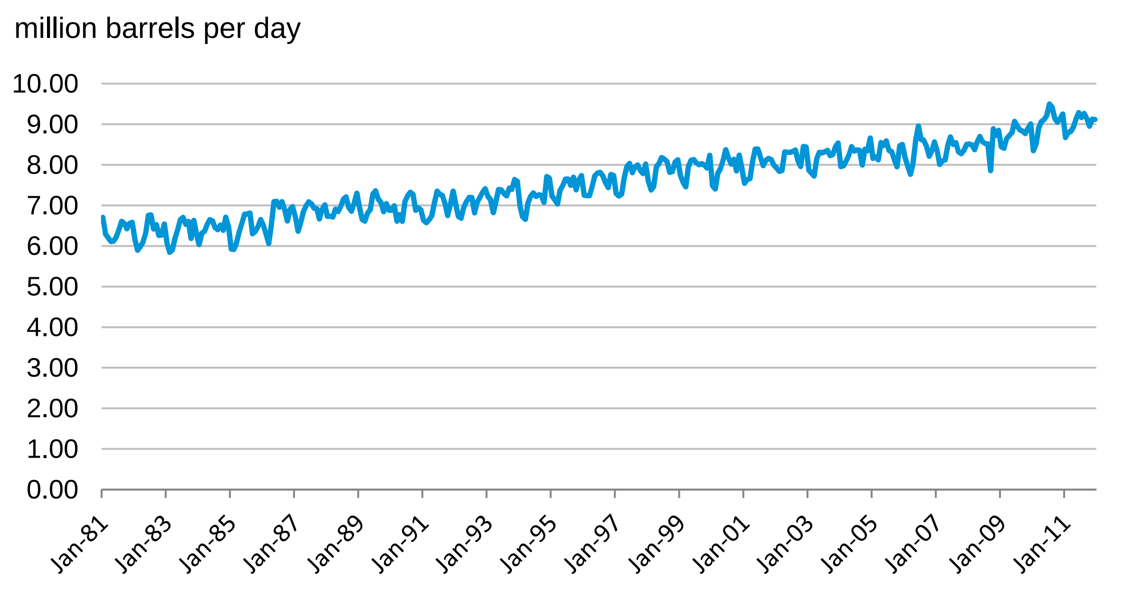
B. Refinery Output Equations

Refinery outputs are generally estimated as functions of refinery inputs and relative product prices.

1. Finished Motor Gasoline

Finished motor gasoline is a complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as defined in ASTM Specification D 4814 or Federal Specification VV-G-1690C, is characterized as having a boiling range of 122 to 158 degrees Fahrenheit at the 10-percent recovery point to 365 to 374 degrees Fahrenheit at the 90-percent recovery point. Motor Gasoline includes conventional gasoline, all types of oxygenated gasoline (including gasohol), and reformulated gasoline, but excludes aviation gasoline. Refinery output of finished motor gasoline does not include some gasoline blending components and oxygenates that are reported as an "adjustment" to finished motor gasoline supply.

Figure 7. U.S. refinery outputs of finished motor gasoline, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

The regression equation for motor gasoline refinery output is shown in equation 9. Motor gasoline output is a function of the necessary inputs to make motor gasoline, the average spread, in real dollars, between motor gasoline and distillate, along with the previous month's stock as well as the 4-year average stock level. The previous 4-year average has generally been found to be the best proxy for the desired stock level. However, the absence of statistical significance indicates an improved specification is needed.

MGROPUS = a0 + a1 * CORIPUSX (9)
+ a2 * UORIPUSX
+ a3 * MBRIPUS
+ a4 * OHRIPUS
+ a5* (MGWHHUS - DSWHUUS)/WPCPIUS
+ a6 * MGTSPUS(-1) – [(MGTSPUS(-13) + MGTSPUS(-13)+ MGTSPUS(-13)+MGTSPUS(-13))/4]
+ a7 * MGROPUS(-1)
+ monthly dummy variables

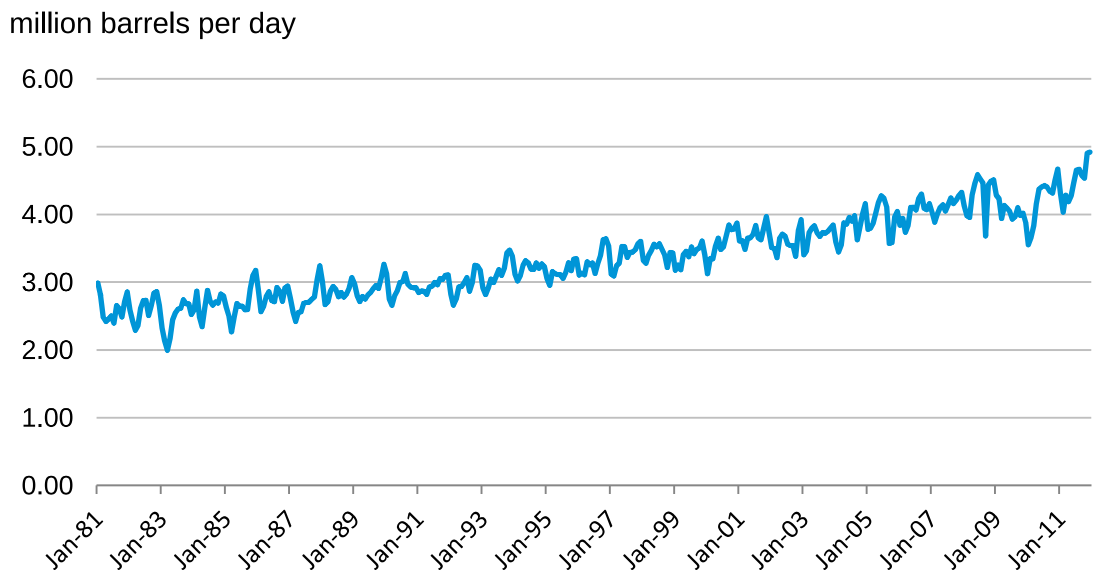
where,

CORIPUSX = crude oil refinery input, million barrels per day
DSWHUUS = diesel fuel refiner price for resale, cents per gallon
LGRIPUS = liquefied petroleum gas refinery input, million barrels per day
LGROPUS = liquefied petroleum gas refinery output, million barrels per day
MBRIPUS = motor gasoline blending components refinery input, million barrels per day
MGROPUS = motor gasoline refinery output, million barrels per day
MGROPUS(-1) = prior month's motor gasoline refinery output, million barrels per day
MGTSPUS = total motor gasoline (finished gasoline and blend components) end-of-month stocks, million barrels
MGTSPUS(-1) = prior end-of-month total motor gasoline finished stocks and blend components stocks, million barrels
MGWHUUS = motor gasoline refiner price for resale, cents per gallon
UORIPUSX = unfinished oils refinery input, million barrels per day
WPCPIUS = producer price index

2. Distillate Fuel

Distillate fuel is a general classification for one of the petroleum fractions produced in conventional distillation operations. It includes diesel fuels and fuel oils. Products known as No. 1, No. 2, and No. 4 diesel fuel are used in on-highway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Products known as No. 1, No. 2, and No. 4 fuel oils are used primarily for space heating and electric power generation.

Figure 8. U.S. refinery outputs of distillate fuel, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

Refinery output of distillate fuel is a function of refinery inputs of crude oil and unfinished oils, the average real spot price spread between motor gasoline and distillate, the deviation of Northeast heating degree days from normal, and the deviation between the previous end-of-month stock level from the previous 4-year average (equation 10).

DFROPUS = a0 + a1 * CORIPUSX (10)
+ a2 * UORIPUSX
+ a3 * (MGWHHUS-DSWHUUS)/WPCPIUS
+ a4 * DFPSPUS(-1) - (DFPSPUS(-13) + DFPSPUS(-25)+ DFPSPUS(-37)+DFSPUS(-49))/4
+ a5 * (ZWHD_NE – ZWHN_NE)/(ZSAJQUS)
+ a6 * DFROPUS(-1)
+ monthly dummy variables

where,

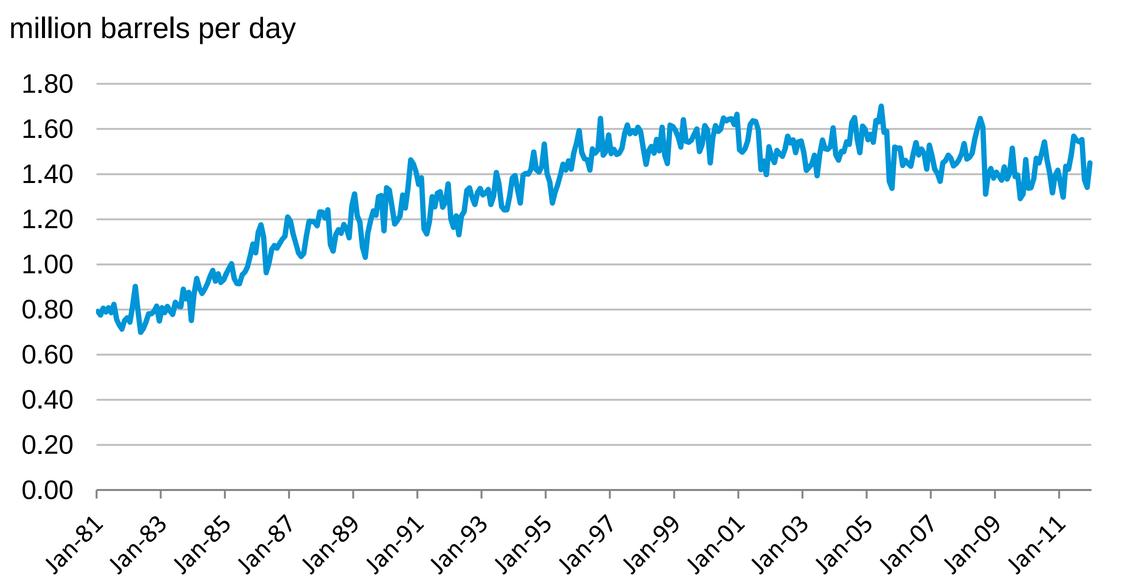
CORIPUSX = crude oil refinery input, million barrels per day
DFPSPUS = distillate fuel stocks end-of-month stocks, million barrels
DFROPUS = distillate refinery output, million barrels per day
DFROPUS(-1) = prior month distillate refinery output, million barrels per day
DSWHUUS = diesel fuel refiner price for resale, cents per gallon
MGWHUUS = motor gasoline refiner price for resale, cents per gallon
UORIPUSX = unfinished oils refinery input, million barrels per day
WPCPIUS = producer price index
ZSAJQUS = number of days in a month
ZWHD_NE = Northeast heating degree days

ZWHN_NE = Northeast heating degree days, normal

3. Jet Fuel

Jet fuel is a refined petroleum product used in jet aircraft engines. It includes kerosene-type jet fuel and naphtha-type jet fuel. Jet fuel production (and consumption) in the United States had been rising relatively steadily in the 1980s and 1990s, following the Airline Deregulation Act (Public Law 95-504), which was signed into law in October 1978. Since 2000, jet fuel production and consumption has fallen as airline fleet average fuel efficiency has improved and passenger and freight load factors have increased.

Figure 9. U.S. refinery outputs of jet fuel, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

Jet fuel refinery output (equation 11) is similar to the equations for the other major products. Jet fuel refinery output is expected to be a positive function of refinery inputs and a negative function of the spread between gasoline or diesel fuel wholesale prices and jet fuel wholesale price.

JFROPUSX = a0 + a1 * CORIPUSX (11)
+ a2 * UORIPUSX
+ a3 * (MGWHUUS-JKTUUS)/WPCPIUS
+ a4 * (DSWHUUS-JKTUUS)/WPCPIUS
+ a4 * (JFPSPUS(-13) + JFPSPUS(-25)+ JFPSPUS(-37)+JFPSPUS(-49))/4
+ a5 * JFROPUSX(-1)
+ monthly dummy variables

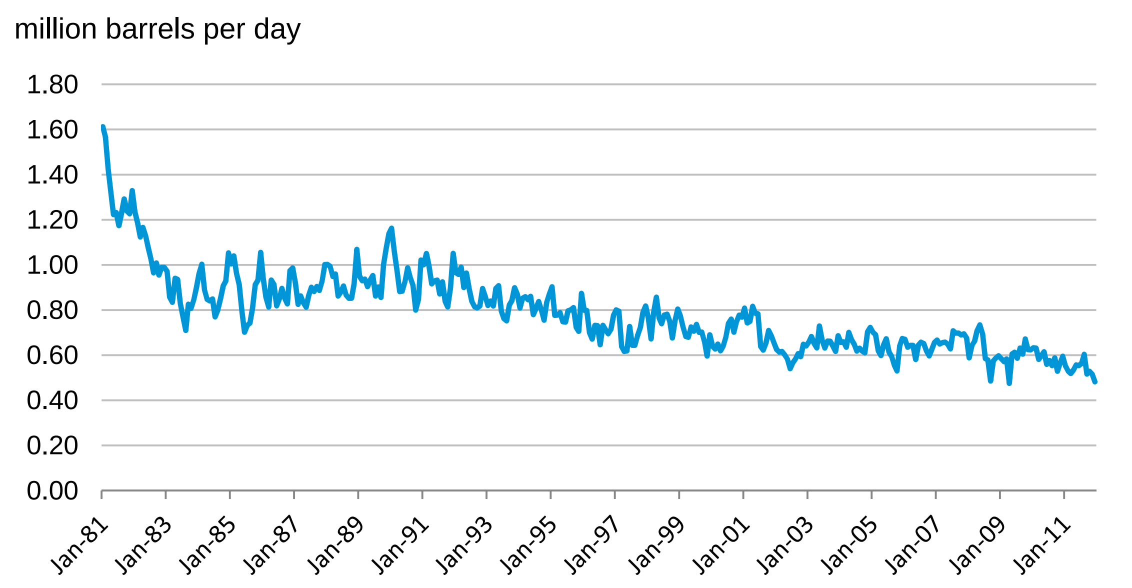
where,

CORIPUSX = crude oil refinery input (initial value), million barrels per day
DSWHUUS = diesel fuel refiner price for resale, cents per gallon
JFROPUS = jet fuel refinery output, million barrels per day
JFROPUS(-1) = prior month jet fuel refinery output, million barrels per day
JFPSPUS = jet fuel end of the month stocks, million barrels
JKTCUUS = kerosene jet fuel refiner price for resale, cents per gallon
UORIPUSX = unfinished oils refinery input (initial value), million barrels per day
WPCPIUS = producer price index

4. Residual Fuel

Residual fuel oil is a general classification for the heavier oils, known as No. 5 and No. 6 fuel oils, that remain after the distillate fuel oils and lighter hydrocarbons are distilled away in refinery operations. It conforms to ASTM Specifications D 396 and D 975and Federal Specification VV-F-815C. No. 5, a residual fuel oil of medium viscosity, is also known as Navy Special and is defined in Military Specification MIL-F-859E, including Amendment 2 (NATO SymbolF-770). It is used in steam-powered vessels in government service and inshore power plants. No. 6 fuel oil includes Bunker C fuel oil and issued for the production of electric power, space heating, vessel bunkering, and various industrial purposes.

Figure 10. U.S. refinery outputs of residual fuel, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

The residual fuel refinery output equation is a simple function of refinery inputs (equation 12). The deviation in stocks from the previous 4-year average is included in the regression equation, but the estimated coefficient is not statistically significant. The previous 4-year average has generally been found to be the best proxy for the desired stock level. However, the absence of statistical significance indicates an improved specification is needed.

RFROPUSX = a0 + a1 * CORIPUSX (12)
+ a2 * UORIPUSX
+ a3 * (RFPSPUS(-13) + RFPSPUS(-25) + RFPSPUS(-37) + RFPSPUS(-49))/4
+ a4 * RFROPUSX (-1)
+ monthly dummy variables

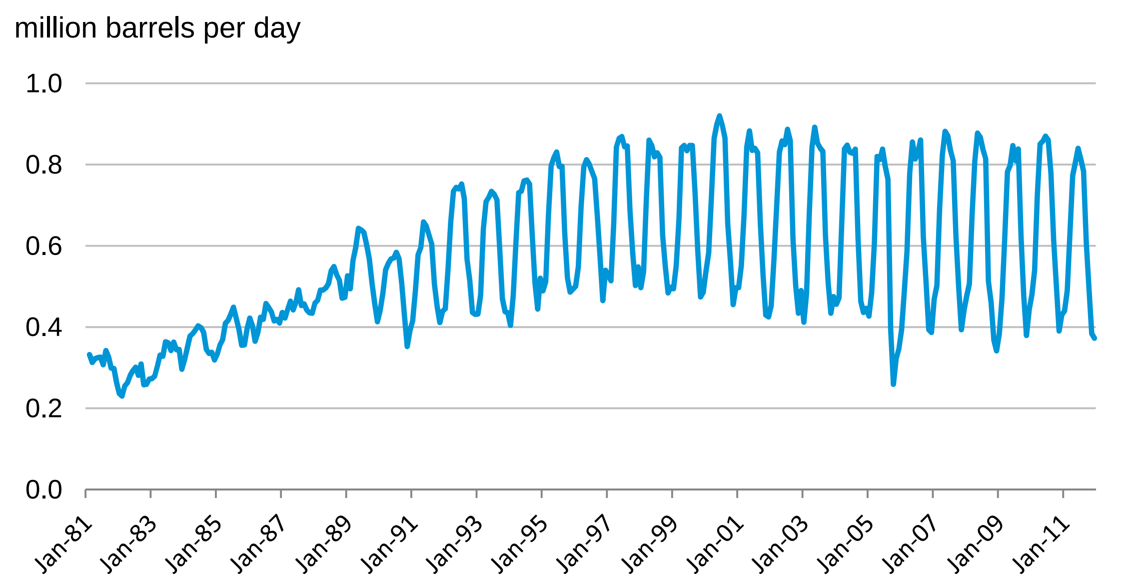
where,

CORIPUS = crude oil refinery input, million barrels per day
RFPSPUS = residual fuel end of the month stocks, million barrels
RFROPUS = residual fuel refinery output, million barrels per day
RFROPUS(-1) = prior month residual fuel refinery output , million barrels per day
UORIPUS = unfinished oils refinery input, million barrels per day

5. *Liquefied Petroleum Gas*

Liquefied petroleum gases are a group of hydrocarbon-based gases derived from crude oil refining or natural gas fractionation. They include ethane, ethylene, propane, propylene, normal butane, butylene, isobutane, and isobutylene. For convenience of transportation, these gases are often liquefied through pressurization.

Figure 11. U.S. refinery outputs of liquefied petroleum gas, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

LPGs are a by-product of the refining process and its yield is subject to the seasonal specifications of motor gasoline produced. LPGs, particularly normal butane, are blended into gasoline because of their low costs. However, blending normal butane raises the gasoline vapor pressure (measured as Reid vapor pressure). The Reid Vapor Pressure of summer-grade motor gasoline is lower than winter-grade gasoline, which leads to more LPG being produced in the summer months. LPG output, shown in equation 13, is a function of seasonal adjustment factors and heating degree days per month which affects the price of LPG.

LGROPUS = a0 + a1 * (LGROPUS_SF*CORIPUSX) (13)
+ a2 * (LGROPUS_SF*UORIPUSX)
+ a3 * (MGYLD*CORIPUS)
+ a4 * (ZWHDPUS – ZWHNPUS)/ZSAJQUS
+ a5 * LGROPUS(-1)
+ monthly dummy variables

where,

CORIPUSX = crude oil refinery input, million barrels per day
LGROPUS = seasonally-adjusted liquefied petroleum gas refinery output, million barrels per day
LGROPUS(-1) = prior month liquefied petroleum gas refinery output, million barrels per day
LGROPUSX_SF = seasonal factor for liquefied petroleum gas refinery output
MGYLD = motor gasoline yield
UORIPUSX = unfinished oils refinery input, million barrels per day
ZSAJQUS = number of days in a month
ZWHDPUS = U.S. heating degree days

ZWHNPUS = U.S. heating degree days, normal

6. *Other Petroleum Products*

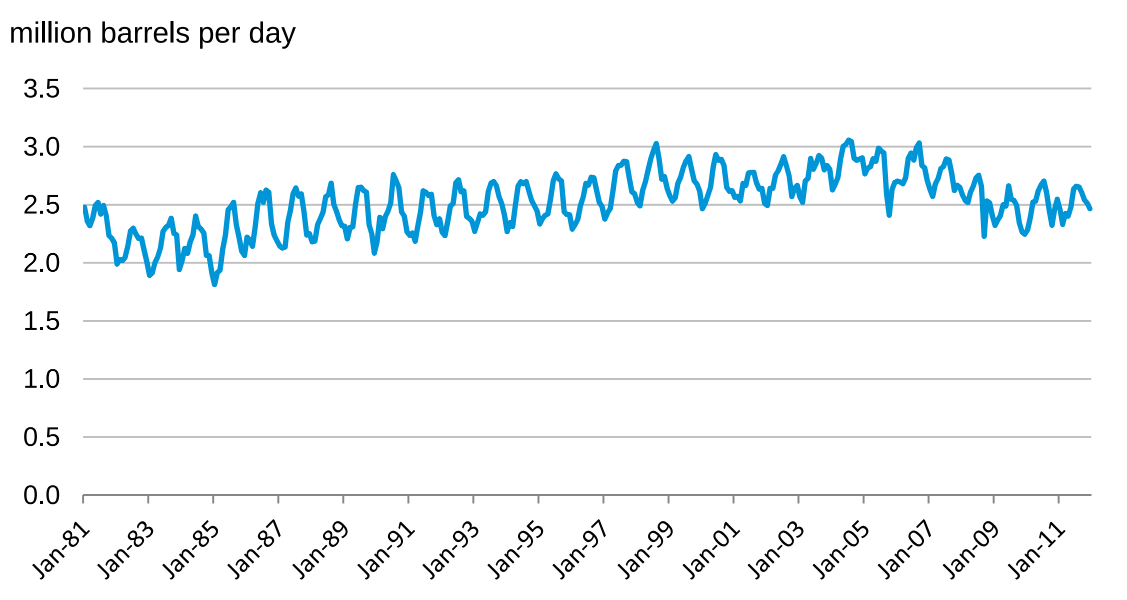
Refineries also output a range of other products (Table 4 and Figure 12).

Table 4. Refinery outputs of other petroleum products, thousand barrels per day

Product	2007	2008	2009	2010	2011
Finished aviation gasoline	16	15	14	15	15
Kerosene	36	16	20	19	16
Petrochemical feedstocks	399	335	313	327	306
Special naphthas	42	41	33	37	38
Lubricants	179	173	151	165	170
Waxes	12	10	8	8	8
Petroleum coke	823	818	799	812	842
Asphalt and road oil	456	410	359	378	364
Still gas	697	670	664	672	678
Miscellaneous products	68	75	71	76	79
Total other petroleum products	2,728	2,563	2,431	2,509	2,514

Source: EIA *Petroleum Supply Monthly*.

Figure 12. U.S. refinery outputs of other petroleum products, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

Refinery output of other products is a function of crude oil and unfinished oils input as shown in equation 14.

PSROPUS = a0 + a1 * CORIPUSX (14)
+ a2 * UORIPUSX
+ a3 * PSROPUS(-1)
+ monthly dummy variables

where,

CORIPUSX = crude oil refinery input (initial value), million barrels per day
UORIPUSX = unfinished oils refinery input (initial value), million barrels per day
PSROPUS = other petroleum products refinery output, million barrels per day
PSROPUS(-1) = prior month other petroleum products refinery output, million barrels per day

7. Total Refinery Output

Total refinery output is the sum of the initial product outputs as shown in equation 15.

PAROPUS = MGROPUS (15)
+ DFROPUS
+ JFROPUS
+ RFROPUS
+ LGROPUS
+ PSROPUS

where,

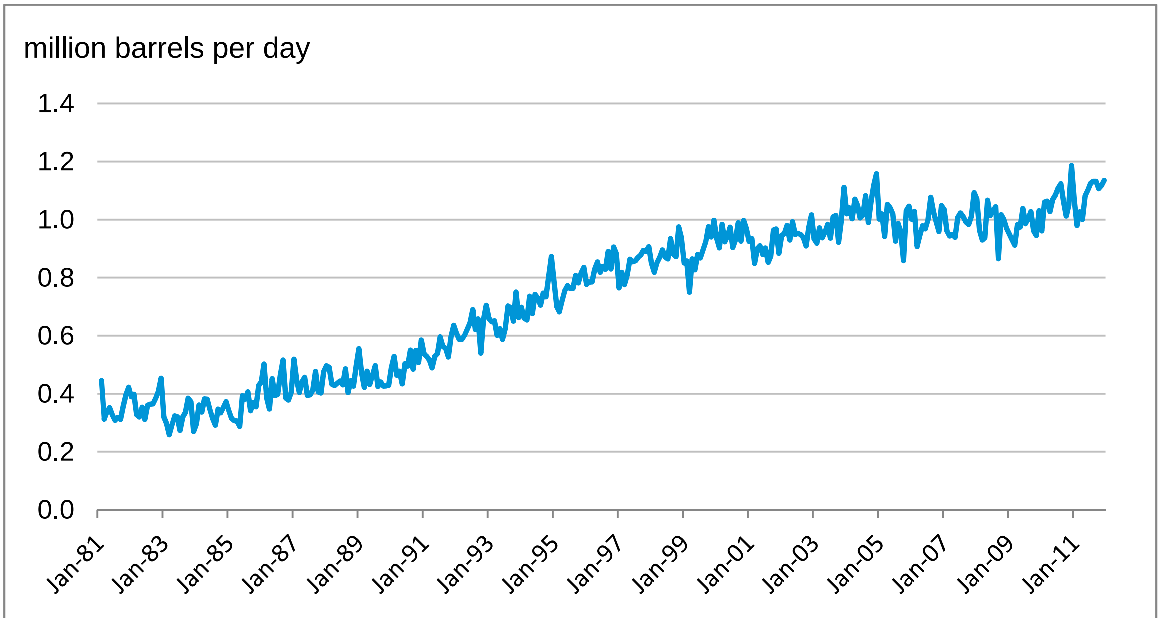
DFROPUS = distillate fuel refinery output, million barrels per day
JFROPUS = jet fuel refinery output, million barrels per day
LGROPUS = liquefied Petroleum Gas refinery output, million barrels per day
MGROPUS = motor gasoline refinery output, million barrels per day
PAROPUS = total refinery output, million barrels per day
PSROPUS = other Petroleum Products refinery output, million barrels per day
RFROPUS = residual fuel refinery output, million barrels per day

6. Refinery Balance

1. Refinery Processing Gain

Refinery processing gain is the volumetric increase that occurs when crude oil and heavy unfinished oils are cracked into lighter and more valuable products in refinery secondary processing units such as cokers, cat crackers, and hydrocrackers. The overall mass of material that enters and leaves the refinery remains the same, however, because long-chain hydrocarbon molecules are "cracked" into smaller molecules, the density of the products decreases and the total volume produced increases.

Figure 13. U.S. refinery processing gain, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

Refinery processing gain is estimated as a function of refinery inputs of crude oil and unfinished oils (equation 16).

PAGLPUS = a0 + a1 * CORIPUSX (16)
    + a2 * UORIPUSX
    + monthly dummy variables

where,

CORIPUSX = crude oil refinery input (initial value), million barrels per day
PAGLPUS = refinery processing gain, million barrels per day
UORIPUSX = unfinished oils refinery input (initial value), million barrels per day

2. Balancing Refinery Inputs, Refinery Outputs, and Refinery Processing Gain

The separate forecasts of refinery inputs, refinery outputs, and refinery processing gain must be adjusted to maintain the volume balance that outputs equals inputs plus processing gain. If refinery outputs are greater or less than the initial value of refinery input plus refinery processing gain, the initial values for crude oil and unfinished oils refinery inputs are proportionally adjusted upwards or downwards to create a balance (equations 17 and 18).

$$CORIPUS = CORIPUSX + (PAROPUS - PARIPUSX - PAGLPUS) * CORIPUSX/(CORIPUSX + UORIPUSX) \quad (17)$$

$$UORIPUS = UORIPUSX + (PAROPUS - PARIPUSX - PAGLPUS) * UORIPUSX/(CORIPUSX + UORIPUSX) \quad (18)$$

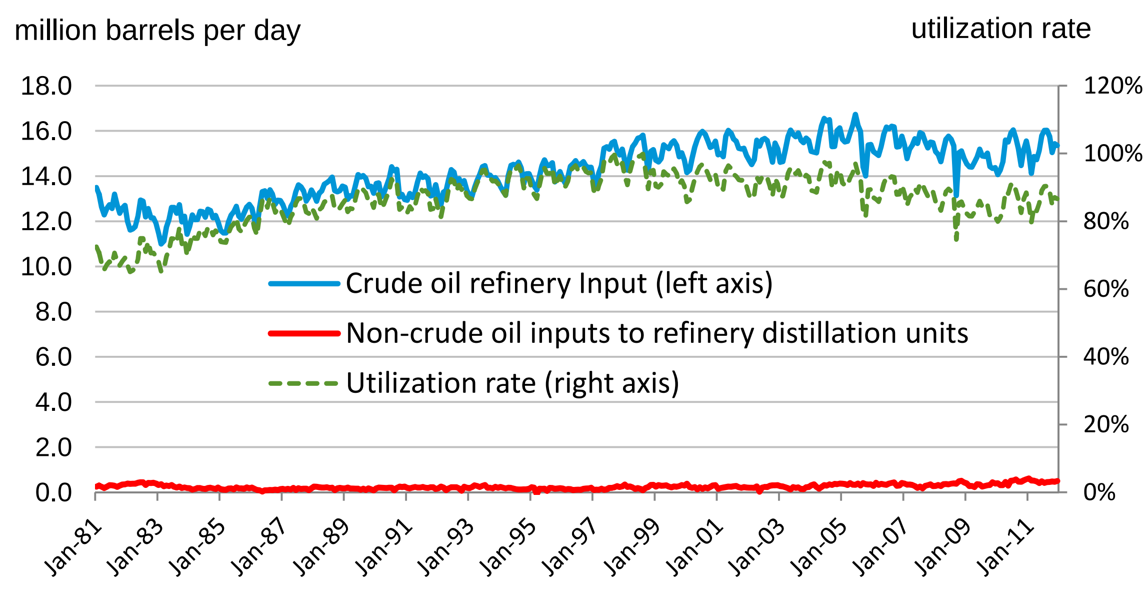
where,

CORIPUS = crude oil refinery inputs, million barrels per day
CORIPUSX = crude oil refinery inputs initial value, million barrels per day
PAGLPUS = refinery processing gain, million barrels per day
PARIPUS = total refinery input, million barrels per day
PARIPUSX = total refinery input (initial value), million barrels per day
UORIPUS = unfinished oils refinery input, million barrels per day
UORIPUSX = unfinished oils refinery input (initial value), million barrels per day

3. *Refinery Capacity and Utilization Rate*

EIA reports refinery utilization rates as total inputs to crude oil atmospheric distillation units divided by total operable atmospheric distillation capacity, expressed as a percentage.

Figure 14. Non-crude oil inputs to crude oil atmospheric distillation and utilization rates, Jan. 1981 - Dec. 2011



Source: EIA, *Petroleum Supply Monthly*, Table 3.

Total inputs to crude oil distillation units are less that total refinery inputs. Some refinery inputs such as unfinished oils may be fed to processing units downstream of atmospheric distillation such as vacuum distillation units and cat crackers. The model assumes all crude oil is fed to atmospheric crude oil distillation units and the inputs of unfinished oils are estimated as a function of total unfinished oil refinery inputs (equation 19).

CODIPUS - CORIPUS = a0 + a1 * UORIPUS (19)
+ a2 * (CODIPUS(-1) – UORIPUS(-1))
+ monthly dummy variables

where,

CODIPUS = total input to atmospheric distillation units, million barrels per day
CORIPUS = crude oil refinery input, million barrels per day
CORIPUS(-1) = previous month crude oil refinery input, million barrels per day y
UORIPUS = unfinished oils refinery input, million barrels per day
UORIPUS(-1) = previous month unfinished oils refinery input, million barrels per day

The STEO does not attempt to forecast changes in operable refining capacity. Refining capacity over the forecast is set equal to operable capacity published in the most recent *Weekly Petroleum Status Report* (equation 20). Any expected future changes to refining capacity, such as planned startup of new units or shutdown of existing units, may be included in the forecast as exogenous adjustments to the forecasted value. The average refinery utilization rate is then total inputs to crude oil atmospheric distillation units divided by total capacity (equation 21).

ORCAPUS = ORCAPUS(-1) (20)

ORUTCUS = CODIPUS / ORCAPUS (21)

where,

CODIPUS = total input to atmospheric distillation units, million barrels per day
ORCAPUS = crude oil refinery input, million barrels per day
ORCAPUS(-1) = previous month crude oil refinery input, million barrels per day y
ORUTCUS = unfinished oils refinery input, million barrels per day

9. Refinery Yields

Refinery yield (expressed as a percentage) represents the percent of finished product produced from input of crude oil and net input of unfinished oils. It is calculated by dividing the sum of crude oil and net unfinished input into the individual net production of finished products (equation 22).

xxYLD = xxROPUS / (CORIPUS + UORIPUS) (22)

where,

CORIPUS = Crude oil refinery input
UORIPUS = Unfinished oils refinery input
xxROPUS = Refinery output of a given product except motor gasoline
xxYLD = Yield of a given product except motor gasoline (e.g., DF, JF, and RF)

To calculate the yield for finished motor gasoline, subtract natural gas liquids inputs, other hydrocarbons and oxygenates inputs, and net input of motor gasoline blending components from the net production of finished motor gasoline (equation 23).

MGYLD = (MGROPUS – MBRIPUS – (LGRIPUS-LGROPUS) – PPRIPUS – OXRIPUS – EORIPUS) / (CORIPUS + UORIPUS) (23)

where,

CORIPUS = crude oil refinery input, million barrels per day
EORIPUS = ethanol refinery input, million barrels per day
LGRIPUS = liquefied petroleum gas input, million barrels per day
LGROPUS = liquefied petroleum gas output, million barrels per day
MBRIPUS = motor gasoline blending components input, million barrels per day

MGYLD = motor gasoline yield
OXRIPUS = other hydrocarbons and oxygenates refinery input, million barrels per day
PPRIPUS = pentanes plus refinery input, million barrels per day
UORIPUS = unfinished oils refinery input, million barrels per day

10. Forecast Evaluations

In order to evaluate the reliability of the forecasts, we generated out-of-sample forecasts and calculated forecast errors. Each equation was estimated through December 2009. Dynamic forecasts were then generated for the period January 2010 through December 2011 using each regression equation. The forecasts are then compared with actual outcomes.

Dynamic forecasts of each equation use the actual values of the exogenous variables on the right-hand side of the regression equations (e.g., consumption and price) but simulated values of the lagged dependent variable. Consequently, the calculated forecast error is not the same as a calculated regression error, which uses the actual value for the lagged dependent variable.

Summary forecast error statistics are reported for each regression equation. The root mean squared Error (RMSE) and the mean absolute error (MAE) depend on the scale of the dependent variable. These are generally used as relative measures to compare forecasts for the same series using different models; the smaller the error, the better the forecasting ability of that model.

The mean absolute percentage error (MAPE) and the Theil inequality coefficient are invariant to scale. The smaller the values, the better the model fit. The Theil inequality coefficient always lies between zero and one, where zero indicates a perfect fit. The Theil inequality coefficient is broken out into bias, variance, and covariance proportions, which sum to 1. The bias proportion indicates how far the mean of the forecast is from the mean of the actual series signaling systematic error. The variance proportion indicates how far the variation of the forecast is from the variation of the actual series. This will be high if the actual data fluctuates significantly but the forecast fails to track these variations from the mean. The covariance proportion measures the remaining unsystematic forecasting errors. For a “good” forecast the bias and variance proportions should be small with most of the forecast error concentrated in the covariance proportion.

A. Refinery Inputs

Table 5 provides a comparison of the out-of-sample dynamic forecasts and actual refinery inputs for each refinery input regression equation for the years 2010 and 2011. A forecast for total refinery inputs is calculated as the sum of the 6 individual product forecasts. In general, the forecast errors for crude oil

(CORIPUSX) and unfinished oils (UORIPUSX) offset each other. The combined forecast for crude oil and unfinished oils refinery inputs was 0.6 percent above actual in 2010 and 1.1 percent below in 2011. The higher-than-actual forecast for the combined crude oil and unfinished oils in 2010 was offset by a lower-than-actual forecast for motor gasoline blending components with total refinery inputs only 4,000 bbl/d lower than actual. The motor gasoline blending components forecast was also lower than actual in 2011, as actual inputs ranged from a low of 191,000 bbl/d in January 2011 to a high of 968,000 bbl/d in April 2011.

Table 5. Actual and out-of-sample refinery input forecasts, annual averages (million barrels per day)

	2010		**2011**	
	Actual	Forecast	Actual	Forecast
Crude oil (CORIPUSX)	14.721	14.616	14.833	14.481
Unfinished oils (UORIPUSX)	0.590	0.794	0.626	0.811
Pentanes Plus (PPRIPUS – PPPRPUS)	0.173	0.184	0.192	0.186
Liquefied petroleum gas (LGRIPUS)	0.287	0.324	0.315	0.321
Gasoline blend components (MBRIPUS)	0.671	0.520	0.599	0.549
Aviation gas blend components (ABRIPUS)	0.000	0.000	0.000	0.000
Total (PARIPUS)	16.443	16.439	16.586	16.348

Figures 15 through 19 show the monthly actual and forecasted values for each of the refinery inputs. The under-predictions of unfinished oils and motor gasoline blending component refinery inputs appear in most months during 2010 and 2011.

Figure 15. CORIPUSX, crude oil refinery inputs out-of-sample forecast versus actual, January 2010 – December 2011

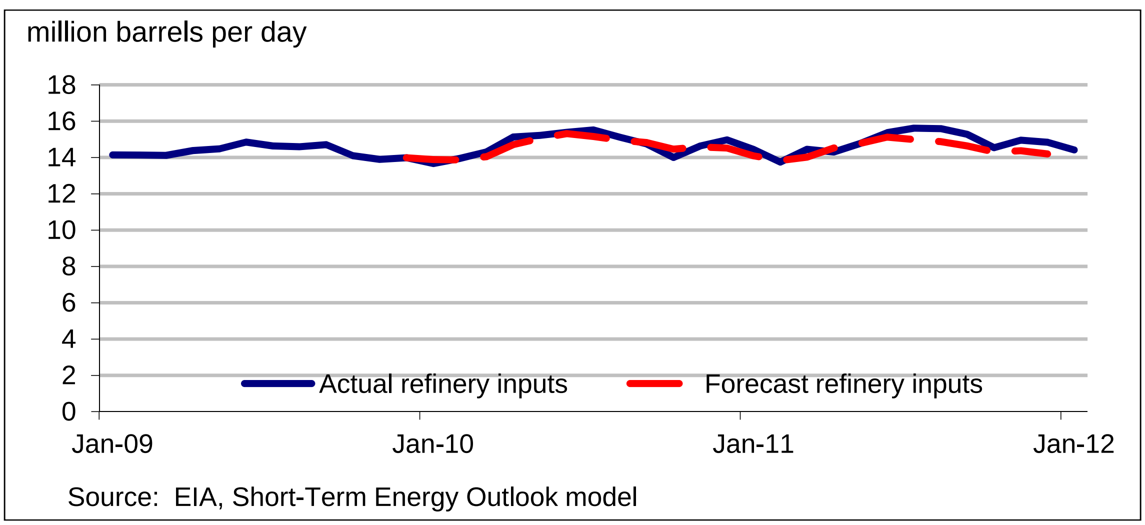


Figure 16. UORIPUSX, unfinished oils refinery inputs out-of-sample forecast versus actual, January 2010 – December 2011

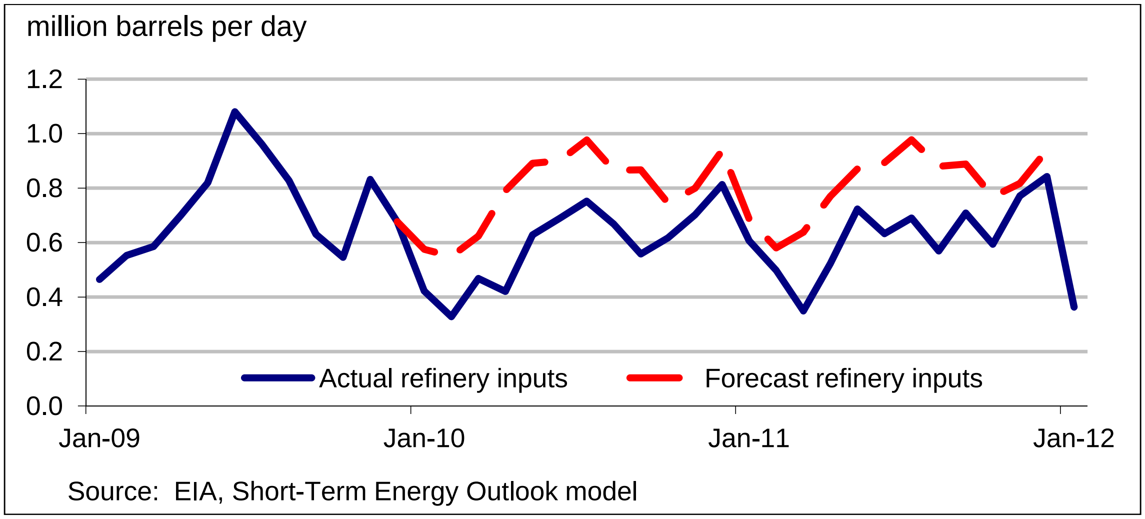


Figure 17. PPRIPUS - PPPRPUS, pentanes plus gasoline blending out-of-sample forecast versus actual, January 2010 – December 2011

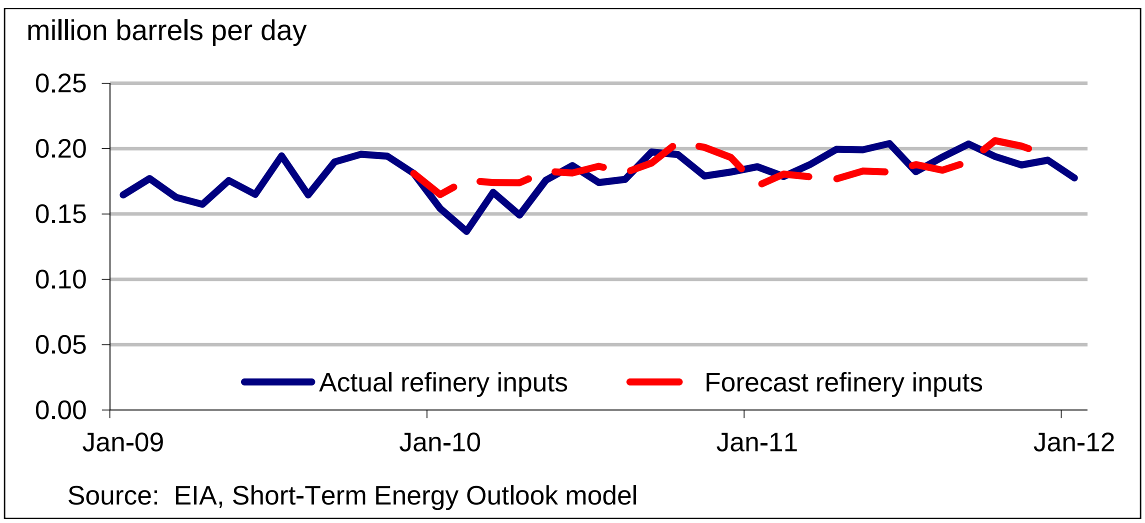


Figure 18. LGRIPUS, liquefied petroleum gas refinery inputs out-of-sample forecast versus actual, January 2010 – December 2011

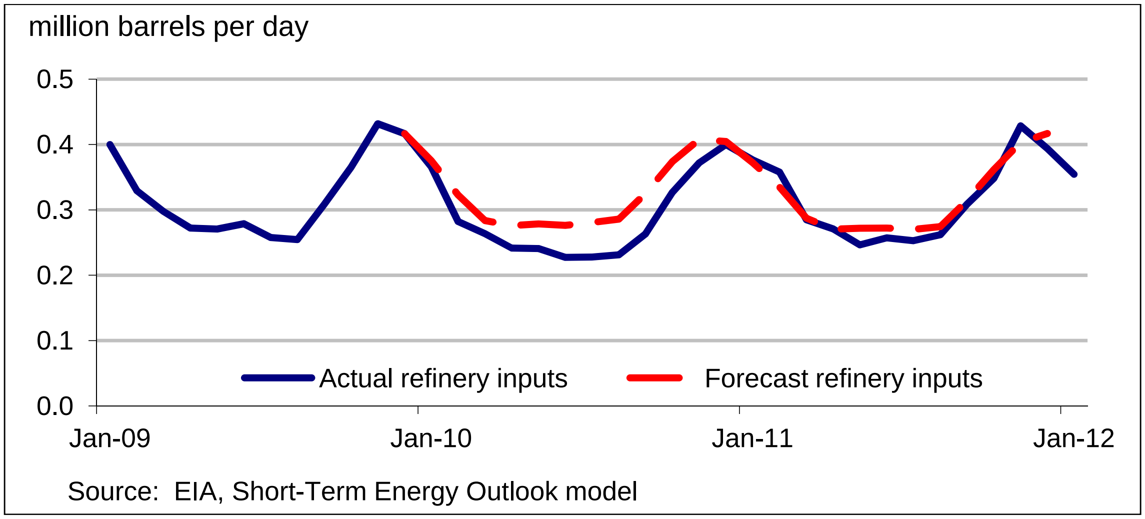
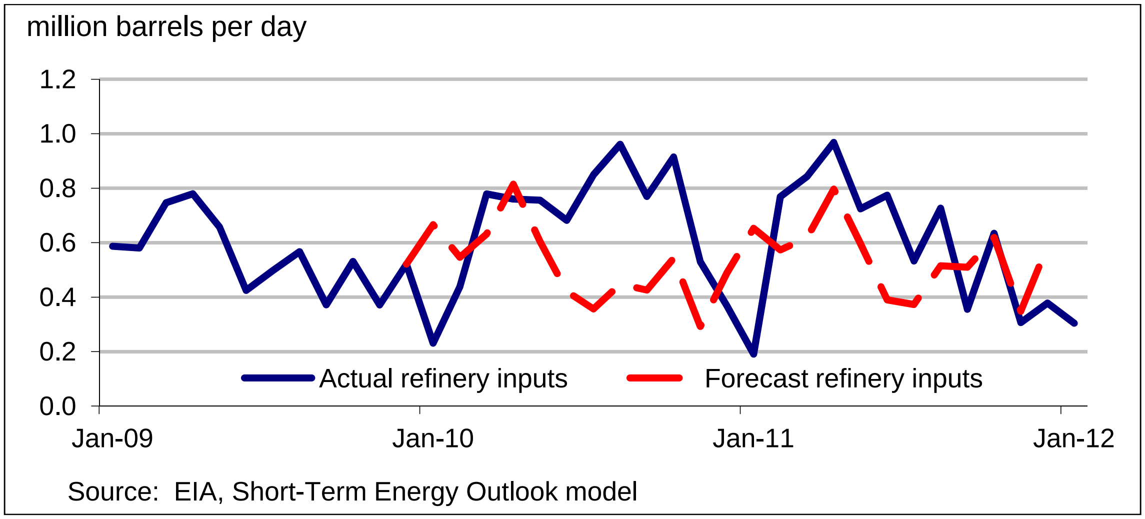


Figure 19. MBRIPUS, motor gasoline blending components refinery inputs out-of-sample forecast versus actual, January 2010 – December 2011



The difficulty in forecasting unfinished oils and motor gasoline blending components also appears in Table 6, which reports summary forecast error statistics for each regression equation. Although the mean absolute percentage error and Theil inequality coefficient are greatest for the motor gasoline blending components refinery inputs, most of the forecast error occurs in the covariance proportion, which implies unsystematic forecast error.

Table 6. Refinery inputs out-of-sample simulation error statistics

	Crude oil	Unfinished oils	Pentanes Plus	Liquefied Petroleum Gas	Motor gasoline blending components
Root mean squared error	0.381	0.144	0.015	0.031	0.273
Mean absolute error	0.316	0.122	0.013	0.026	0.233
Means absolute percent error	2.1	23.4	7.3	9.4	46.9
Theil inequality coefficient	0.013	0.107	0.041	0.049	0.223
Bias proportion	0.35	0.68	0.03	0.46	0.14
Variance proportion	0.12	0.03	0.16	0.11	0.12
Covariance proportion	0.53	0.30	0.81	0.43	0.74

B. Refinery Outputs

Table 7 provides a comparison of the out-of-sample dynamic forecasts and actual refinery outputs for each refinery output regression equation for the years 2010 and 2011. A forecast for total refinery outputs is calculated as the sum of the 6 individual product forecasts. The forecast errors for 2010 were generally smaller than those for 2011. The largest volume forecast error was for distillate fuel production in 2011 (0.221 million bbl/d, or 4.9 percent). The model correctly forecast declines in gasoline and LPG refinery output but over-predicted the increase in distillate fuel output. The model over-predicted residual fuel output and under-predicted other petroleum product output in both years.

Table 7. Actual and out-of-sample refinery output forecasts, annual averages (million barrels per day)

	2010		2011	
	Actual	Forecast	Actual	Forecast
Finished motor gasoline (MGROPUS)	9.057	9.023	9.035	9.008
Distillate fuel (DFROPUS)	4.222	4.221	4.487	4.708
Jet fuel (JFROPUS)	1.418	1.408	1.449	1.462
Residual fuel (RFROPUS)	0.585	0.611	0.538	0.621
Liquefied petroleum gas (LGROPUS)	0.658	0.644	0.620	0.613
Other petroleum products (PSROPUS)	2.509	2.444	2.514	2.438
Total (PAROPUS)	18.448	18.352	18.643	18.849

Figures 20 through 25 show the monthly actual and forecasted values for each of the refinery outputs.

Figure 20. MGROPUS, finished motor gasoline refinery outputs out-of-sample forecast versus actual, January 2010 – December 2011

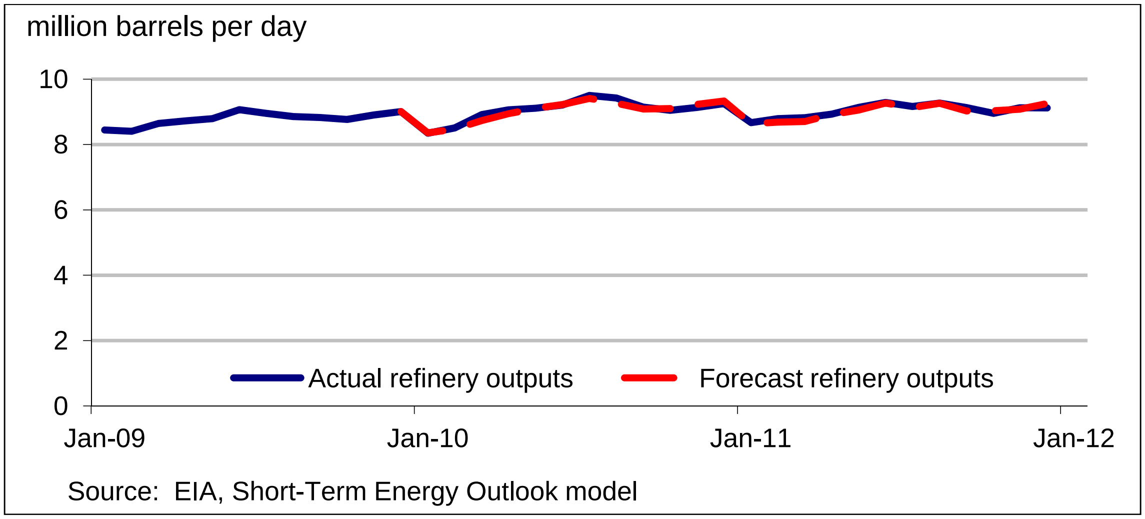


Figure 21. DFROPUS, distillate fuel oil refinery outputs out-of-sample forecast versus actual, January 2010 – December 2011

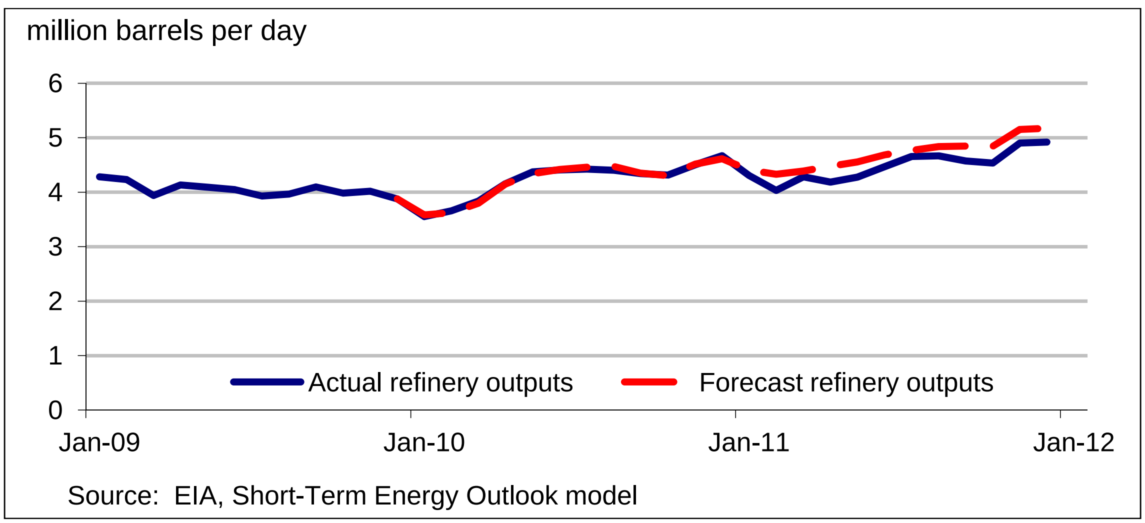


Figure 22. JFROPUS, jet fuel oil refinery outputs out-of-sample forecast versus actual, January 2010 – December 2011

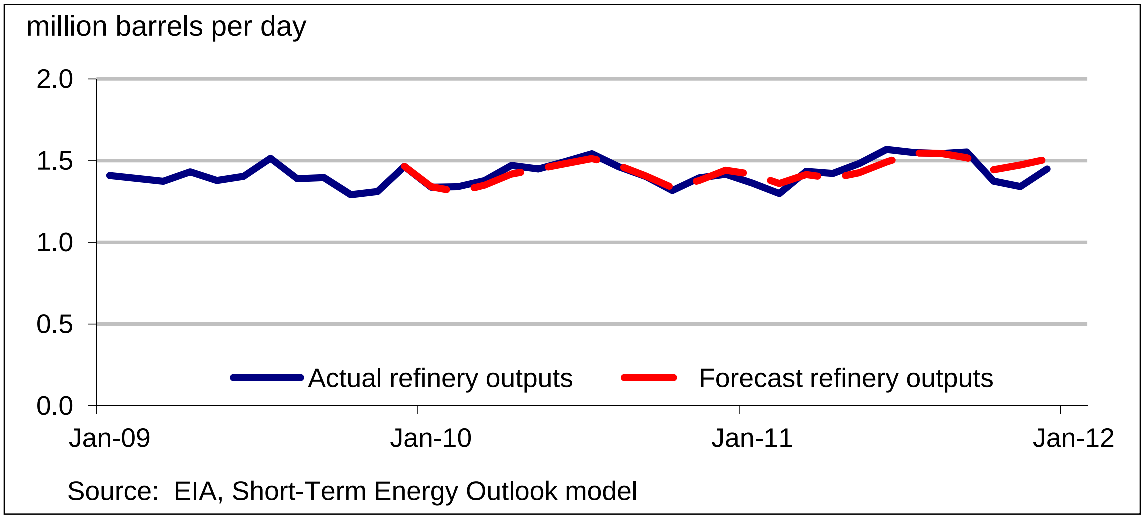


Figure 23. RFROPUS, residual fuel oil refinery outputs out-of-sample forecast versus actual, January 2010 – December 2011

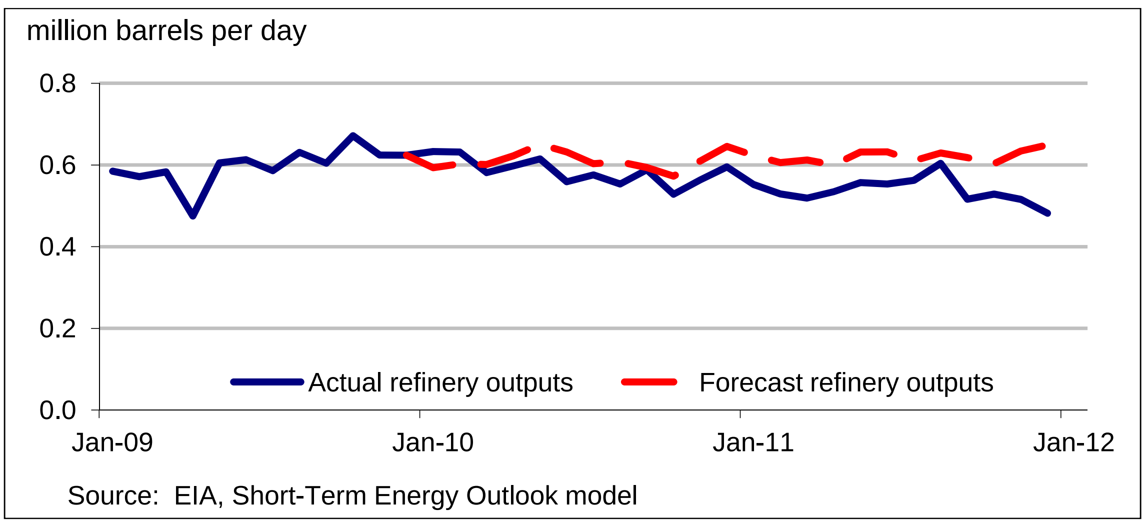


Figure 24. LGROPUS, liquefied petroleum gas refinery outputs out-of-sample forecast versus actual, January 2010 – December 2011

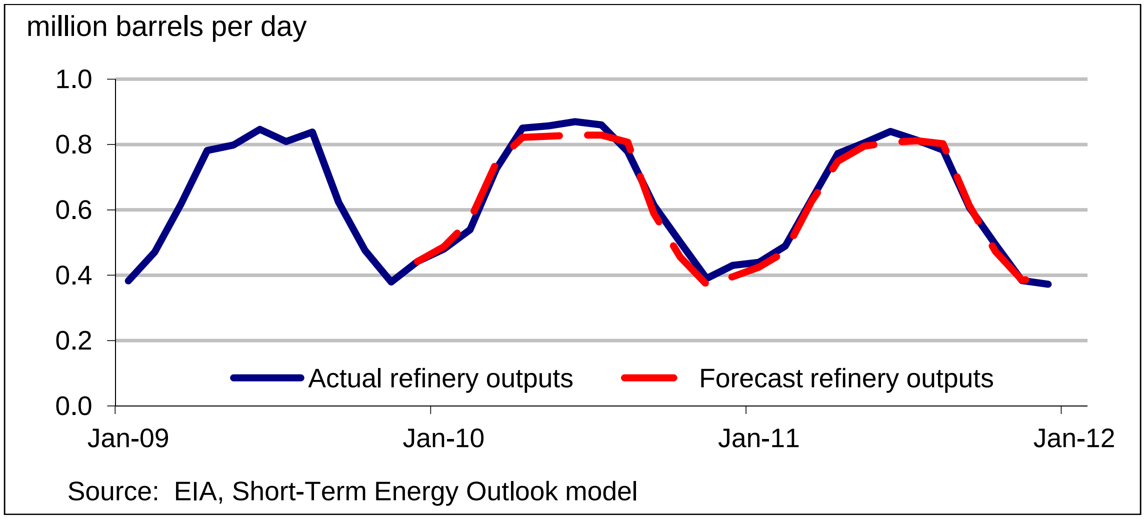
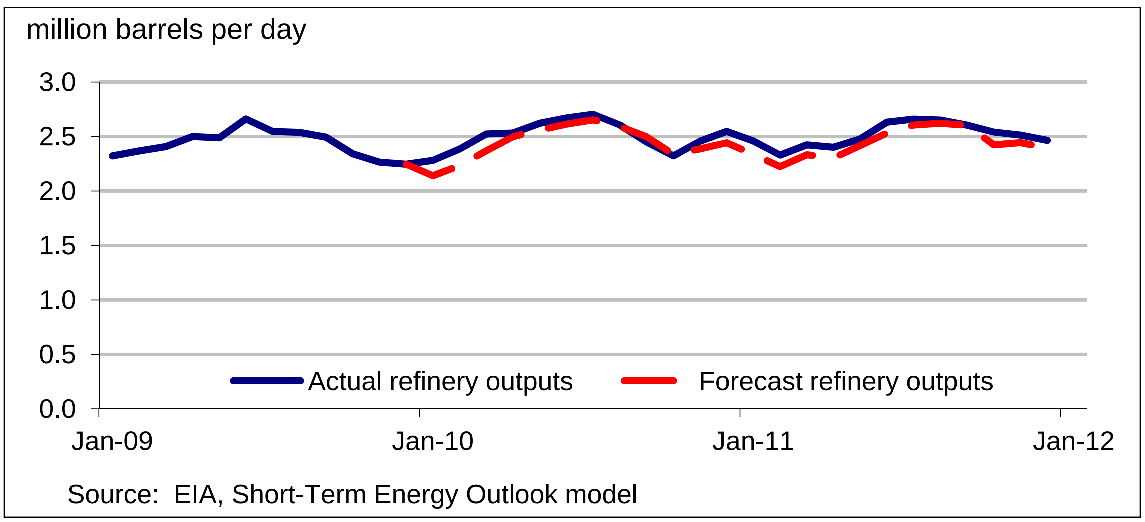


Figure 25. PSROPUS, other petroleum products refinery outputs out-of-sample forecast versus actual, January 2010 – December 2011



The consistent over- and under-predictions of distillate fuel, residual fuel, and other petroleum products are also revealed in Table 8, which reports summary forecast error statistics for each regression equation. The bias proportions of the Theil inequality coefficient are the highest for these forecasts.

Table 8. Refinery outputs out-of-sample simulation error statistics

	Finished motor gasoline	Distillate fuel oil	Jet fuel	Residual fuel oil	Liquefied petroleum gas	Other petroleum products
Root mean squared error	0.086	0.167	0.046	0.070	0.024	0.087
Mean absolute error	0.070	0.125	0.035	0.060	0.021	0.076
Means absolute percent error	0.8	2.8	2.4	11.1	3.5	3.1
Theil inequality coefficient	0.005	0.019	0.016	0.059	0.019	0.018
Bias proportion	0.13	0.44	0.002	0.61	0.19	0.66
Variance proportion	0.02	0.14	0.08	0.08	0.01	0.07
Covariance proportion	0.85	0.43	0.92	0.31	0.80	0.27

C. Refinery Balance

Table 9 provides a comparison of the out-of-sample dynamic forecasts and actual values for refinery processing gain and distillation capacity inputs for the years 2010 and 2011. Refinery processing gain forecasts were close to actual realized values while non-crude oil distillation input forecasts were significantly lower.

Table 9. Actual and out-of-sample refinery balance forecasts, annual averages (million barrels per day)

	2010		2011	
	Actual	Forecast	Actual	Forecast
Refinery processing gain (PAGLPUS)	1.068	1.050	1.085	1.075
Non-crude distillation inputs (CODIPUS - CORIPUS)	0.454	0.315	0.482	0.326

Figures 26 and 27 show the monthly actual and forecasted values for two forecasted series.

Figure 26. PAGLPUS, refinery processing gain out-of-sample forecast versus actual, January 2010 – December 2011

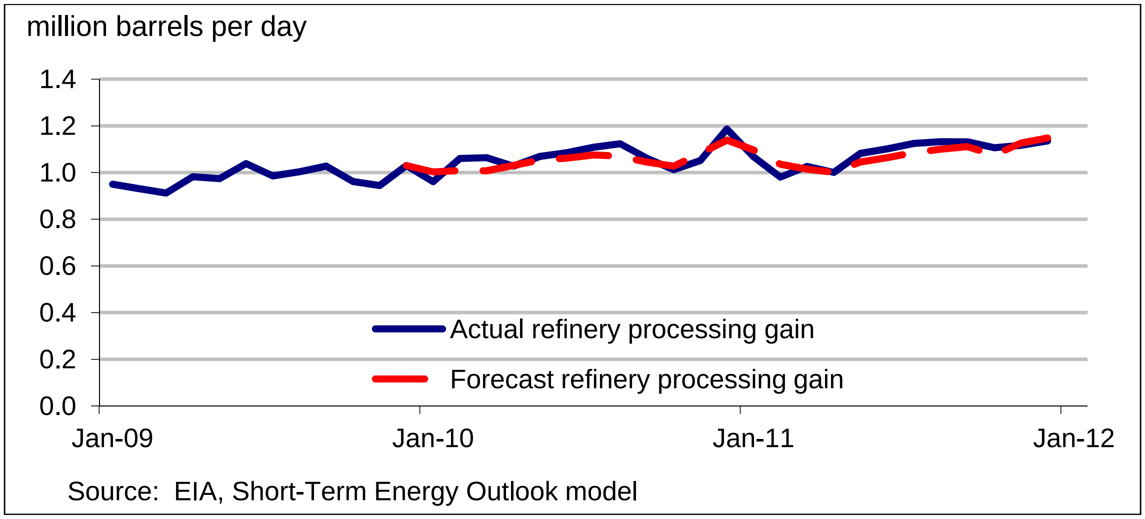
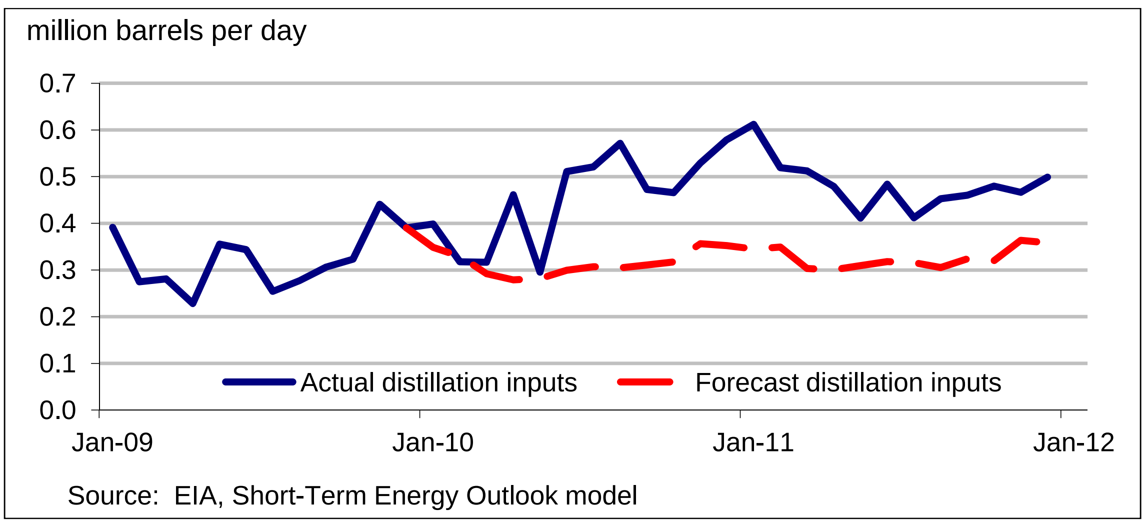


Figure 27. CODIPUS - CORIPUS, refinery distillation inputs (excluding crude oil) out-of-sample forecast versus actual, January 2010 – December 2011



The under-prediction of the non-crude oil refinery distillation inputs is shown in the large errors and Theil inequality coefficient bias proportion in Table 8.

Table 9. Refinery outputs out-of-sample simulation error statistics

	Refinery processing gain	Refinery distillation inputs
Root mean squared error	0.034	0.164

Mean absolute error	0.029	0.148
Means absolute percent error	2.7	29.9
Theil inequality coefficient	0.016	0.206
Bias proportion	0.15	0.81
Variance proportion	0.12	0.11
Covariance proportion	0.73	0.09

Appendix A. Variable Definitions, Units, and Sources

Table A1. Variable Definitions, Units, and Sources

Variable Name	Units	Definition	Sources History	Sources Forecast
ABRIPUS	MMBD	Aviation gasoline blending components refinery inputs	PSM	STEO
APR	Integer	= 1 if April, 0 otherwise	-	-
AUG	Integer	= 1 if August, 0 otherwise	-	-
CODIPUS	MMBD	Total inputs to crude oil atmospheric distillation	PSM	STEO
CORIPUS	MMBD	Crude oil refinery inputs	PSM	STEO
DEC	Integer	= 1 if December, 0 otherwise	-	-
DFPSPUS	MMB	End of month distillate fuel oil stocks	PSM	STEO
DFROPUS	MMBD	Distillate fuel oil refinery output	PSM	STEO
DFTCPUS	MMBD	Distillate fuel oil demand	PSM	STEO
DFYLD	P	Distillate fuel oil yield	PSM	STEO
DSWHUUS	CPG	Diesel fuel refiner price for resale	PMM	STEO
EORIPUS	MMBD	Fuel ethanol refinery inputs	PSM	STEO
EOTCPUS	MMBD	Fuel ethanol blending into motor gasoline	PSM	STEO
FEB	Integer	= 1 if February, 0 otherwise	-	-
JAN	Integer	= 1 if January, 0 otherwise	-	-
JFPSPUS	MMB	End-of-month jet fuel stocks	PSM	STEO
JFROPUS	MMBD	Jet fuel refinery output	PSM	STEO
JFTCPUS	MMBD	Jet fuel demand	PSM	STEO
JFYLD	P	Jet fuel yield	PSM	STEO
JKTCUUS	CPG	Jet fuel refiner price for resale	PMM	STEO
JUL	Integer	= 1 if July, 0 otherwise	-	-
JUN	Integer	= 1 if June, 0 otherwise	-	-
LGRIPUS	MMBD	Liquefied petroleum gas refinery input	PSM	STEO
LGROPUS	MMBD	Liquefied petroleum gas refinery output	PSM	STEO
LGROPUS_SF	MMBD	Liquefied petroleum gas initial refinery output seasonally factored	STEO	STEO
LGYLD	P	Liquefied petroleum gas yield	PSM	STEO
MAR	Integer	= 1 if March, 0 otherwise	-	-
MAY	Integer	= 1 if May, 0 otherwise	-	-
MBRIPUS	MMBD	Motor gasoline blending components refinery input	PSM	STEO
MGROPUS	MMBD	Motor gasoline refinery output	PSM	STEO
MGTCPUSX	MMBD	Motor gasoline demand	PSM	STEO
MGTSPUS	MMB	Motor gasoline stocks and blend components	PSM	STEO
MGWHUUS	CPG	Motor gasoline refiner price for resale	PMM	STEO

MGYLD	P	Motor gasoline yield	PSM	STEO
NOV	Integer	= 1 if November, 0 otherwise	-	-
OCT	Integer	= 1 if October, 0 otherwise	-	-
OHRIPUS	MMBD	Other hydrocarbons/oxygenates refinery inputs	PSM	STEO
ORCAPUS	MMBD	Refinery atmospheric distillate operable capacity	PSM	STEO
ORUTCUS	P	Refinery atmospheric distillate operable capacity utilization rate	PSM	STEO
OXRIPUS	MMBD	Oxygenates (excluding ethanol) refinery inuts	PSM	STEO
PAGLPUS	MMBD	Refinery processing gain	PSM	STEO
PARIPUS	MMBD	Total refinery inputs	PSM	STEO
PAROPUS	MMBD	Total refinery outputs	PSM	STEO
PPRIPUS	MMBD	Pentanes plus refinery inputs	PSM	STEO
PSRIPUS	MMBD	Other petroleum products refinery inputs	PSM	STEO
PSROPUS	MMBD	Other petroleum products refinery output	PSM	STEO
PSYLD	P	Other petroleum products yield	PSM	STEO
RACPUUS	DBBL	Refiner cost of crude oil	PMM	STEO
RFPSPUS	MMB	Residual fuel oil end-of-month stocks	PSM	STEO
RFROPUS	MMBD	Residual fuel refinery output	PSM	STEO
RFYLD	P	Residual fuel oil yield	PSM	STEO
SEP	Integer	= 1 if September, 0 otherwise	-	-
TIME	Integer	Counts the number of months from January 1975 – Present	-	-
UORIPUS	MMBD	Unfinished oils refinery inputs	PSM	STEO
WPCPIUS	Index	U.S. Producer Price Index	GI	GI
ZSAJQUS	Integer	Number of days in a month	-	-
ZWHD_NE	HDD	Heating degree days, Northeast	NOAA	NOAA
ZWHDPUS	HDD	Heating degree days, U.S.	NOAA	NOAA
ZWHN_NE	HDD	Heating degree days normal, Northeast	NOAA	NOAA
ZWHNPUS	HDD	Heating degree days normal, U.S.	NOAA	NOAA

Table A2. Units key

CPG	Cents per gallon
DPB	Dollars per barrel
HDD	Heating degree days
Index	Index value
Integer	Number = 0 or 1
MMBD	Million barrels per day
P	Fraction or percentage

Table A3. Sources key

GI	IHS-Global Insight
NOAA	National Oceanic and Atmospheric Organization
PMM	EIA Petroleum Marketing Monthly
PSM	EIA Petroleum Supply Monthly
STEO	Short-term Energy Outlook Model

Appendix B. Eviews Model Program File

```
' -----------------------------------------------------------------------------------------------------------
'--------- Refinery Input
' -----------------------------------------------------------------------------------------------------------

:EQ_CORIPUSX

:EQ_UORIPUSX

:EQ_PPRIPUS

:EQ_LGRIPUS

:EQ_MBRIPUS

:EQ_ABRIPUS

@IDENTITY PSRIPUS  = ABRIPUS

@IDENTITY PARIPUSX  = CORIPUSX  + UORIPUSX  + PPRIPUS  + LGRIPUS  + MBRIPUS  + ABRIPUS  +
OHRIPUS

' -----------------------------------------------------------------------------------------------------------
'--------- Refinery Output
' -----------------------------------------------------------------------------------------------------------

:EQ_MGROPUS

:EQ_DFROPUS

:EQ_JFROPUS

:EQ_RFROPUS

:EQ_LGROPUS

:EQ_PSROPUS

@IDENTITY PAROPUS  = MGROPUS  + DFROPUS  + JFROPUS  + RFROPUS  + LGROPUS  + PSROPUS

' -----------------------------------------------------------------------------------------------------------
'--------- Refinery Processing Gain
' -----------------------------------------------------------------------------------------------------------

:EQ_PAGLPUS

' -----------------------------------------------------------------------------------------------------------
'--------- Balance Refinery Inputs and Refinery Outputs
' -----------------------------------------------------------------------------------------------------------

@IDENTITY CORIPUS  = CORIPUSX  + (PAROPUS  - PARIPUSX  - PAGLPUS)  * CORIPUSX  / (CORIPUSX  +
UORIPUSX)

@IDENTITY UORIPUS  = UORIPUSX  + (PAROPUS  - PARIPUSX  - PAGLPUS)  * UORIPUSX  / (CORIPUSX  +
UORIPUSX)

@IDENTITY PARIPUS  = CORIPUS  + UORIPUS  + ABRIPUS  + LGRIPUS  + PPRIPUS  + MBRIPUS  + OHRIPUS
```

```
' ----------------------------------------------------------------------------------------------------------
'--------- Refinery Yields
' ----------------------------------------------------------------------------------------------------------

@IDENTITY MGYLD  = (MGROPUS  - MBRIPUS  - (LGRIPUS  - LGROPUS)  - PPRIPUS  - OXRIPUS  - EORIPUS)
/ (CORIPUS  + UORIPUS)

@IDENTITY DFYLD  = DFROPUS  / (CORIPUS  + UORIPUS)

@IDENTITY JFYLD  = JFROPUS  / (CORIPUS  + UORIPUS)

@IDENTITY RFYLD  = RFROPUS  / (CORIPUS  + UORIPUS)

@IDENTITY LGYLD  = LGROPUS  / (CORIPUS  + UORIPUS)

@IDENTITY PSYLD  = PSROPUS  / (CORIPUS  + UORIPUS)

' ----------------------------------------------------------------------------------------------------------
'--------- Refining Capacity and Utilization
' ----------------------------------------------------------------------------------------------------------

:EQ_CODIPUS

ORCAPUS  = ORCAPUS(-1)

@IDENTITY ORUTCUS  = CODIPUS  / ORCAPUS
```

Appendix C. Regression Results

Table 10. CORIPUSX, crude oil refinery inputs, regression results

Dependent Variable: CORIPUSX
Method: Least Squares
Sample: 2001M01 2011M12
Included observations: 132

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.927559	1.094688	1.760829	0.0812
MGTCPUSX-EOTCPUS+DFTCPUS+JFTCPUS	0.294304	0.107453	2.738911	0.0072
MGTCPUSX(-1)-EOTCPUS(-1)+DFTCPUS(-1)+JFTCPUS(-1)	0.184460	0.124866	1.477263	0.1426
UORIPUSX	-0.433547	0.141222	-3.069967	0.0027
LGRIPUS-LGROPUS	-1.489934	0.462576	-3.220951	0.0017
((2*MGWHUUS+DSWHUUS)-(3*RACPUUS*100/42))/3	0.002932	0.002359	1.242789	0.2167
(D08ON-D12ON)*@TREND(2007:12)	0.010734	0.003151	3.406853	0.0009
D0409	-0.600727	0.219669	-2.734696	0.0073
D0509+D0510	-0.868446	0.187046	-4.642953	0.0000
D0706	-0.545691	0.224648	-2.429095	0.0168
D0809	-1.681777	0.248154	-6.777148	0.0000
D0810	1.095183	0.257505	4.253052	0.0000
D1010	-0.587530	0.225648	-2.603741	0.0105
D1104	-0.624073	0.223477	-2.792560	0.0062
FEB	-0.164909	0.117379	-1.404934	0.1630
MAR	-0.302608	0.186445	-1.623045	0.1076
APR	-0.052635	0.268774	-0.195833	0.8451
MAY	0.011729	0.282039	0.041586	0.9669
JUN	0.081909	0.274587	0.298300	0.7661
JUL	-0.067800	0.269647	-0.251439	0.8020
AUG	-0.198831	0.261342	-0.760809	0.4485
SEP	-0.036646	0.159626	-0.229573	0.8189
OCT	0.007852	0.118822	0.066080	0.9474
NOV	0.677182	0.098609	6.867332	0.0000
DEC	0.531723	0.116526	4.563149	0.0000
CORIPUSX(-1)	0.389440	0.066345	5.869893	0.0000

R-squared	0.908272	Mean dependent var	14.99794
Adjusted R-squared	0.886638	S.D. dependent var	0.607469
S.E. of regression	0.204530	Akaike info criterion	-0.161627
Sum squared resid	4.434251	Schwarz criterion	0.406198
Log likelihood	36.66737	Hannan-Quinn criter.	0.069111
F-statistic	41.98373	Durbin-Watson stat	1.736440
Prob(F-statistic)	0.000000		

Table 11. UORIPUSX, unfinished oils refinery inputs, regression results

Dependent Variable: UORIPUSX
Method: Least Squares
Sample: 2001M01 2011M12
Included observations: 132

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.175196	0.054081	3.239490	0.0016
D04ON*@TREND(2003:12)-D08ON*@TREND(2007:12)	0.003448	0.000624	5.521543	0.0000
D0112	-0.265896	0.099852	-2.662898	0.0089
D0202	0.268133	0.098911	2.710869	0.0078
D0212	0.227775	0.099772	2.282966	0.0244
D0503	-0.232766	0.098637	-2.359836	0.0201
D0504	0.409023	0.099432	4.113590	0.0001
D0803	0.271736	0.098901	2.747540	0.0070
D0906	0.310563	0.098375	3.156927	0.0021
D03	-0.084617	0.031958	-2.647718	0.0093
D10	-0.075636	0.031921	-2.369481	0.0196
FEB	-0.013935	0.044761	-0.311323	0.7562
MAR	0.041076	0.048547	0.846093	0.3994
APR	0.165528	0.045925	3.604343	0.0005
MAY	0.251657	0.041094	6.123938	0.0000
JUN	0.193069	0.040833	4.728268	0.0000
JUL	0.287413	0.039876	7.207670	0.0000
AUG	0.165340	0.039743	4.160198	0.0001
SEP	0.193973	0.040250	4.819257	0.0000
OCT	0.104393	0.040272	2.592216	0.0108
NOV	0.197833	0.041932	4.717949	0.0000
DEC	0.302273	0.042929	7.041157	0.0000
UORIPUSX(-1)	0.288185	0.075599	3.812030	0.0002

R-squared	0.814806	Mean dependent var	0.583833
Adjusted R-squared	0.777428	S.D. dependent var	0.197360
S.E. of regression	0.093110	Akaike info criterion	-1.753049
Sum squared resid	0.944963	Schwarz criterion	-1.250743
Log likelihood	138.7013	Hannan-Quinn criter.	-1.548935
F-statistic	21.79876	Durbin-Watson stat	2.011140
Prob(F-statistic)	0.000000		

Table 12. PPRIPUS – PPPRPUS, pentanes plus gasoline blending, regression results

Dependent Variable: PPRIPUS-PPPRPUS
Method: Least Squares
Sample: 2001M06 2011M12
Included observations: 127

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.176760	0.058816	3.005291	0.0033
MGYLD	-0.149280	0.110351	-1.352777	0.1789
D0508	-0.042339	0.011381	-3.720296	0.0003
D08	-0.021197	0.004671	-4.538074	0.0000
D0809	-0.031272	0.011765	-2.658033	0.0090
D1002	-0.033888	0.011550	-2.934114	0.0041
FEB	0.015032	0.005153	2.917421	0.0043
MAR	0.011184	0.004957	2.256188	0.0261
APR	0.009294	0.004910	1.893043	0.0610
MAY	0.018529	0.004947	3.745378	0.0003
JUN	0.015565	0.004721	3.296774	0.0013
JUL	0.016437	0.004717	3.484814	0.0007
AUG	0.013165	0.004832	2.724494	0.0075
SEP	0.022914	0.004911	4.666214	0.0000
OCT	0.030420	0.004749	6.405500	0.0000
NOV	0.020670	0.004789	4.316127	0.0000
DEC	0.017270	0.004722	3.657221	0.0004
PPRIPUS(-1)-PPPRPUS(-1)	0.369321	0.078369	4.712605	0.0000

R-squared	0.684515	Mean dependent var	0.181091
Adjusted R-squared	0.635310	S.D. dependent var	0.017743
S.E. of regression	0.010715	Akaike info criterion	-6.103686
Sum squared resid	0.012515	Schwarz criterion	-5.700572
Log likelihood	405.5840	Hannan-Quinn criter.	-5.939906
F-statistic	13.91172	Durbin-Watson stat	1.945782
Prob(F-statistic)	0.000000		

Table 13. LGRIPUS, liquefied petroleum gas refinery inputs, regression results

Dependent Variable: LGRIPUS
Method: Least Squares
Sample: 2001M01 2011M12
Included observations: 132

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.093068	0.028878	-3.222768	0.0017
(ZWHDPUS-ZWHNPUS)/ZSAJQUS	-0.002419	0.000875	-2.764664	0.0067
MGROPUS	0.019431	0.004715	4.121195	0.0001
D06+D07+D08	0.013359	0.004349	3.071878	0.0027
D0612	0.035085	0.014624	2.399081	0.0181
D0711	0.049923	0.014290	3.493673	0.0007
D0810	0.046967	0.014770	3.179925	0.0019
D1002	-0.035060	0.014301	-2.451671	0.0158
D1111	0.038111	0.014230	2.678151	0.0085
D1112	-0.040035	0.014853	-2.695372	0.0081
FEB	-0.016615	0.006120	-2.714991	0.0077
MAR	-0.042717	0.006769	-6.310637	0.0000
APR	-0.028419	0.008999	-3.157840	0.0021
MAY	-0.018016	0.010351	-1.740487	0.0846
JUN	-0.020928	0.010635	-1.967875	0.0516
JUL	-0.021587	0.010469	-2.062030	0.0416
AUG	-0.017849	0.010542	-1.693139	0.0933
SEP	0.021534	0.009756	2.207203	0.0294
OCT	0.042026	0.008261	5.087508	0.0000
NOV	0.042763	0.007258	5.891922	0.0000
DEC	0.025556	0.006531	3.913148	0.0002
LGRIPUS(-1)	0.741127	0.051973	14.25994	0.0000

R-squared	0.969180	Mean dependent var	0.282931
Adjusted R-squared	0.963296	S.D. dependent var	0.069641
S.E. of regression	0.013342	Akaike info criterion	-5.644766
Sum squared resid	0.019581	Schwarz criterion	-5.164299
Log likelihood	394.5546	Hannan-Quinn criter.	-5.449526
F-statistic	164.7172	Durbin-Watson stat	1.832591
Prob(F-statistic)	0.000000		

Table 14. MBRIPUS, motor gasoline blending components refinery inputs, regression results

Dependent Variable: MBRIPUS
Method: Least Squares
Sample: 2008M02 2011M12
Included observations: 47

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.247519	0.113075	2.188982	0.0358
MBFPPUS	0.508949	0.194556	2.615955	0.0133
FEB	0.249173	0.100334	2.483425	0.0183
MAR	0.329599	0.093183	3.537107	0.0012
APR	0.415418	0.097622	4.255370	0.0002
MAY	0.233258	0.106124	2.197974	0.0351
JUN	0.204017	0.097540	2.091627	0.0442
JUL	0.191683	0.093922	2.040872	0.0493
AUG	0.361454	0.093249	3.876216	0.0005
SEP	0.106294	0.098215	1.082256	0.2870
OCT	0.289091	0.093749	3.083655	0.0041
NOV	-0.041036	0.096256	-0.426326	0.6726
DEC	0.114114	0.095479	1.195168	0.2405
MBRIPUS(-1)	0.311297	0.153061	2.033813	0.0501

R-squared	0.722002	Mean dependent var	0.611072
Adjusted R-squared	0.612488	S.D. dependent var	0.193825
S.E. of regression	0.120657	Akaike info criterion	-1.149626
Sum squared resid	0.480417	Schwarz criterion	-0.598518
Log likelihood	41.01620	Hannan-Quinn criter.	-0.942240
F-statistic	6.592758	Durbin-Watson stat	1.906114
Prob(F-statistic)	0.000006		

Table 15. ABRIPUS, aviation gasoline blending components refinery inputs, regression results

Dependent Variable: ABRIPUS
Method: Least Squares
Sample: 2006M01 2011M12
Included observations: 72

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000258	0.000190	-1.353314	0.1818
D0701+D0702	-0.005851	0.000380	-15.40413	0.0000
D0802	-0.001668	0.000516	-3.233192	0.0021
D0810	0.002381	0.000521	4.571293	0.0000
D0904	-0.002862	0.000510	-5.606979	0.0000
D0905+D0906	0.002295	0.000365	6.292341	0.0000
D0910	0.003322	0.000521	6.374654	0.0000
D1005	-0.001675	0.000516	-3.246824	0.0020
JAN	0.000411	0.000278	1.476331	0.1459
FEB	0.001686	0.000293	5.745231	0.0000
MAR	0.000431	0.000269	1.603204	0.1149
APR	0.000220	0.000282	0.779056	0.4395
MAY	0.000290	0.000294	0.986662	0.3284
JUN	-1.05E-05	0.000276	-0.038076	0.9698
JUL	8.85E-05	0.000269	0.328854	0.7436
AUG	0.000251	0.000270	0.929456	0.3569
SEP	0.000325	0.000269	1.206177	0.2332
OCT	-0.000447	0.000301	-1.486676	0.1431
NOV	0.000486	0.000269	1.805077	0.0769
ABRIPUS(-1)	0.022667	0.045330	0.500035	0.6192

R-squared	0.893784	Mean dependent var	-5.54E-05
Adjusted R-squared	0.854975	S.D. dependent var	0.001223
S.E. of regression	0.000466	Akaike info criterion	-12.27517
Sum squared resid	1.13E-05	Schwarz criterion	-11.64276
Log likelihood	461.9061	Hannan-Quinn criter.	-12.02341
F-statistic	23.03004	Durbin-Watson stat	2.169788
Prob(F-statistic)	0.000000		

Table 16. MGROPUS, Motor gasoline refinery output, regression results

Dependent Variable: MGROPUS
Method: Least Squares
Sample: 2003M01 2009M12
Included observations: 84

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.253801	0.665025	4.892751	0.0000
CORIPUSX	0.323711	0.030711	10.54069	0.0000
UORIPUSX	0.496429	0.066937	7.416331	0.0000
MBRIPUS	0.811909	0.077511	10.47482	0.0000
OHRIPUS	0.924700	0.137272	6.736252	0.0000
(MGWHUUS-DSWHUUS)/WPCPIUS	0.009844	0.001276	7.713899	0.0000
MGTSPUS(-1)-((MGTSPUS(-13)+MGTSPUS(-25)+MGTSPUS(-37)+MGTSPUS(-49))/4)	0.000675	0.001461	0.462367	0.6455
D0510	0.288944	0.099517	2.903466	0.0052
D0704+D0705	-0.207614	0.061497	-3.376016	0.0013
D0803	0.268551	0.089888	2.987605	0.0041
D0806	-0.228473	0.086397	-2.644455	0.0104
D0808+D0809	-0.283439	0.066672	-4.251264	0.0001
FEB	-0.168803	0.048307	-3.494361	0.0009
MAR	-0.408694	0.060649	-6.738659	0.0000
APR	-0.399096	0.066792	-5.975200	0.0000
MAY	-0.373875	0.069533	-5.376935	0.0000
JUN	-0.291051	0.070035	-4.155788	0.0001
JUL	-0.332010	0.060856	-5.455634	0.0000
AUG	-0.329734	0.064083	-5.145396	0.0000
SEP	-0.164606	0.045895	-3.586586	0.0007
OCT	-0.064688	0.051634	-1.252826	0.2151
NOV	0.134067	0.045663	2.935975	0.0047
DEC	0.177055	0.046311	3.823153	0.0003
MGROPUS(-1)	-0.057343	0.065012	-0.882040	0.3813

R-squared	0.955283	Mean dependent var	8.402881
Adjusted R-squared	0.938141	S.D. dependent var	0.301812
S.E. of regression	0.075065	Akaike info criterion	-2.105966
Sum squared resid	0.338086	Schwarz criterion	-1.411447
Log likelihood	112.4506	Hannan-Quinn criter.	-1.826775
F-statistic	55.72870	Durbin-Watson stat	1.682293
Prob(F-statistic)	0.000000		

Table 17. DFROPUS, Distillate fuel refinery output, regression results

Dependent Variable: DFROPUS
Method: Least Squares
Date: 05/11/12 Time: 15:24
Sample: 2001M01 2011M12
Included observations: 132

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.547636	0.280829	-5.510965	0.0000
CORIPUSX	0.209335	0.017384	12.04200	0.0000
UORIPUSX	0.342461	0.059620	5.744035	0.0000
(MGWHUUS-DSWHUUS)/WPCPIUS	-0.009174	0.001029	-8.913653	0.0000
DFPSPUS(-1)-((DFPSPUS(-13)+DFPSPUS(-25)+DFPSPUS(-37)+DFPSPUS(-49))/4)	0.001494	0.000735	2.033003	0.0446
(ZWHD_NE-ZWHN_NE)/ZSAJQUS	-0.001473	0.002731	-0.539369	0.5908
D09ON*@TREND(2008:12)-D12ON*@TREND(2011:12)	0.009258	0.000959	9.652519	0.0000
D0303	0.253267	0.082032	3.087430	0.0026
D0409	-0.236851	0.079482	-2.979923	0.0036
D0803	-0.224111	0.085049	-2.635099	0.0097
D0810	0.499852	0.082609	6.050810	0.0000
D0901+D0902	0.279956	0.059123	4.735175	0.0000
D0909	0.219476	0.081366	2.697385	0.0081
D0610+D0611	-0.196957	0.058836	-3.347582	0.0011
D1102	-0.183357	0.081188	-2.258430	0.0260
FEB	0.164311	0.034717	4.732931	0.0000
MAR	0.189258	0.035708	5.300129	0.0000
APR	0.221498	0.036985	5.988794	0.0000
MAY	0.160282	0.039376	4.070515	0.0001
JUN	0.082442	0.039611	2.081279	0.0398
JUL	0.036607	0.040618	0.901262	0.3695
AUG	0.077144	0.037563	2.053725	0.0425
SEP	0.034449	0.036388	0.946701	0.3460
OCT	0.160126	0.035455	4.516254	0.0000
NOV	0.223177	0.036892	6.049378	0.0000
DEC	0.133380	0.036936	3.611132	0.0005
DFROPUS(-1)	0.505214	0.041357	12.21583	0.0000

R-squared	0.960220	Mean dependent var	3.997724
Adjusted R-squared	0.950370	S.D. dependent var	0.336636
S.E. of regression	0.074995	Akaike info criterion	-2.162534
Sum squared resid	0.590551	Schwarz criterion	-1.572870
Log likelihood	169.7272	Hannan-Quinn criter.	-1.922921
F-statistic	97.48154	Durbin-Watson stat	1.794296
Prob(F-statistic)	0.000000		

Table 18. JFROPUS, Jet fuel refinery output, regression results

Dependent Variable: JFROPUS
Method: Least Squares
Date: 06/27/12 Time: 15:43
Sample: 2001M01 2011M12
Included observations: 132

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.426123	0.110358	-3.861274	0.0002
CORIPUSX	0.085067	0.007844	10.84545	0.0000
UORIPUSX	0.018638	0.026167	0.712249	0.4779
(MGWHUUS-JKTCUUS)/WPCPIUS	-0.001191	0.000379	-3.138342	0.0022
(DSWHUUS-JKTCUUS)/WPCPIUS	-0.004258	0.001449	-2.937763	0.0041
JFPSPUS(-1)-((JFPSPUS(-13)+JFPSPUS(-25)+JFPSPUS(-37)+JFPSPUS(-49))/4)	-0.003623	0.001338	-2.706984	0.0079
D01+D02	0.043951	0.009475	4.638840	0.0000
D0109	-0.116603	0.035942	-3.244213	0.0016
D0111	-0.118083	0.036228	-3.259455	0.0015
D0306	-0.108392	0.036978	-2.931258	0.0041
D0511	0.076199	0.036702	2.076159	0.0403
D0812	-0.080880	0.036305	-2.227770	0.0280
D0907	0.106045	0.036493	2.905900	0.0045
D0912	0.139493	0.036680	3.802956	0.0002
D1110+D1111	-0.080790	0.025503	-3.167879	0.0020
FEB	0.009149	0.014688	0.622907	0.5347
MAR	0.039487	0.015118	2.611941	0.0103
APR	0.014452	0.016401	0.881191	0.3802
MAY	-0.002380	0.018007	-0.132197	0.8951
JUN	0.005887	0.018747	0.314015	0.7541
JUL	0.011151	0.018725	0.595482	0.5528
AUG	-0.005232	0.016960	-0.308468	0.7583
SEP	-0.015959	0.015826	-1.008375	0.3156
OCT	-0.007188	0.015303	-0.469694	0.6395
NOV	0.003397	0.017504	0.194039	0.8465
DEC	0.015597	0.017851	0.873739	0.3843
JFROPUS(-1)	0.410751	0.047490	8.649247	0.0000

R-squared	0.872948	Mean dependent var	1.482273
Adjusted R-squared	0.841487	S.D. dependent var	0.084083
S.E. of regression	0.033476	Akaike info criterion	-3.775697
Sum squared resid	0.117671	Schwarz criterion	-3.186033
Log likelihood	276.1960	Hannan-Quinn criter.	-3.536085
F-statistic	27.74732	Durbin-Watson stat	2.038823
Prob(F-statistic)	0.000000		

Table 19. RFROPUS, Residual fuel refinery output, regression results

Dependent Variable: RFROPUS
Method: Least Squares
Date: 06/13/12 Time: 15:00
Sample: 2003M01 2011M12
Included observations: 108

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.018873	0.123629	0.152656	0.8790
CORIPUSX	0.022092	0.007941	2.782191	0.0067
UORIPUSX	0.023507	0.024111	0.974929	0.3324
RFPSPUS(-1)-((RFPSPUS(-13)+RFPSPUS(-25)+RFPSPUS(-37)+RFPSPUS(-49))/4)	-0.000732	0.000922	-0.794231	0.4293
@TREND(2002:12)	-0.000444	0.000149	-2.981833	0.0037
D0605	-0.090616	0.033007	-2.745384	0.0074
D0707	0.100948	0.032935	3.065075	0.0029
D0804	0.074724	0.033587	2.224755	0.0287
D0904	-0.109081	0.033424	-3.263524	0.0016
D0910	0.100579	0.033392	3.012094	0.0034
D1112	-0.092358	0.033689	-2.741513	0.0075
FEB	0.012484	0.014811	0.842870	0.4017
MAR	-0.006908	0.014712	-0.469549	0.6399
APR	-0.007851	0.016783	-0.467777	0.6411
MAY	0.014760	0.017740	0.832026	0.4077
JUN	-0.022609	0.017651	-1.280897	0.2037
JUL	-0.044963	0.018660	-2.409623	0.0181
AUG	-0.014756	0.017602	-0.838305	0.4042
SEP	-0.030344	0.015382	-1.972719	0.0518
OCT	-0.019367	0.015897	-1.218317	0.2265
NOV	0.004007	0.016105	0.248818	0.8041
DEC	0.015951	0.017024	0.936933	0.3514
RFROPUS(-1)	0.465427	0.076789	6.061120	0.0000

R-squared	0.763939	Mean dependent var	0.621348
Adjusted R-squared	0.702840	S.D. dependent var	0.056684
S.E. of regression	0.030900	Akaike info criterion	-3.929698
Sum squared resid	0.081157	Schwarz criterion	-3.358503
Log likelihood	235.2037	Hannan-Quinn criter.	-3.698099
F-statistic	12.50345	Durbin-Watson stat	1.788698
Prob(F-statistic)	0.000000		

Table 20. LGROPUS, Liquid petroleum gas refinery output, regression results

Dependent Variable: LGROPUS
Method: Least Squares
Date: 06/13/12 Time: 15:42
Sample: 2001M01 2011M12
Included observations: 132

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.199696	0.066051	-3.023345	0.0031
LGROPUSX_SF*CORIPUSX	0.014102	0.004716	2.990067	0.0035
LGROPUSX_SF*UORIPUSX	0.058554	0.011607	5.044657	0.0000
MGYLD*CORIPUS	0.050979	0.010644	4.789655	0.0000
(ZWHDPUS-ZWHNPUS)/ZSAJQUS	-0.000913	0.001158	-0.787916	0.4325
@TREND(2000:12)	-0.000169	6.13E-05	-2.760459	0.0068
D0301	-0.054132	0.020255	-2.672449	0.0087
D04+D05+D06	-0.035068	0.004666	-7.516203	0.0000
D0509	-0.144472	0.020815	-6.940791	0.0000
D0510	-0.105903	0.022788	-4.647292	0.0000
D0912+D1001+D1002+D1003	0.050874	0.010570	4.813219	0.0000
D1008	-0.041481	0.020128	-2.060838	0.0417
FEB	0.046139	0.010019	4.605111	0.0000
MAR	0.116844	0.024261	4.816051	0.0000
APR	0.142056	0.042520	3.340882	0.0011
MAY	0.094821	0.049215	1.926692	0.0566
JUN	0.074809	0.050125	1.492440	0.1385
JUL	0.069323	0.048383	1.432786	0.1548
AUG	0.080587	0.046481	1.733784	0.0858
SEP	-0.026513	0.027407	-0.967365	0.3355
OCT	-0.020660	0.013597	-1.519508	0.1316
NOV	-0.057189	0.010303	-5.550821	0.0000
DEC	-0.036212	0.008918	-4.060352	0.0001
LGROPUS(-1)	0.287169	0.051388	5.588225	0.0000

R-squared	0.991398	Mean dependent var	0.638012
Adjusted R-squared	0.989566	S.D. dependent var	0.184466
S.E. of regression	0.018842	Akaike info criterion	-4.942454
Sum squared resid	0.038344	Schwarz criterion	-4.418308
Log likelihood	350.2019	Hannan-Quinn criter.	-4.729465
F-statistic	541.1961	Durbin-Watson stat	1.847904
Prob(F-statistic)	0.000000		

Table 21. PSROPUS, Other petroleum products refinery output, regression results

Dependent Variable: PSROPUS
Method: Least Squares
Date: 06/13/12 Time: 16:25
Sample: 2002M01 2011M12
Included observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.020326	0.140398	-7.267375	0.0000
CORIPUSX	0.205222	0.010365	19.80036	0.0000
UORIPUSX	0.169428	0.028560	5.932334	0.0000
@TREND(2001:12)	-0.002292	0.000231	-9.934333	0.0000
D02	-0.084130	0.018125	-4.641658	0.0000
D0207	0.091648	0.040454	2.265500	0.0257
D03	-0.038371	0.016062	-2.388881	0.0189
D0304	-0.094023	0.040653	-2.312807	0.0229
D0505	-0.107953	0.039064	-2.763523	0.0069
D0611	0.103484	0.039659	2.609323	0.0105
D0710	-0.087771	0.038875	-2.257766	0.0262
D1001+D1002+D1003	0.101365	0.023392	4.333336	0.0000
FEB	0.073930	0.016607	4.451803	0.0000
MAR	0.089742	0.016593	5.408579	0.0000
APR	0.042290	0.018135	2.331932	0.0218
MAY	0.023358	0.019599	1.191793	0.2363
JUN	0.018173	0.019878	0.914241	0.3629
JUL	0.003241	0.021139	0.153334	0.8785
AUG	0.029215	0.019660	1.486059	0.1405
SEP	0.039945	0.018826	2.121824	0.0364
OCT	0.060681	0.017464	3.474654	0.0008
NOV	0.003007	0.018453	0.162928	0.8709
DEC	-0.036158	0.019227	-1.880624	0.0631
PSROPUS(-1)	0.237918	0.041012	5.801196	0.0000

R-squared	0.971852	Mean dependent var	2.672536
Adjusted R-squared	0.965108	S.D. dependent var	0.195994
S.E. of regression	0.036610	Akaike info criterion	-3.600110
Sum squared resid	0.128671	Schwarz criterion	-3.042612
Log likelihood	240.0066	Hannan-Quinn criter.	-3.373708
F-statistic	144.1101	Durbin-Watson stat	1.569600
Prob(F-statistic)	0.000000		

Table 22. PAGLPUS, Refinery processing gain, regression results

Dependent Variable: PAGLPUS
Method: Least Squares
Date: 06/14/12 Time: 10:17
Sample: 2000M01 2011M12
Included observations: 144

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.475818	0.111293	-4.275382	0.0000
CORIPUSX	0.067688	0.007172	9.437994	0.0000
UORIPUSX	0.120774	0.025200	4.792659	0.0000
TIME	0.001017	0.000113	8.962754	0.0000
D0003	0.092839	0.034679	2.677066	0.0084
D01	-0.043038	0.011234	-3.831077	0.0002
D0310	-0.085964	0.034522	-2.490103	0.0141
D0507	-0.132775	0.034653	-3.831536	0.0002
D06+D07+D08+D09	-0.058900	0.008039	-7.326486	0.0000
FEB	0.006879	0.013843	0.496939	0.6201
MAR	-0.032391	0.014483	-2.236392	0.0271
APR	-0.064570	0.015912	-4.058001	0.0001
MAY	-0.071270	0.017355	-4.106462	0.0001
JUN	-0.084210	0.017278	-4.873686	0.0000
JUL	-0.087008	0.017544	-4.959406	0.0000
AUG	-0.057560	0.016739	-3.438704	0.0008
SEP	-0.047688	0.014616	-3.262705	0.0014
OCT	-0.025280	0.014524	-1.740598	0.0843
NOV	-0.027549	0.015625	-1.763161	0.0804
DEC	-0.004386	0.015760	-0.278303	0.7812
PAGLPUS(-1)	0.072730	0.064097	1.134684	0.2587

R-squared	0.801362	Mean dependent var	0.994570
Adjusted R-squared	0.769063	S.D. dependent var	0.067902
S.E. of regression	0.032631	Akaike info criterion	-3.873068
Sum squared resid	0.130968	Schwarz criterion	-3.439970
Log likelihood	299.8609	Hannan-Quinn criter.	-3.697082
F-statistic	24.81079	Durbin-Watson stat	1.928462
Prob(F-statistic)	0.000000		

Table 23. CODIPUS, Inputs to refinery atmospheric distillation capacity, regression results

Dependent Variable: CODIPUS-CORIPUS
Method: Least Squares
Date: 06/27/12 Time: 12:08
Sample: 2001M01 2011M12
Included observations: 132

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.056507	0.030131	1.875340	0.0633
UORIPUS	0.065451	0.034273	1.909695	0.0587
D0101	-0.150217	0.059526	-2.523529	0.0130
D0205	-0.238352	0.059399	-4.012756	0.0001
D1004	0.152699	0.059423	2.569714	0.0115
D1005	-0.113705	0.060179	-1.889439	0.0614
D1006	0.191020	0.059080	3.233228	0.0016
JAN	0.002246	0.026142	0.085922	0.9317
FEB	-0.010983	0.026478	-0.414802	0.6791
MAR	-0.020406	0.026140	-0.780645	0.4366
APR	-0.004888	0.025190	-0.194039	0.8465
MAY	-0.022639	0.025578	-0.885120	0.3780
JUN	0.004390	0.025165	0.174434	0.8618
JUL	-0.008659	0.024198	-0.357857	0.7211
AUG	-0.001117	0.024248	-0.046074	0.9633
SEP	0.003186	0.024233	0.131478	0.8956
OCT	0.001455	0.024760	0.058783	0.9532
NOV	0.027220	0.024308	1.119781	0.2652
CODIPUS(-1)-CORIPUS(-1)	0.724236	0.056984	12.70951	0.0000

R-squared	0.736212	Mean dependent var	0.326006
Adjusted R-squared	0.694192	S.D. dependent var	0.101834
S.E. of regression	0.056314	Akaike info criterion	-2.783276
Sum squared resid	0.358356	Schwarz criterion	-2.368327
Log likelihood	202.6962	Hannan-Quinn criter.	-2.614660
F-statistic	17.52077	Durbin-Watson stat	2.212610
Prob(F-statistic)	0.000000		