Independent Statistics & Analysis
U.S. Energy Information Administration

Short-Term Energy Outlook Model Documentation: Coal Module

April 2016

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1. Overview

The U.S. Energy Information Administration's *Short-Term Energy Outlook* (STEO) produces monthly projections of energy supply, demand, trade, and prices over a 13-24 month period. Every January, the forecast horizon is extended through December of the following year. The STEO model is an integrated system of econometric regression equations and identities that link the various components of the U.S. energy industry together in order to develop consistent forecasts. The regression equations are estimated and the STEO model is solved using the Eviews 8 econometric software package from IHS Global Inc. Diagnostics for the regression equations are given in Appendix C.[1] The model consists of various modules specific to each form of energy resource. All modules provide projections for the United States, and some modules provide more detailed forecasts for different regions of the country.

The coal module provides forecasts of coal supply (production, stocks, waste coal), trade (imports and exports), consumption, prices, coal coke (production, consumption, trade, and stocks), and raw steel production. The coal module contains 73 equations, of which 23 are estimated regression equations. Some of the input variables to the coal module are exogenous, coming from other modules in the *STEO* model (e.g., natural gas and petroleum prices) or forecasts produced by other organizations (e.g., weather forecasts from the National Oceanic and Atmospheric Administration). A projection of national coal prices is developed using the coal module, which is passed to several other modules in STEO. The coal module, in conjunction with the STEO electricity fuel consumption module, returns a projection of national coal demand. Figure 1 provides a visual overview of the production, trade, and power sector stocks portions of the coal module.

[1] Because of autocorrelation in the time series data used in the regression analyses, some of the p-values given in Appendix C may be understated. Prior information about energy market dynamics, however, indicates that the explanatory variables that have been retained in the models are important drivers of the corresponding dependent variables.

Figure 1. Short-Term Energy Outlook Coal Module (production, trade, power sector stocks)

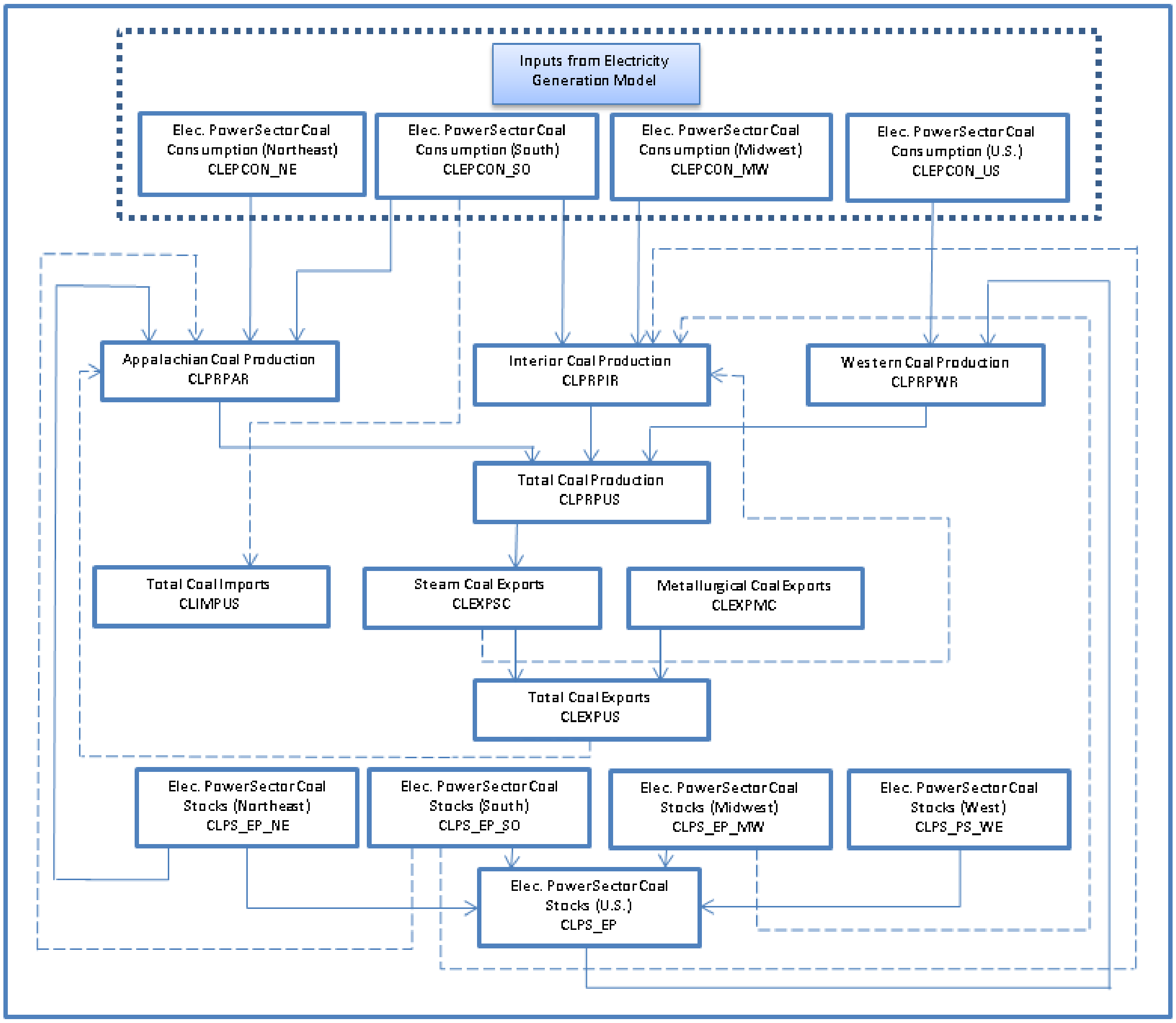


Figure 2 provides a visual overview of the coal consumption and consumer stocks portions of the coal module. Inputs from the STEO electricity fuel consumption module, as well as the coal coke section (Figure 3), provide exogenous inputs to consumption and stocks.

Figure 2. Short-Term Energy Outlook Coal Module (consumption, consumer stocks)

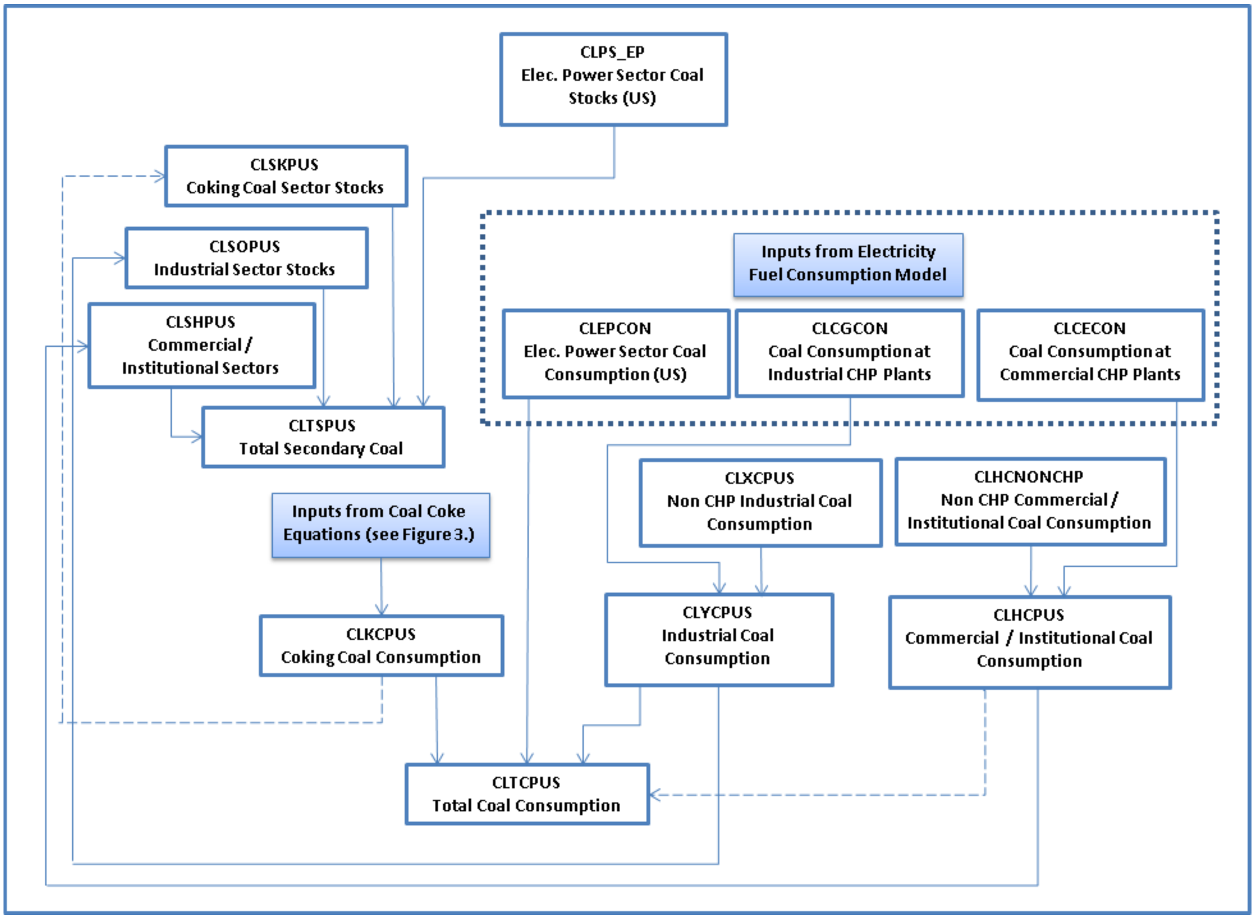
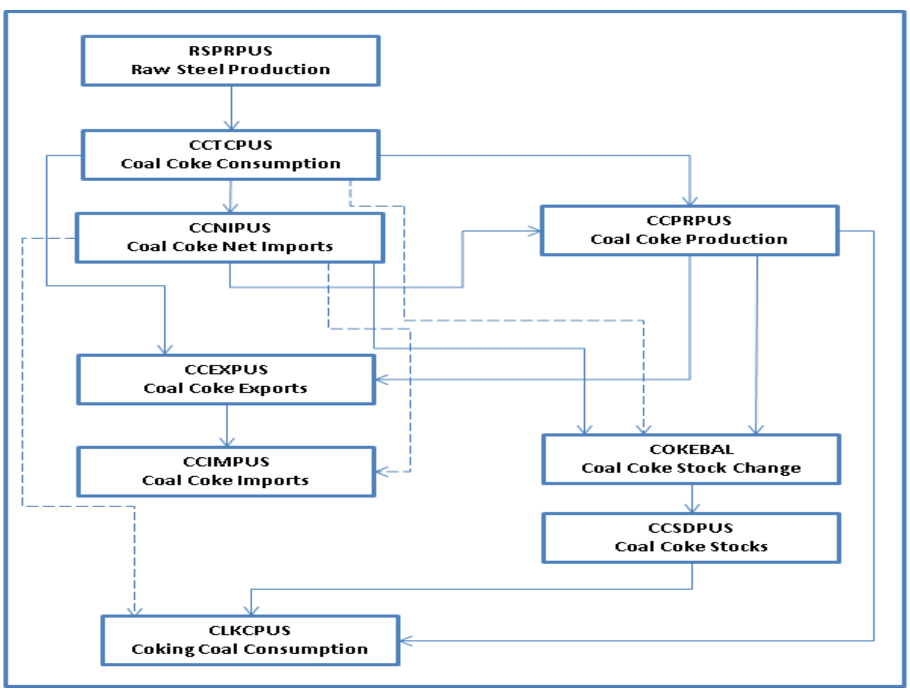
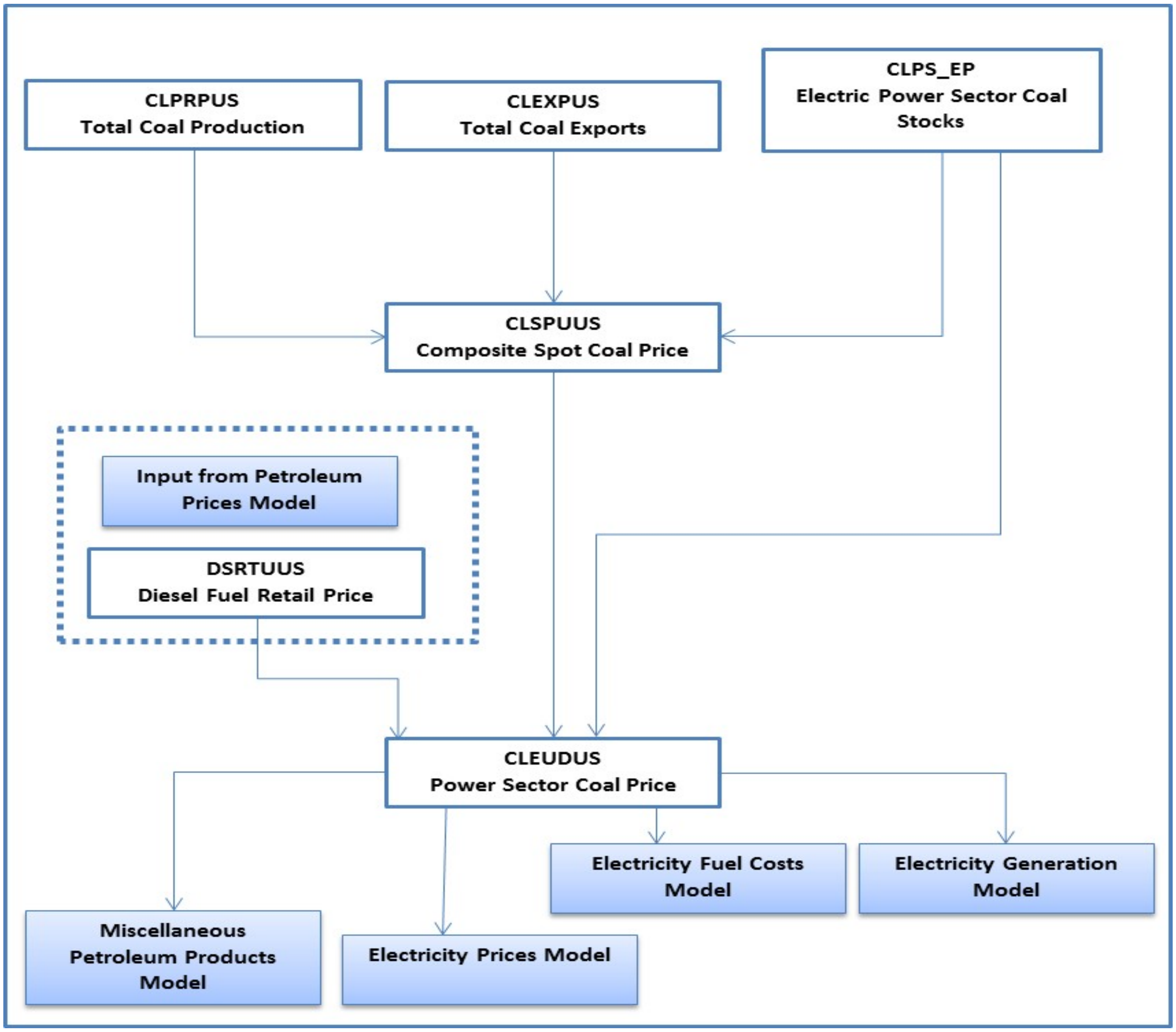


Figure 3. Short-Term Energy Outlook Coal Module (coal coke)



A visual overview of the prices section of the coal module is shown in Figure 4. Exogenous inputs are provided by other sections of the coal module (production, trade, and stocks), and by the petroleum prices module. The forecasted electric power sector coal price then serves as an exogenous input to several STEO models: electricity generation model, electricity fuel costs model, electricity prices model, and the miscellaneous petroleum products model.

Figure 4. Short-Term Energy Outlook Coal Module (prices)



2. Data Sources

The sources for monthly coal module data are

- EIA *Weekly Coal Production* for estimated monthly-from-weekly production values for more recent months
- EIA *Coal News and Markets* for estimated monthly-from-weekly coal spot prices
- EIA *Electric Power Monthly (EPM)* Tables ES1.A, ES2.A, ES2.B,2.1A, 2.1B, 2.1C,3.1, and 3.3,for monthly values of electric power sector coal data (consumption, stocks, and prices)
- EIA *Monthly Energy Review (MER)* Tables 6.1, 6.2, and 6.3 for monthly values of non-electric power sector data (waste coal supplied, consumption and stocks)
- EIA *Quarterly Coal Report (QCR)* Tables ES1, ES2, 1, 2, 4, 7, 9, 11, 32, and 37 for estimated monthly-from-quarterly values for production data and coal coke data (production, consumption, stocks)
- U.S. Department of Commerce, Bureau of the Census, Monthly Reports IM 145 (imports) and EM 545 (exports) as reported on the EIA website
- American Iron and Steel Institute for estimated monthly-from-weekly values for raw steel production

The *STEO* model uses macroeconomic variables such as population, gross domestic product (GDP), income, employment, and industrial production as explanatory variables in the regression-based equations. The macroeconomic forecasts are provided 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. EIA derives U.S. population-weighted degree days using current-year rather than base-year (typically the most recent decennial census) populations to weight State degree days to capture the effect of population migration on space cooling and heating demand (see *Short-Term Energy Outlook Supplement: 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 1 shows an example of this convention using total coal production. In this example, CLPRPUSX is the identifying code for coal (CL) production (PR) in physical units (P) for the United States (US). The variable holds a temporary value (X) that may be adjusted before it is stored to the final CLPRPUS data series. Examples of the identifiers used in this naming convention are provided following Table 1. Underscores used in many variable names do not count as a position in the naming convention.

Table 1. Variable naming convention

Variable name: CLPRPUSX

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

Type of energy categories:

CC = coal coke
CL = coal
DS = diesel fuel
NG = natural gas
RS = raw steel
ZW = weather

Energy activity or end-use sector:

CD = cooling degree days
CN = cooling degree days normal
EP = electric power sector
EU = electric utility sector
EX = exports
FC = synfuels
HC = commercial/ institutional sector
HD = heating degree days
HN = heating degree days normal
IM = imports
KC = coking coal
NI = net imports
PR = production
PS = stocks
SP = spot prices

TC = total consumption
XC = other industrial excluding coke plants and synfuels
YC = other industrial excluding coke plants
ZC = retail and general industry (excludes power sector)
WC = waste coal

Type of data:

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

Geographic identification or special equation factor:

<u>Coal Producing Regions</u>
AR = Appalachian region
IR = Interior region
WR = Western region

<u>Coal Types</u>
MC = metallurgical coal
SC = steam coal

<u>Demand Regions</u>
MW = Midwest
NE = Northeast
SO = South
US = United States
WE = West

Data treatment:

SA = series seasonally adjusted by Census X-11 method
SF = seasonal factors derived by 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. When monthly dummy variables are used in an equation, all of the months are included with the exception of December, i.e., December is indicated when the other monthly dummy variables are all zero.

The expressions "*(JAN+FEB+MAR+OCT+NOV+DEC)" and "*(APR+MAY+JUN+JUL+AUG+SEP)" occur in equations using variables based on heating or cooling degree days, respectively, indicating that the variable will be valid in the months specified. These occur as a set of interactive dummy variables in the affected equations, i.e., the value for degree days times 1 or 0 depending on whether or not the month falls within the months specified.

Specific monthly dummy variables may also be included in regression equations where the observed data are considered to be outliers because of infrequent and unpredictable events such as hurricanes, survey error, or other factors. They are generally introduced when the absolute value of the estimated regression error associated with an observation 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" is the last two digits of the year and "mm" is the number of the month (from "01" for January to "12" for December). Thus, a monthly dummy variable for March 2002 would be denoted by D0203 (i.e., D0203 = 1 if March 2002, = 0 otherwise).

The term "monthly dummy variables" in the equation definitions that follow refers to the 11 monthly dummy variables, as well as any specific monthly dummy variables for particular month and year that may also be included in regression equations.

Dummy variables for specific years are designated Dyy, where "yy" is 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" is 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.

A trend variable, TIME, is used in one equation to represent a function that counts the number of months from January 1975 – present. Another trend function, @TREND(*base date*), is used in conjunction with DxxON dummy variable to represent a time trend that increases by one for each observation in the time series. The trend equals 0 for each observation up to and including *basedate* and increases by 1 for each month thereafter.

Many of the estimated variables are a defined, in part, as functions of the previous month's value, or lagged term, denoted as the variable name with a negative 1 in parentheses, i.e., VARNAME(-1). Lagged terms are incorporated into the estimators to address the existence of auto-correlation in the regression results, based on the reported Durbin-Watson statistics as a first-degree, auto-regressive function (AR1).

No subscripts are used in the variable names, because each corresponds to a particular year/month combination.

4. Production

A. Introduction

The coal production section of the coal market module contains three estimated regression equations and one identity. The estimated regression equations for coal production are for Appalachian region production, Interior region production, and Western region production.

The production section of the module produces forecasts of temporary values for each coal producing region (each equation's dependent variable ID ends with an "X"). The regional production forecasts are then adjusted upward or downward so that total coal supply equals total coal consumption (see "Coal Balance" section).

Preliminary monthly estimates of coal production are the sum of weekly estimates developed by the U.S. Energy Information Administration (EIA) and published in the *Weekly Coal Production Report (WCPR)*. When a week extends into a new month, production is allocated on a daily basis and added to the appropriate month.

EIA estimates the preliminary weekly coal production based on Association of American Railroads (AAR) weekly car-loading data. Coal production data are collected quarterly by the U.S. Mine Safety and Health Administration (MSHA). When MSHA production data become available for a given quarter, EIA revises the *WCPR* weekly estimates for that quarter. Once revised, the sum of the weekly estimates in that quarter will match the quarterly MSHA production in any state, and a similar calculation is done for the monthly estimates. EIA also aggregates the state-level data to the level of producing regions. Below are the definitions of the EIA-defined regions:

- Appalachian region: Alabama, Eastern Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia
- Interior region: Arkansas, Illinois, Indiana, Kansas, Louisiana, Mississippi, Missouri, Oklahoma, Texas, and Western Kentucky
- Western region: Alaska, Arizona, Colorado, Montana, New Mexico, North Dakota, Utah, Washington, and Wyoming

A key variable in the coal production equation is regional coal consumption by the electric power sector. Historical values are derived from the EIA *Electric Power Monthly*. The regions are defined as follows:

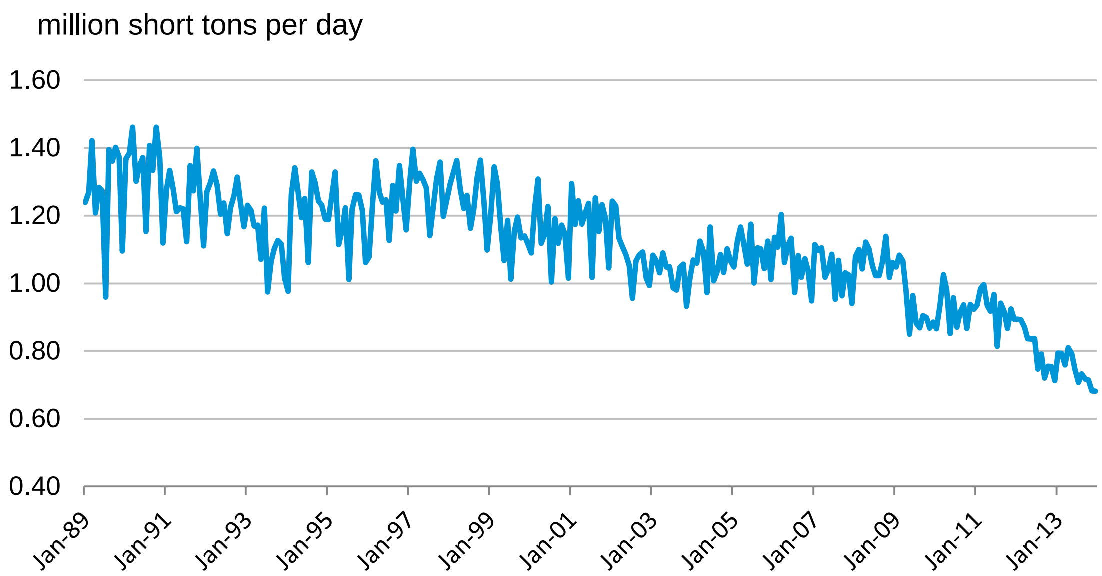
- Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.
- Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.
- South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.
- West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

B. Coal Production Equations

1. Appalachian Coal Production

Appalachian coal production (Figure 5) is driven primarily by domestic consumption of coal, particularly in the eastern United States, and by the exports of both metallurgical and steam coal.

Figure 5. Appalachian region coal production, Jan. 1989 - Dec. 2013



Source: Monthly estimates based on EIA, *Quarterly Coal Report*, Table 2.

Appalachian coal production is expected to be a positive function of consumption, coal exports, and the previous month's production (Equation 1). Appalachian coal production is also expected to be a negative function of coal inventories held in the South and Northeast. About 90% of coal consumed in the United States is consumed in the electric power sector, so the equation uses the consumption of coal in the power sector in the South and Northeast, which represented about 62% of the use of Appalachian coal in 2013. Coal production in the region was a positive function of coal exports; however, the coefficient was not statistically significant.

CLPRPARX = a0 + a1 * CLEXPUS (1)
+ a2 * (CLEPCON_NE + CLEPCON_SO) / 1000
+ a3 * (CLPS_EP_NE + CLPS_EP_SO)
+ a4 * D10ON
+ a5 * CLPRPARX(-1)
+ monthly dummy variables

where

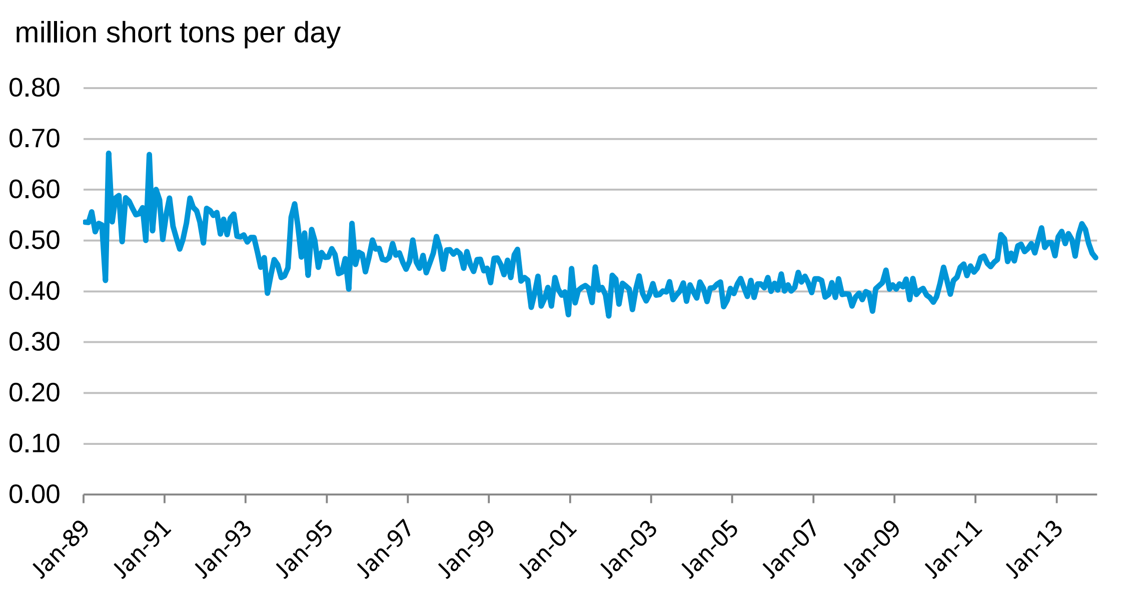
CLPRPARX = Appalachian region coal production (initial value), million short tons per day

CLEXPUS = total coal exports, million short tons per day
CLEPCON_NE = consumption of coal by electric power sector in the Northeast region, thousand tons per day
CLEPCON_SO = consumption of coal by electric power sector in the South region, thousand tons per day
CLPS_EP_NE = stocks of coal held by electric power sector in the Northeast region, million tons
CLPS_EP_SO = stocks of coal held by electric power sector in the South region, million tons
D10ON = dummy variable equal to 1 if the month is on or after January, 2010
CLPRPARX(-1) = prior month Appalachian region coal production (initial value), million short tons per day

2. Interior Coal Production

Interior coal production (Figure 6) is driven primarily by domestic consumption of coal, particularly in the Midwest and South, and by the exports of steam coal.

Figure 6. Interior region coal production, Jan. 1989 - Dec. 2013



Source: Monthly estimates based on EIA, *Quarterly Coal Report*, Table 2.

Interior coal production is expected to be a positive function of consumption, steam coal exports, and the previous period's production (Equation 2). Interior coal production is also expected to be a negative function of power sector coal inventories in the South and Midwest. The equation uses the consumption of coal in the power sector in the South and Midwest, which combined represented about 95% of the use of Interior coal production in 2013. However, the estimated coefficient on the power sector coal consumption variable was negative. Over the estimation period, interior coal production increased while power sector coal consumption in these regions declined. The growth in production was supported, in part, by shipments and use outside of the region, which are not currently captured by the model.

$$
\begin{aligned}
CLPRPIRX = a0 &+ a1 * CLEXPSC \\
&+ a2 * (CLEPCON\_MW + CLEPCON\_SO) / 1000 \\
&+ a3 * (CLPS\_EP\_MW + CLPS\_EP\_SO) \\
&+ a5 * D10ON \\
&+ a6 * CLPRPIRX(-1) \\
&+ \text{monthly dummy variables}
\end{aligned} \tag{2}
$$

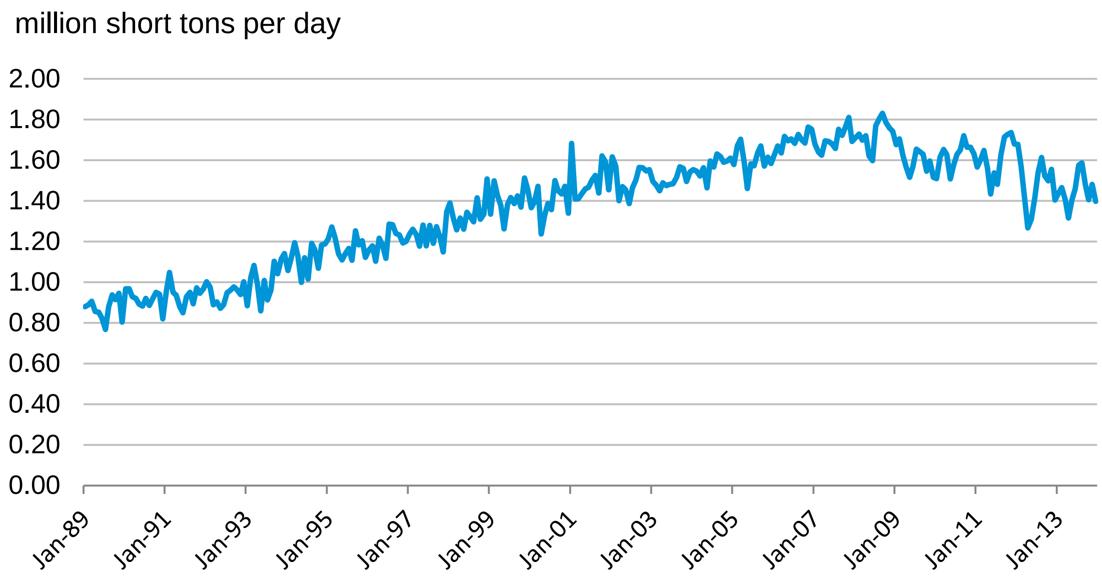
where

CLPRPIRX = Interior region coal production (initial value), million short tons per day
CLEXPSC = steam coal exports, million short tons per day
CLEPCON_MW = consumption of coal by electric power sector in the Midwest region, thousand tons per day
CLEPCON_SO = consumption of coal by electric power sector in the South region, thousand tons per day
CLPS_EP_MW = stocks of coal held by electric power sector in the Midwest region, million tons
CLPS_EP_SO = stocks of coal held by electric power sector in the South region, million tons
D10ON = dummy variable equal to 1 if the month is on or after January, 2010
CLPRPIRX(-1) = prior month Interior region coal production (initial value), million short tons per day

3. Western Coal Production

The Western coal production region, which includes the Powder River Basin (PRB), is the largest coal-producing region in the United States. Western coal production (Figure 7) is primarily driven by domestic consumption, although small amounts are exported.

Figure 7. Western region coal production, Jan. 1989 - Dec. 2013



Source: Monthly estimates based on EIA, *Quarterly Coal Report*, Table 2.

Western coal production is expected to be a function of coal consumption, inventories, and the previous period's production (Equation 3). Coal produced in the PRB, the majority of Western coal production, is consumed throughout the United States, primarily for electricity generation. The equation uses total U.S. power sector coal consumption and total U.S. coal inventories held in the power sector. The estimated coefficient on coal stocks was not statistically significant.

CLPRPWRX = a0 (3)
+ a1 * CLEPCON_US / 1000
+ a2 * CLPS_EP_US
+ a3 * D08ON
+ a4 * CLPRPWRX(-1)
+ monthly dummy variables

where

CLPRPWRX = Western region coal production (initial value), million short tons per day
CLEPCON_US = consumption of coal by electric power sector, thousand tons per day
CLPS_EP_US = stocks of coal held by electric power sector, million tons
D08ON = dummy variable equal to 1 if the month is on or after January, 2008
CLPRPWRX(-1) = prior month Western region coal production (initial value), million short tons per day

4. Total Coal Production

Total coal production is the sum of regional production (Equation 4).

$$\text{CLPRPUSX} = \text{CLPRPARX} + \text{CLPRPIRX} + \text{CLPRPWRX} \quad (4)$$

where

CLPRPUSX = total coal production (initial value), million short tons per day
CLPRPARX = Appalachian region coal production (initial value), million short tons per day
CLPRPIRX = Interior region coal production (initial value), million short tons per day
CLPRPWRX = Western region coal production (initial value), million short tons per day

5. Coal Trade

A. Introduction

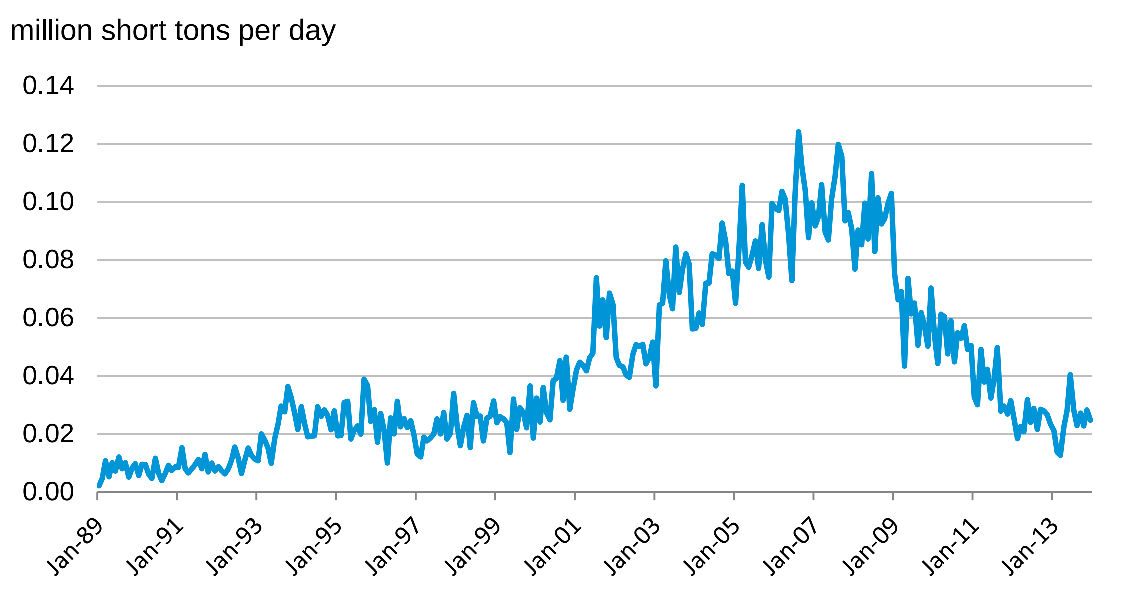
The coal trade section of the model contains three estimated regression equations and one identity. The estimated equations are for total coal imports, steam coal exports, and metallurgical coal exports. Monthly data for coal imports and exports are collected by the U.S. Department of Commerce, Bureau of the Census. EIA's *MER* publishes data for total imports and exports, while the *QCR* publishes the data for imports and exports by type (steam or metallurgical).

B. Coal Trade Equations

1. Total Coal Imports

U.S. coal imports have fallen significantly from their peak level of 36.3 million tons in 2007 to less than 9 million in 2013, and imports remain a small component of overall U.S. coal consumption—only 3% during the peak year of 2007 and less than 1% in 2013 (Figure 8). Steam coal imports make up the majority of imports, and this coal is primarily consumed by power generators located on the East Coast and the Gulf Coast.

Figure 8. U.S. total coal imports, Jan. 1989 - Dec. 2013



Source: EIA, *Quarterly Coal Report*, Table 18.

Coal imports are modeled as a function of electric power sector coal consumption in the South region and the previous month's coal imports (Equation 5). Electric power sector consumption in the Northeast region was considered for inclusion in the model, but many of the plants that received coal imports in this region have been retired or are slated for retirement soon.

CLIMPUS = a0 + a1 * (CLEPCON_SO) / 1000 (5)
+ a2 * D09ON
+ a3 * CLIMPUS(-1)
+ monthly dummy variables

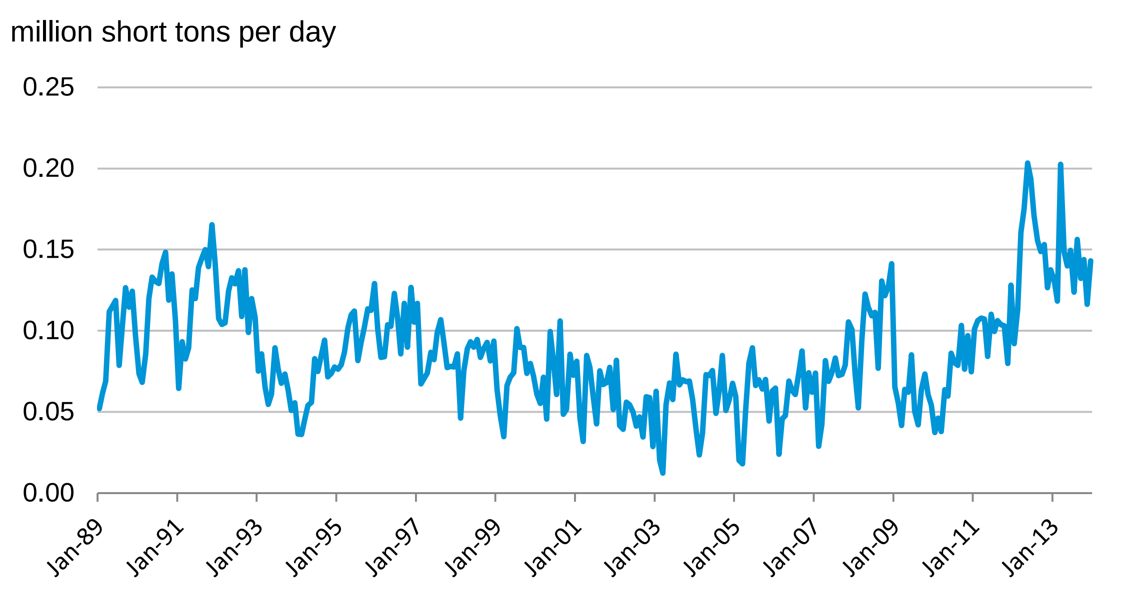
where

CLIMPUS = coal imports, million short tons per day
CLEPCON_SO = consumption of coal by electric power sector in the South region, thousand tons per day
D09ON = dummy variable equal to 1 beginning January 2009; 0 otherwise.
CLIMPUS(-1) = prior month coal imports, million short tons per day

2. Steam Coal Exports

Steam coal is used primarily for electricity generation but is also used in the industrial, commercial, and residential sectors for the production of steam and direct heat. Steam coal is produced in all of the coal-producing regions, but the majority of exports have traditionally originated from the Appalachian and Interior regions. Figure 9 shows the historic volatility in coal exports, which are sensitive to global market conditions.

Figure 9. U.S. steam coal exports, Jan. 1989 - Dec. 2013



Source: EIA, *Quarterly Coal Report*, Table 7.

Steam coal exports are estimated as a function of coal production, domestic steam coal consumption, the U.S. dollar exchange rate, world GDP, and the previous period's steam coal exports (Equation 6). The exchange rate is used to capture the "competitiveness" of U.S. coal exports in relation to coal exported from other countries. World GDP is used to capture the worldwide demand for electricity, as short-term changes in electricity use are often positively correlated with changes in economic output. The estimated coefficients on the foreign exchange rate and world GDP were not statistically significant. The estimated coefficient on coal consumption was negative and statistically significant, while the coefficient on production was positive but not statistically significant.

CLEXPSC = a0 + a1 * CLPRPUS (6)
+ a2 * (CLTCPUS-CLKCPUS)
+ a3 * FOREX_WORLD
+ a4 * RGDPQ_WORLD
+ a5 * CLEXPSC(-1)
+ monthly dummy variables

where

CLEXPSC = steam coal exports, million short tons per day
CLPRPUS = total coal production, million short tons per day
CLTCPUS = total coal consumption, million short tons per day
CLKCPUS = coke plant (metallurgical coal) coal consumption, million short tons per day
FOREX_WORLD = real U.S. dollar exchange rate, index, January 2010=100
RGDPQ_WORLD = world oil-consumption weighted GDP, index, 2010 Q1 = 100
CLEXPSC(-1) = prior month steam coal exports, million short tons per day

3. Metallurgical Coal Exports

Metallurgical coal is used to produce coal coke, which in turn is used as a fuel and as a reducing agent for smelting of iron ore in blast furnaces. The majority of metallurgical coal exported is produced in the Appalachian region, but smaller quantities are produced in the Western region. Figure 10 illustrates the historic volatility in metallurgical coal exports.

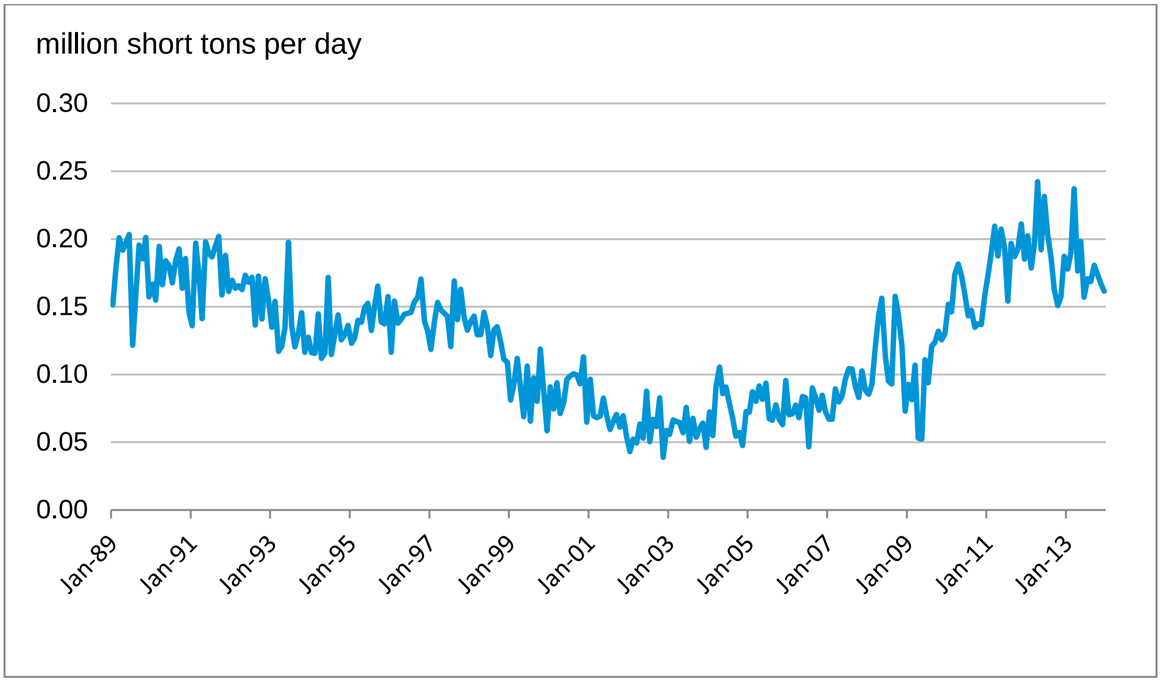
Metallurgical coal exports (Equation 7) are modeled as a function of the U.S. dollar exchange rate, the World GDP, and the previous month's metallurgical coal exports.

CLEXPMC = a0 + a1 * RGDPQ_WORLD (7)
+ a2 * FOREX_WORLD
+ a3 * D08ON
+ a4 * CLEXPMC(-1)
+ monthly dummy variables

where

CLEXPMC = metallurgical coal exports, million short tons per day
RGDPQ_WORLD = world oil-consumption weighted GDP, index, 2010 Q1 = 100
FOREX_WORLD = real U.S. dollar exchange rate, index, January 2010=100
D08ON = dummy variable equal to 1 beginning January 2008; 0 otherwise.
CLEXPMC(-1) = prior month metallurgical coal exports, million short tons per day

Figure 10. U.S. metallurgical coal exports, Jan. 1989 - Dec. 2013



4. Total Coal Exports

Total coal exports are the sum of steam coal exports and metallurgical coal exports (Equation 8).

CLEXPUS = CLEXPSC + CLEXPMC (8)

where

CLEXPUS = total coal exports, million short tons per day
CLEXPSC = steam coal exports, million short tons per day
CLEXPMC = metallurgical coal exports, million short tons per day

6. Coal Stocks (Inventories)

A. Introduction

The coal stocks section of the coal module contains seven estimated regression equations and nine identities. The estimated equations are for regional power sector inventories, coke plant stocks, other industrial sector stocks, and commercial / institutional inventories. Regional coal inventories are estimated separately for the electric power sector and summed to obtain the estimate of national total electric power sector coal stocks.

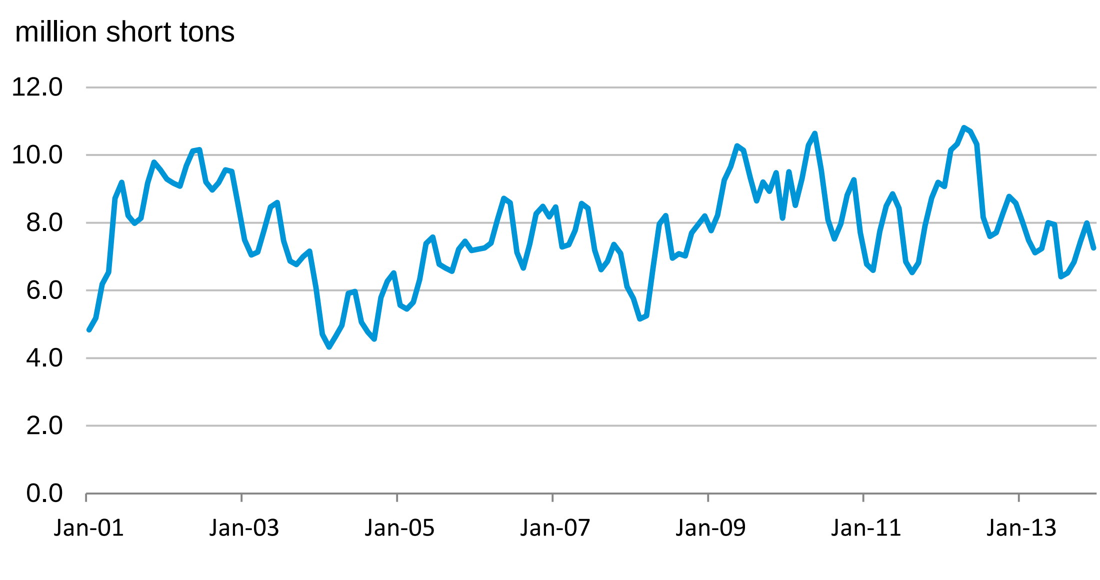
Historical monthly data for coal inventories held by the power sector are published in EIA's *EPM*. Quarterly data for coal stocks held in other sectors is reported in EIA's *QCR*, while monthly estimates appear in EIA's *MER*.

B. Coal Stock Equations

1. Electric Power Sector Stocks, Northeast

Coal is the third largest source of electricity generation in the Northeast, behind nuclear power and natural gas. Of the 4 regions of the nation, the Northeast has the lowest share of electricity generation from coal. Coal-fired generation is concentrated in the Middle Atlantic (New Jersey, New York and Pennsylvania). The historical pattern of coal inventories in the Northeast is shown in Figure 11.

Figure 11. Northeast electric power stocks, Jan. 2001 - Dec. 2013



Source: EIA, *Electric Power Monthly*, Table 3.3

Northeast region power sector coal stocks are modeled as a function of cooling degree day deviations from normal during the spring and summer months and the previous month's regional coal inventory (Equation 9).

CLPS_EP_NE = a0 + a1 *(APR+MAY+JUN+JUL+AUG+SEP) * (ZWCD_NE – ZWCN_NE)/ZSAJQUS (9)
+ a2 * CLPS_EP_NE(-1)
+ monthly dummy variables

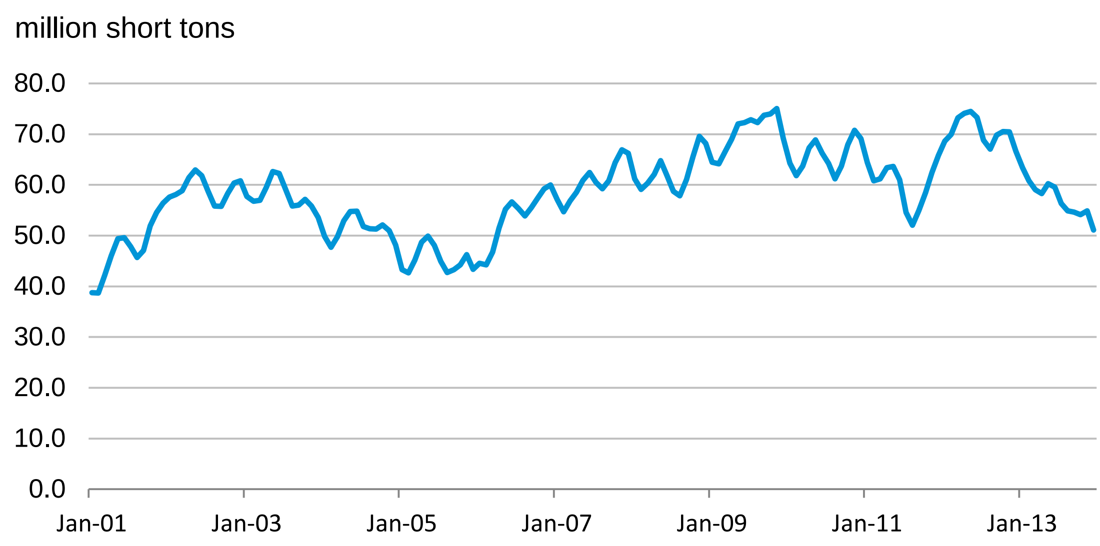
where

CLPS_EP_NE = electric power sector coal stocks, Northeast, million short tons
ZWCD_NE = Northeast cooling degree days
ZWCN_NE = Northeast cooling degree days, normal (20-year average, 1991-2010)
ZSAJQUS = number of days in the reference month
CLPS_EP_NE(-1) = prior month electric power sector coal stocks, Northeast, million short tons

2. *Electric Power Sector Stocks, Midwest*

In the Midwest, coal-fired electricity generation exceeds electricity generation from all other sources combined. The historical pattern of coal inventories in the Midwest is shown in Figure 12.

Figure 12. Midwest electric power sector stocks, Jan. 2001 - Dec. 2013



Source: EIA, *Electric Power Monthly*, Table 3.3

Midwest region power sector coal stocks are modeled as a function of cooling degree day deviations from normal during the spring and summer months and the previous month's regional coal inventory (Equation 10).

CLPS_EP_MW = a0 + a1 *(APR+MAY+JUN+JUL+AUG+SEP)*(ZWCD_MW – ZWCN_MW)/ZSAJQUS (10)

+ a2 * CLPS_EP_MW(-1)
+ monthly dummy variables

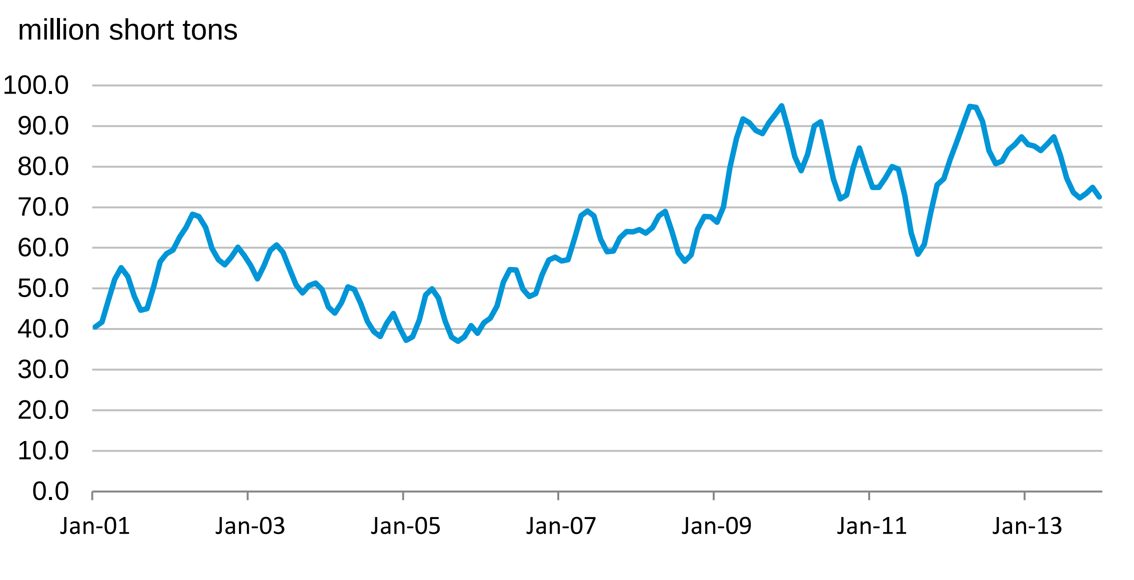
where

CLPS_EP_MW = electric power sector coal stocks, Midwest, million short tons
ZWCD_MW = Midwest cooling degree days
ZWCN_MW = Midwest cooling degree days, normal (20-year average, 1991-2010)
ZSAJQUS = number of days in the reference month
CLPS_EP_MW(-1) = prior month electric power sector coal stocks, Midwest, million short tons

3. Electric Power Sector Stocks, South

Coal is the largest source of electricity generation in the South, the nation's largest electricity producing region. The region's coal-fired generation is the largest in the United States. The historical pattern of coal inventories in the South is shown in Figure 13.

Figure 13. South electric power sector stocks, Jan. 2001 - Dec. 2013



Source: EIA, *Electric Power Monthly*, Table 3.3

South region power sector coal stocks are modeled as a function of cooling degree day deviations from normal during the spring and summer months, heating degree day deviations from normal during the fall and winter months, and the previous month's regional coal inventory (Equation 11).

CLPS_EP_SO = a0 + a1 *(APR+MAY+JUN+JUL+AUG+SEP) * (ZWCD_SO – ZWCN_SO)/ZSAJQUS (11)
+ a2 * (JAN+FEB+MAR+OCT+NOV+DEC) * (ZWHD_SO – ZWHN_SO)/ZSAJQUS
+ a2 * CLPS_EP_SO(-1)
+ monthly dummy variables

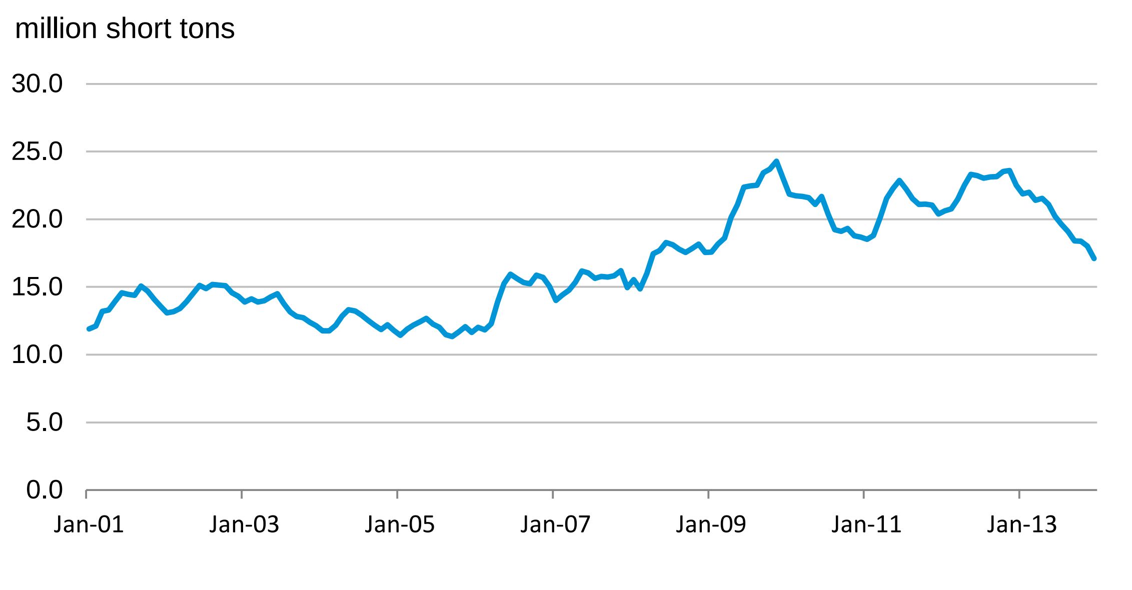
where

CLPS_EP_SO = electric power sector coal stocks, South, million short tons
ZWCD_SO = South cooling degree days
ZWCN_SO = South cooling degree days, normal (20-year average, 1991-2010)
ZSAJQUS = number of days in the reference month
ZWHD_SO = South heating degree days
ZWHN_SO = South heating degree days, normal
CLPS_EP_SO(-1) = prior month electric power sector coal stocks, South, million short tons

4. Electric Power Sector Stocks, West

Coal is the second largest source of electricity generation in the West, where renewable-based generation (hydropower and other renewables) is the region's largest source. The historical pattern of coal inventories in the West is shown in Figure 14.

Figure 14. West electric power sector stocks, Jan. 2001 - Dec. 2013



Source: EIA, *Electric Power Monthly*, Table 3.3

West region power sector coal stocks are modeled as a function of cooling degree day deviations from normal during the spring and summer months, heating degree day deviations from normal during the fall and winter months, and the previous month's regional coal inventory (Equation 12). In contrast to the other 3 regions where weather shocks (colder-than-normal winter or warmer summer) reduce coal stocks, the estimated coefficients on the weather deviations from normal are not statistically significant in the West region.

CLPS_EP_WE = a0 + a1 *(APR+MAY+JUN+JUL+AUG+SEP) * (ZWCD_WE – ZWCN_WE)/ZSAJQUS (12)
+ a2 * (JAN+FEB+MAR+OCT+NOV+DEC) * (ZWHD_WE – ZWHN_WE)/ZSAJQUS
+ a2 * CLPS_EP_WE(-1)

+ monthly dummy variables

where

CLPS_EP_WE = electric power sector coal stocks, West, million short tons
ZWCD_WE = West cooling degree days
ZWCN_WE = West cooling degree days, normal (20-year average, 1991-2010)
ZSAJQUS = number of days in the reference month
ZWHD_WE = West heating degree days
ZWHN_WE = West heating degree days, normal (20-year average, 1991-2010)
CLPS_EP_WE(-1) = prior month electric power sector coal stocks, West, million short tons

5. Electric Power Sector Stocks, Total

Total electric power sector stocks are computed as a sum of the regional stocks as shown in Equation 13.

CLPS_EP_US = CLPS_EP_NE + CLPS_EP_MW + CLPS_EP_SO + CLPS_EP_WE (13)

where

CLPS_EP_US = total electric power sector coal stocks, million short tons
CLPS_EP_NE = electric power sector coal stocks, Northeast, million short tons
CLPS_EP_MW = electric power sector coal stocks, Midwest, million short tons
CLPS_EP_SO = electric power sector coal stocks, South, million short tons
CLPS_EP_WE = electric power sector coal stocks, West, million short tons

For purposes of reporting results for the STEO model, the aggregate regional stocks are stored as a separate variable, as shown in Equation 14.

CLPS_EP = CLPS_EP_US (14)

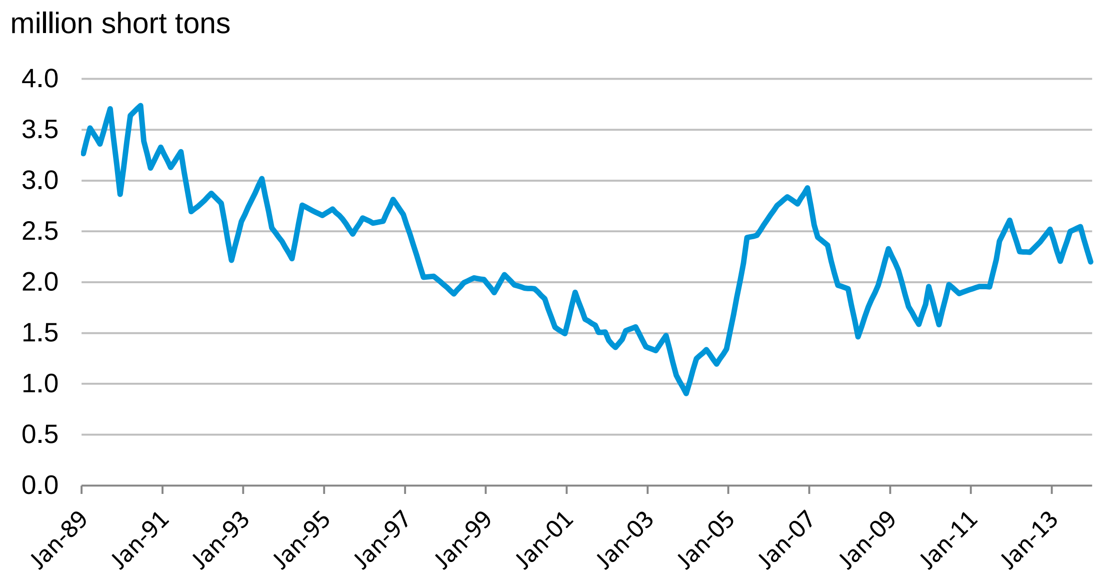
where

CLPS_EP = total electric power sector coal stocks, million short tons
CLPS_EP_US = total electric power sector coal stocks, million short tons

6. Coke Plant Coal Stocks

With changes in steel production methods, coal stocks held at plants that produce coke have declined significantly over the past 30 years, going from over 9 million short tons in 1980 to less than 3 million tons in 2013, as shown in Figure 15. Monthly changes in coke plant stocks are estimated by using one-third of the reported quarterly change.

Figure 15. Coke plant stocks, Jan. 1989 - Dec. 2013



Source: EIA, *Quarterly Coal Report*, Table 37.

Coal stocks held at coke plants are modeled as a function of the month's coke plant coal consumption and the previous month's coal inventory (Equation 15).

CLSKPUSX = a0 + a1 * CLKCPUS (15)
+ a2 * CLSKPUSX(-1)
+ monthly dummy variables

where

CLSKPUSX = coke plant coal stocks (initial value), million short tons
CLKCPUS = coke plant coal consumption, million short tons per day
CLSKPUS(-1) = prior month coke plant coal stocks (initial value), million short tons

The coal stocks variable is converted from a temporary variable to a final variable for external reporting, as shown in Equation 16.

CLSKPUS = CLSKPUSX (16)

where

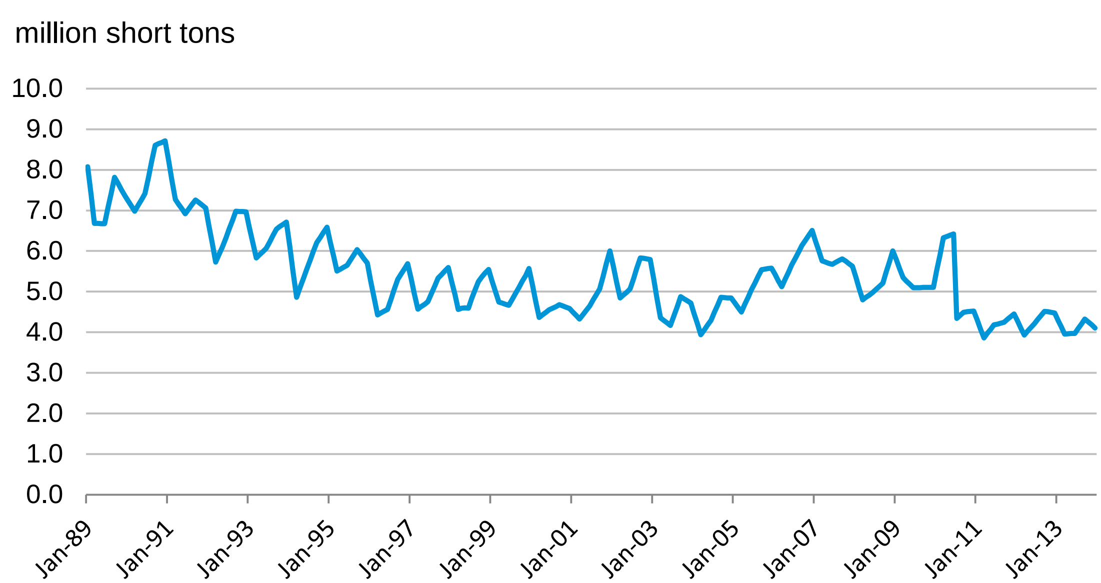
CLSKPUS = coke plant coal stocks, million short tons
CLSKPUSX = coke plant coal stocks (initial value), million short tons

7. *Industrial Sector Coal Stocks*

With many industries switching from coal to natural gas as a processing fuel, coal stocks held at industrial plants have declined significantly over the past 30 years, going from nearly 12 million short tons in 1980 to just over 4 million tons in 2013, as shown in Figure 16.

Through 1977, stocks for the industrial sector were derived by using reported data to modify baseline figures from a one-time Bureau of Mines survey of consumers. For 1978–1982, monthly estimates were derived by judgmentally proportioning reported quarterly data, based on representative seasonal patterns of supply and demand. Beginning in 1983, monthly industrial coal stocks are estimated by using one-third of the current quarterly change to indicate the monthly change in stocks. Quarterly stocks are taken directly from data reported on Form EIA-3.

Figure 16. Industrial sector stocks excluding coke plants, Jan. 1989 - Dec. 2013



Source: EIA, *Quarterly Coal Report*, Table 37.

Coal stocks held by the industrial sector are modeled as a function of the month's industrial sector coal consumption and the previous month's coal inventory (Equation 17).

CLSOPUSX = a0 + a1 * CLYCPUS (17)
+ a2 * CLSOPUSX(-1)
+ monthly dummy variables

where

CLSOPUSX = industrial sector coal stocks (initial value), million short tons
CLYCPUS = industrial sector coal consumption, million short tons per day
CLSOPUSX(-1) = prior month industrial sector coal stocks (initial value), million short tons

The coal stocks are converted from the temporary variable to a final variable for external reporting in Equation 18.

$$CLSOPUS = CLSOPUSX \quad (18)$$

where

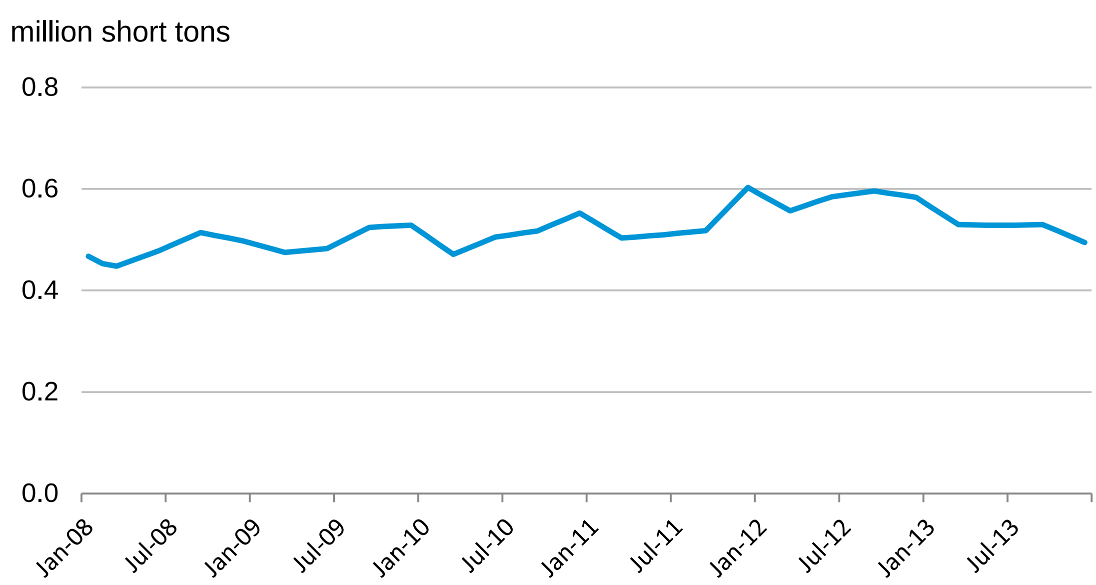
CLSOPUS = industrial sector coal stocks, million short tons
CLSOPUSX = industrial sector coal stocks (initial value), million short tons

8. Commercial / Institutional Sector Coal Stocks

Coal stocks held by the commercial / institutional sector, the smallest end-use sector, are less than 1% of those held by the largest sector (electric power sector), averaging approximately 500,000 tons on average from 2008 through 2013 as shown in Figure 17.

Through 1979, stock estimates for the residential and commercial sector were taken directly from reported data. For 1980–2007, stock estimates were not collected. Beginning in 2008, quarterly commercial (excluding residential) stocks data are collected on Form EIA-3. Monthly commercial / institutional coal stocks are estimated by using one-third of the current quarterly change to indicate the monthly change in stocks.

Figure 17. Commercial / institutional stocks, Jan. 2008 - Dec. 2013



Source: EIA, *Quarterly Coal Report*, Table 37.

Coal stocks held by the commercial / institutional sector are modeled as a function of the month's commercial / institutional sector coal consumption and the previous month's coal inventory (Equation

19). The estimated coefficient on coal consumption was negative as expected but was not statistically significant.

CLSHPUS = a0 + a1 * CLHCPUS (19)
+ a2 * D11ON
+ a3 * CLSHPUS(-1)
+ monthly dummy variables

where
CLSHPUS = commercial / institutional sector coal stocks, million short tons
CLHCPUS = commercial / institutional consumption, million short tons per day
D11ON = Dummy variable equal to 1 if the month is on or after January, 2011
CLSHPUS(-1) = prior month commercial / institutional sector coal stocks, million short tons

9. Total End-use Sector (Secondary) Coal Stocks

Total end-use sector coal stocks are the sum of the sector stocks (Equation 20).

CLSTPUS = CLPS_EP + CLSKPUS + CLSOPUS + CLSHPUS (20)

where
CLSTPUS = total end-use sector coal stocks, million short tons
CLPS_EP = total electric power sector coal stocks, million short tons
CLSKPUS = coke plant coal stocks, million short tons
CLSOPUS = industrial sector coal stocks, million short tons
CLSHPUS = commercial / institutional sector coal stocks, million short tons

Monthly secondary stock withdrawals (additions) per day are estimated as shown in equation 21.

CLST_DRAW = (CLSTPUS(-1) - CLSTPUS) / ZSAJQUS (21)

where
CLST_DRAW = secondary stock withdrawals, million short tons per day
CLSTPUS(-1) = prior month total end-use sector coal stocks, million short tons
CLSTPUS = total end-use sector coal stocks, million short tons
ZSAJQUS = number of days in the reference month

10. Total Coal Stocks

Total coal stocks are the sum of primary and secondary coal stocks (Equation 22).

CLPS_TOT = CLTSPUS + CLSDPUS (22)

where

CLPS_TOT = total coal stocks, million short tons
CLSTPUS = total end-use sector (secondary) coal stocks, million short tons
CLSDPUS = producer / distributor (primary) coal stocks, million short tons

Monthly primary stock withdrawals (additions) per day are estimated as shown in equation 23.

CLSD_DRAW = (CLSDPUS(-1) - CLSDPUS) / ZSAJQUS (23)

where

CLSD_DRAW = primary stock withdrawals, million short tons per day
CLSDPUS(-1) = prior month producer / distributor (primary) coal stocks, million short tons
CLSDPUS = producer / distributor (primary) coal stocks, million short tons
ZSAJQUS = number of days in the reference month

11. Producer / Distributor (Primary) Coal Stocks

Through 1997, estimates of quarterly stocks at producers and distributors were taken directly from reported data, and monthly data were estimated by using one-third of the current quarterly change to indicate the monthly change in stocks. Beginning in 1998, only end-of-year stocks are taken from reported data. Annually, once the new end-of-year data becomes available, an exogenous forecast of producer/distributor stocks is generated based on the trends of Appalachian and Interior production at that time. The equation, which is exogenous to the coal module, is only revised when new data becomes available.

Monthly estimates of producer/distributor stocks are modeled as shown in equation 23a.

CLSDPUS = a0 + a1 * (CLPRPAR + CLPRPIR) (23a)
+ a2 * D1007
+ a3 * D1101
+ a4 * D1103
+ a5 * D1201
+ a6 * CLSDPUS(-1)
+ monthly dummy variables

where

CLSDPUS = producer/distributor coal stocks, million short tons
CLPRPAR = Appalachian region coal production, million short tons per day
CLPRPIR = Interior region coal production, million short tons per day
D1007 = Dummy variable equal to 1 if the month is July, 2010
D1101 = Dummy variable equal to 1 if the month is January, 2011
D1103 = Dummy variable equal to 1 if the month is March, 2011
D1201 = Dummy variable equal to 1 if the month is January, 2012

CLSDPUS(-1) = prior month producer/distributor coal stocks, million short tons

7. Raw Steel and Coal Coke

A. Introduction

The raw steel and coal coke section of the coal module contains five estimated regression equations and five identities. The estimated equations are for raw steel production, coal coke consumption, coal coke net imports, coal coke production, and coal coke exports.

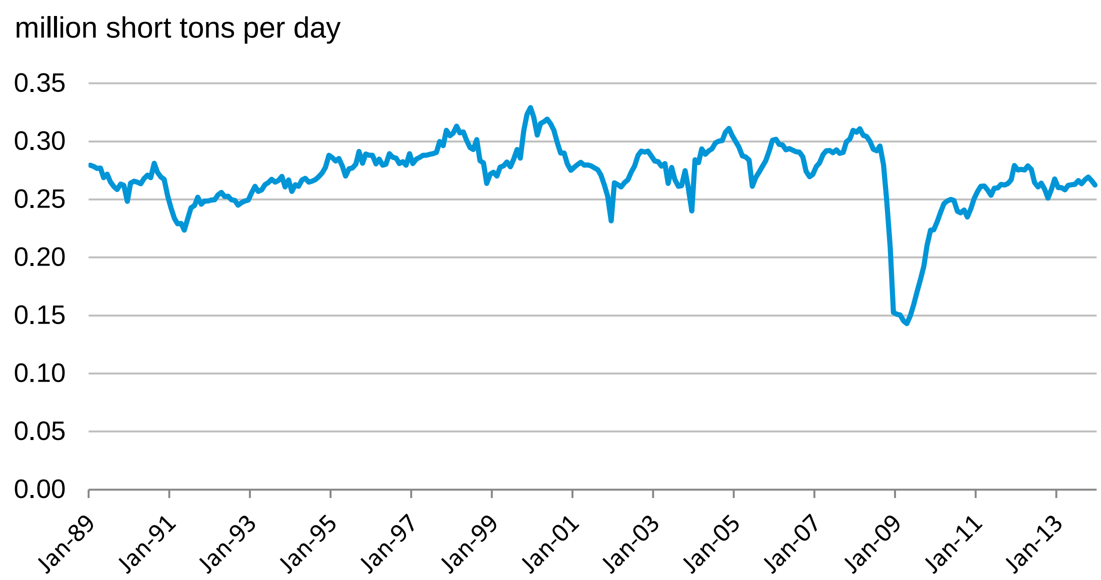
Monthly estimates for raw steel production are based on weekly production provided by the American Iron and Steel Institute. Monthly data for coal coke imports and exports are collected by the U.S. Department of Commerce, Bureau of the Census. EIA's *MER* publishes the Census data for coal coke imports, exports, and net imports (imports-exports), while the *QCR* publishes the Census data for coal coke imports and coal coke exports. Monthly estimates for coal coke production, coal coke consumption, and coal coke stocks are based on quarterly data published in the *QCR.*

B. Raw Steel and Coal Coke Equations

1. Raw Steel Production

Raw steel is produced by two methods, basic oxygen furnace (BOF) processing, and electric arc furnace (EAF) processing. BOF steelmaking, which utilizes coal coke as a raw material, accounts for approximately 40% of the raw steel produced in the United States. The majority of U.S. raw steel produced utilizes EAF steelmaking. The EAF process, which uses nearly 100% recycled steel, does not rely on coal coke. Figure 18 shows raw steel production from 1989 through 2013.

Figure 18. Raw steel production, Jan. 1981 - Dec. 2011



Source: American Iron and Steel Institute.

As a key indicator of coal coke consumption, seasonally-adjusted raw steel production is estimated as a function of the primary metals industrial production index, real fixed investment, business inventory change, and the previous month's raw steel production level (equation 24). A trend variable is included for the decline of raw steel production starting at the end of 2008.

RSPRPUS_SA = a0 + a1 * ZO331IUS (24)
+ a2 * I87RXUS
+ a3 * KRDRXUS
+ a4 * @TREND(2008:12)
+ a5 * RSPRPUS_SA(-1)

where

RSPRPUS_SA = seasonally-adjusted raw steel production, million short tons per day
ZO331IUS = industrial production index, primary metals, index, 2007=100
I87RXUS = real fixed investment, billion chained 2009 dollars
KRDRXUS = business inventory change, billion chained 2009 dollars
@TREND(2008:12) = a trend that begins with 1 in January 2009 and increases by one each month
RSPRPUS_SA(-1) = prior month seasonally-adjusted raw steel production, million short tons per day

Total raw steel production (not seasonally adjusted) is then estimated by multiplying seasonally-adjusted raw steel production by its seasonal adjustment factor, as shown in Equation 25.

RSPRPUS = RSPRPUS_SA * RSPRPUS_SF (25)

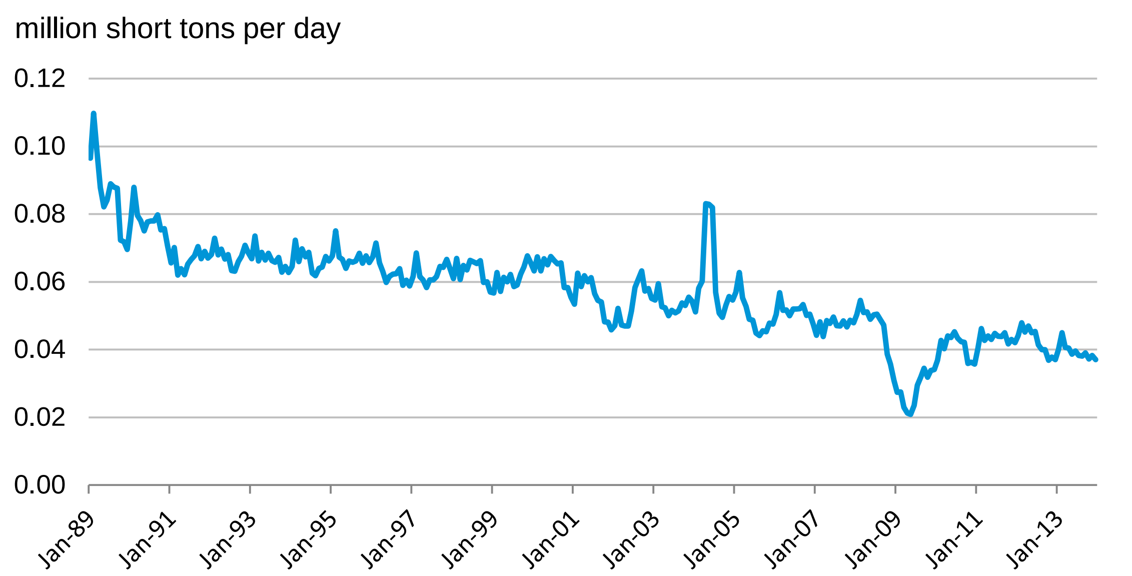
where

RSPRPUS = raw steel production, million short tons per day
RSPRPUS_SA = seasonally-adjusted raw steel production, million short tons per day
RSPRPUS_SF = raw steel production seasonal factor

2. *Coal Coke Consumption*

Coal coke consumed at BOF facilities, whether domestically produced or imported, has declined as EAF steelmaking has overtaken BOF steelmaking in the United States as shown in Figure 19.

Figure 19. Coal coke consumption, Jan. 1989 - Dec. 2013



Source: Monthly estimates based on EIA, *Quarterly Coal Report*, Table ES2.

Coal coke consumption is modeled as a function of the current and previous months' raw steel production and the previous month's coal coke consumption level (Equation 26).

CCTCPUS = a0 + a1 * RSPRPUS (26)
+ a2 * RSPRPUS(–1)
+a3 * CCTCPUS (-1)
+ monthly dummy variables

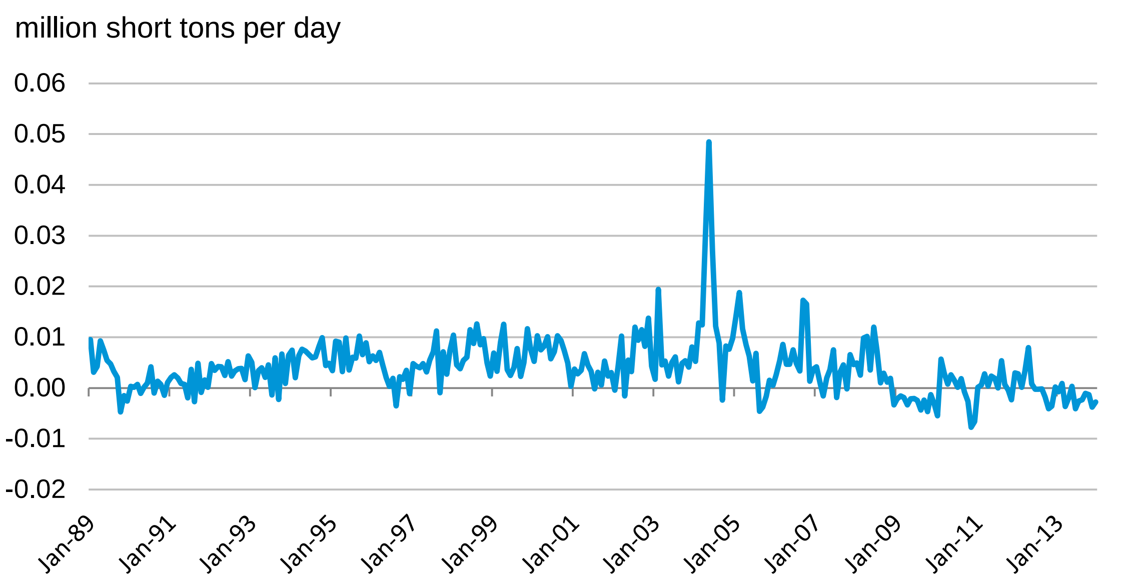
where

CCTCPUS = coal coke consumption, million short tons per day
RSPRPUS = raw steel production, million short tons per day
RSPRPUS(-1) = prior month raw steel production, million short tons per day
CCTCPUS(-1) = prior month coal coke consumption, million short tons per day

3. Coal Coke Net Imports

There has been a significant shift in the U.S. trade of coal coke in the past decade. Coal coke imports averaged 3.8 million short tons annually from 2001-2005 but only just above 2 million short tons from 2006-2010. At the same time, coal coke exports have risen from an average of 1.2 million short tons per year (2001-2005) to 1.6 million short tons annually (2006-2010). Coal coke net imports from 1989 through 2013 are provided in Figure 20.

Figure 20. Coal coke net imports, Jan. 1989 - Dec. 2013



Source: EIA, *Quarterly Coal Report*, Table ES2.

Coal coke net imports are estimated as a function of the current and prior month coal coke consumption and the prior month coal coke net imports (Equation 27).

$$\begin{aligned} CCNIPUS = {} & a0 + a1 * CCTCPUS \\ & + a2 * CCTCPUS(-1) \\ & + a3 * CCNIPUS(-1) \\ & + \text{monthly dummy variables} \end{aligned} \tag{27}$$

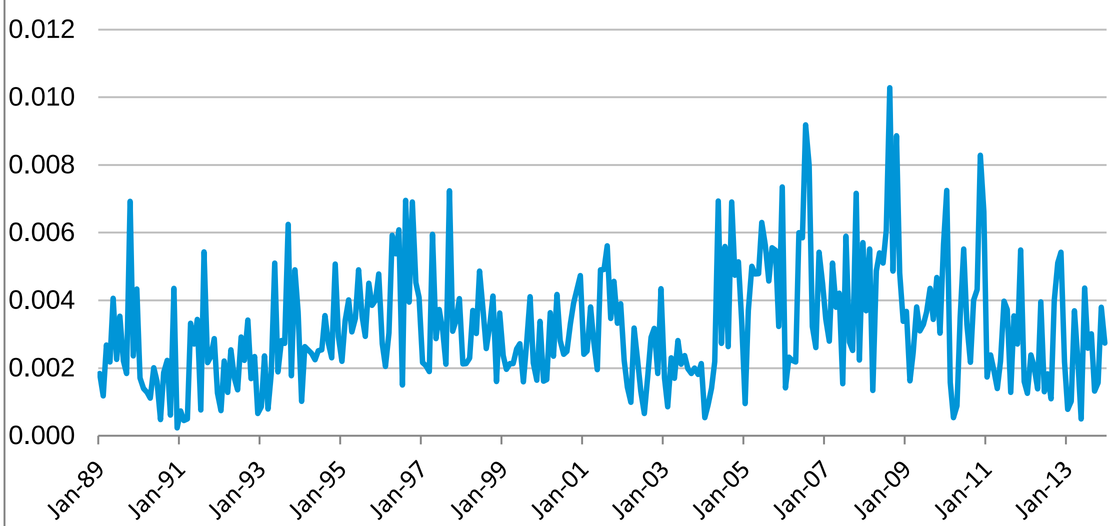
where

CCNIPUS = coal coke net imports, million short tons per day
CCTCPUS = coal coke consumption, million short tons per day
CCTCPUS(-1) = prior month coal coke consumption, million short tons per day
CCNIPUS(-1) = previous month coal coke net imports, million short tons per day

4. Coal Coke Exports

Coal coke exports rose from an average of 1.2 million short tons per year (2001-2005) to 1.6 million short tons annually (2006-2010), but have only averaged 0.9 million short tons annually over the past 3 years (2011-2013). Coal coke exports from 1989 through 2013 are provided in Figure 21.

Figure 21. Coal coke exports, Jan. 1989 - Dec. 2013



Source: EIA, *Quarterly Coal Report*, Table ES2.

Coal coke exports are estimated as a function of the current and prior month coal coke consumption and production, as well as the prior month coal coke net imports (Equation 28). The estimated coefficients on the production and consumption variables were not statistically significant.

CCEXPUS = a0 + a1 * CCTCPUS (28)
+ a2 * CCPRPUS
+ a2 * @TREND(2008:12)
+ monthly dummy variables

where

CCEXPUS = coal coke exports, million short tons per day
CCTCPUS = coal coke consumption, million short tons per day
CCPRPUS = coal coke production, million short tons per day
@TREND(2008:12) = a trend that begins with 1 in January 2009 and increases by one for each month

5. Coal Coke Imports

Coal coke imports are calculated as the sum of coal exports and coal net imports, as shown in Equation 29.

CCIMPUS = CCEXPUS + CCNIPUS (29)

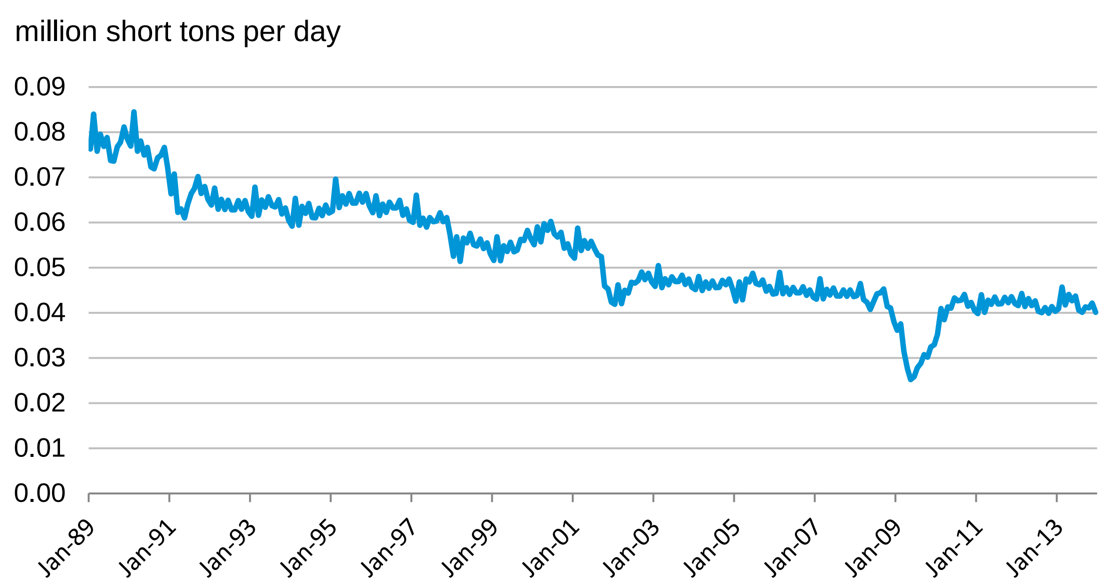
where,

CCIMPUS = coal coke imports, million short tons per day
CCEXPUS = coal coke exports, million short tons per day
CCNIPUS = coal coke net imports, million short tons per day

6. Coal Coke Production

Coal coke is produced by the baking of metallurgical coal at very high temperatures in the absence of oxygen. With the rise of EAF steelmaking, the need for coal coke, and subsequently its production, has fallen. Production of coal coke, which was 27.6 million short tons in 1990, fell to just over 15 million short tons in 2010 and has averaged 15.3 million short tons over the past three years (2011-2013), as illustrated in Figure 22.

Figure 22. Coal coke production, Jan. 1989 - Dec. 2013



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

Coal coke production is estimated as a function of the current and previous months' coal coke consumption, coal coke net imports, and the previous month's coal coke production (Equation 30).

CCPRPUS = a0 + a1 * CCTCPUS (30)
+ a2 * CCTCPUS(-1)
+ a3 * CCNIPUS
+ a4 * CCPRPUS(-1)
+ monthly dummy variables

where

CCPRPUS = coal coke production, million short tons per day
CCTCPUS = coal coke consumption, million short tons per day
CCTCPUS(-1) = prior month coal coke consumption, million short tons per day
CCNIPUS = coal coke net imports, million short tons per day
CCPRPUS(-1) = prior month coal coke production, million short tons per day

7. Coal Coke Stocks

The *STEO* assumes that the coal coke market is balanced; thus any differences between coal coke demand and supply are met by coal coke stock change (build or withdrawal). This change to coal coke stocks is represented in equation 31.

COKEBAL = CCTCPUS - CCPRPUS - CCNIPUS (31)

where
COKEBAL = coal coke stock change, million short tons per day
CCTCPUS = coal coke consumption, million short tons per day
CCPRPUS = coal coke production, million short tons per day
CCNIPUS = coal coke net imports, million short tons per day

To calculate current month coal coke stocks, the calculated coal coke stock change from the prior month is subtracted from coal coke stock value in the previous month (Equation 32).

CCSDPUS = CCSDPUS(-1) - (COKEBAL * ZSAJQUS) (32)

where
CCSDPUS = coal coke stocks, million short tons
CCSDPUS(-1) = prior month coal coke stocks, million short tons
COKEBAL = coal coke stock change, million short tons per day
ZSAJQUS = number of days in the reference month

8. Industrial and Commercial Coal Consumption

A. Introduction

The coal consumption section of the coal module contains three estimated regression equations and five identities. The estimated equations are for coke plant coal consumption, commercial / institutional coal consumption excluding consumption for combined heat and power, and industrial coal consumption excluding consumption for combined heat and power and synfuels. National coal consumption for the electric power sector is not determined in the coal module, but is instead passed to the coal module directly from the electricity generation and fuel consumption modules in STEO.

Monthly estimates for coal consumption, excluding that used at facilities generating electricity, are published in the *MER*. The estimates are based on quarterly data collected by EIA that is published in the *QCR*.

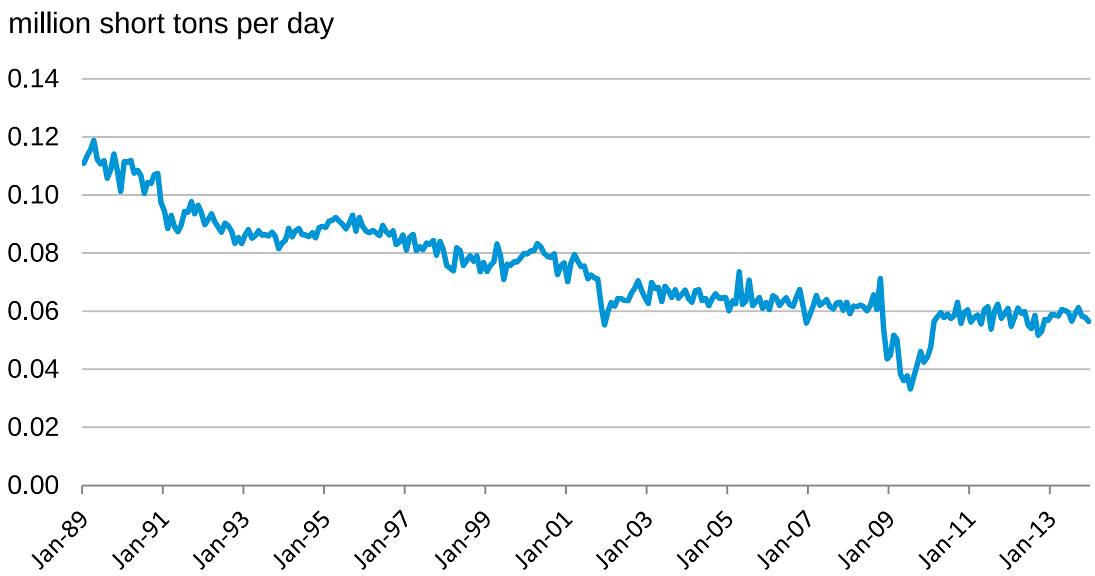
B. Coal Consumption Equations

1. Coke Plant Coal Consumption

Coal consumed at the 19 domestic coke plants is primarily for the production of coal coke. The advent of EAF steelmaking led to a decrease in the amount of coal coke produced and the consumption of coal at coke plants, which decreased from 38.9 million short tons in 1990 to 21.5 million short tons in 2013 as seen in Figure 23.

Through 1979, monthly coke plant consumption data were taken directly from reported data. For 1980–1987, coke plant consumption estimates were derived by proportioning reported quarterly data by using the ratios of monthly-to-quarterly consumption data in 1979, the last year in which monthly data were reported. Beginning in 1988, monthly coke plant consumption estimates are derived from the reported quarterly data by using monthly ratios of raw steel production data from the American Iron and Steel Institute (AISI). The ratios are the monthly raw steel production from open hearth and basic oxygen process furnaces as a proportion of the quarterly production from those kinds of furnaces.

Figure 23. Coal coke plant consumption, Jan. 1989 - Dec. 2013



Source: Monthly estimases based on EIA, *Quarterly Coal Report*, Table 32.

Coal coke plant consumption is estimated as a function of coal coke production, coal coke net imports, and the previous month's coke plant consumption (Equation 33).

$$\begin{aligned} CLKCPUS = {} & a0 + a1 * CCPRPUS \\ & + a2 * CCNIPUS \\ & + a3 * CLKCPUS(-1) \\ & + \text{monthly dummy variables} \end{aligned} \tag{33}$$

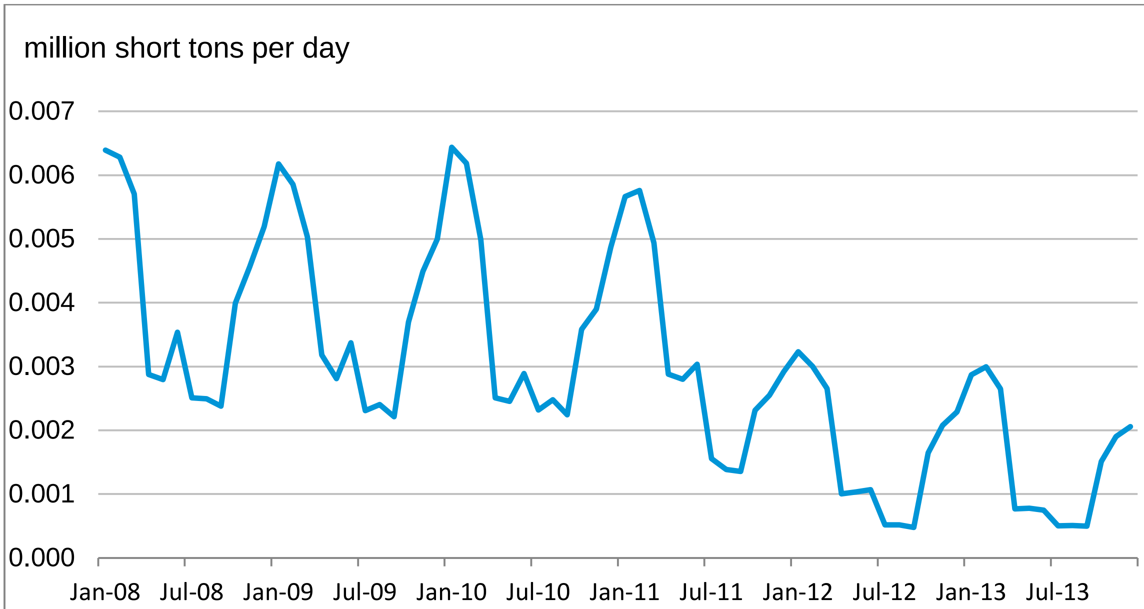
where

CLKCPUS = coal consumption at coke plants, million short tons per day
CCPRPUS = coal coke production, million short tons per day
CCNIPUS = coal coke net imports, million short tons per day
CLKCPUS(-1) = prior month coal consumption at coke plants, million short tons per day

2. Commercial / Institutional Coal Consumption

Coal consumed in the commercial / institutional sector is primarily for the generation of steam. This steam is then used to generate either electricity, heat, or both (combined heat and power (CHP)). Consumption of coal, excluding consumption for combined heat and power, has fallen from 6.7 million short tons in 1990 to 2.0 million short tons in 2013. Prior to 2008, coal consumed in the residential sector was also included. Commercial / institutional coal consumption from 2008 through 2013 is provided in Figure 24.

Figure 24. Commercial / institutional coal consumption, Jan. 2008 - Dec. 2013



Source: Monthly estimates based on EIA, *Quarterly Coal Report*, Table 32.

Commercial / institutional sector coal consumption at facilities not classified as combined heat and power or as electricity only is estimated as a function of heating degree days in the East North Central and Middle Atlantic Census regions and the previous month's consumption (Equation 34).

CLHCNONCHP = a0 + a1 * ZWHD_ENC (34)
+ a2 * ZWHD_MAC
+ a3 * CLHCNONCHP(-1)
+ monthly dummy variables

where

CLHCNONCHP = commercial / institutional coal consumption, excluding combined heat and power plants, million short tons per day
ZWHD_ENC = East North Central heating degree days
ZWHD_MAC = Middle Atlantic heating degree days
CLHCNONCHP(-1) = prior month commercial / institutional coal consumption, excluding combined heat and power plants, million short tons per day

Total commercial / institutional coal consumption is defined as the sum of coal consumed at combined heat and power plants (includes electricity only plants in the sector) and non-combined heat and power plants (Equation 35). Coal consumption at combined heat and power plants is passed to the coal module directly from the electricity generation and fuel consumption modules in STEO.

CLHCPUS = CLHCNONCHP + CLCECON (35)

where

CLHCPUS = commercial / institutional coal consumption, million short tons per day

CLHCNONCHP = commercial / institutional coal consumption, excluding combined heat and power plants, million short tons per day

CLCECON = commercial / institutional coal consumption at combined heat and power plants, million short tons per day

3. Industrial Coal Consumption

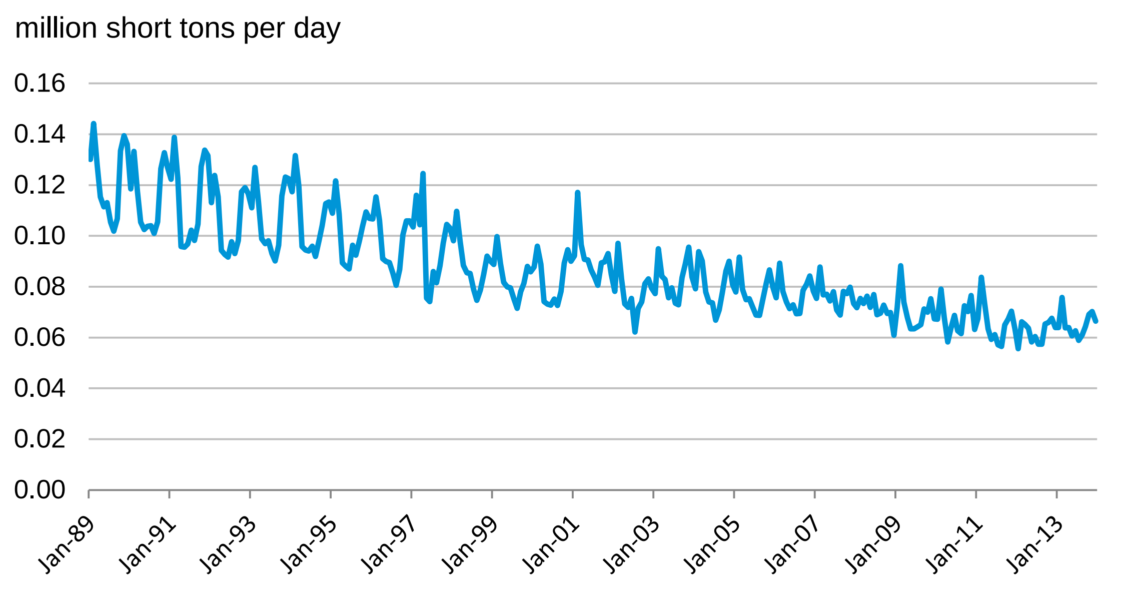
Coal consumed in the industrial sector (excluding coke plants) is used to generate steam (often in combined heat and power plants), as a direct fuel (cement kilns), and as a feedstock in the manufacture of chemicals, pharmaceuticals, and synthetic fuels.

Through 1977, monthly consumption data for the “other industrial” sector (all industrial users minus coke plants) were derived by using reported data to modify baseline consumption figures from the most recent Bureau of the Census Annual Survey of Manufactures or Census of Manufactures. For 1978 and 1979, monthly estimates were derived from data reported on Forms EIA-3 (Quarterly Survey of Non-Electric Sector Coal Data) and EIA-6 (Emergency Coal Supply Survey). For 1980–1987, monthly figures were estimated by proportioning quarterly data by using the ratios of monthly-to-quarterly consumption data in 1979, the last year in which monthly data were reported on Form EIA-3.

Beginning in 1988, monthly consumption for the other industrial sector is estimated from reported quarterly data by using ratios derived from industrial production indices published by the Board of Governors of the Federal Reserve System. Indices for six major industry groups are used as the basis for calculating the ratios: food manufacturing, which is North American Industry Classification System (NAICS) code 311; paper manufacturing, NAICS 322; chemical manufacturing, NAICS 325; petroleum and coal products, NAICS 324; non-metallic mineral products manufacturing, NAICS 327; and primary metal manufacturing, NAICS 331. Each monthly ratio is computed as a monthly sum of the weighted indices as a proportion of the quarterly sum of the weighted indices, where the weights are the 1977 industry group proportions of coal consumption (see EIA Monthly Energy Review coal section notes).

Through 2007, quarterly consumption data for the other industrial sector were derived by adding beginning stocks at manufacturing plants to current receipts and subtracting ending stocks at manufacturing plants. In this calculation, current receipts are the greater of either reported receipts from manufacturing plants (Form EIA-3 Quarterly Survey of Non-Electric Sector Coal Data) or reported shipments to the other industrial sector (Form EIA-6 Emergency Coal Supply Survey), thereby ensuring that agriculture, forestry, fishing, and construction consumption data were included where appropriate. Beginning in 2008, quarterly consumption totals for other industrial coal include data for manufacturing and mining only. Other industrial coal consumption from 1989 through 2013 is provided in Figure 25.

Figure 25. Industrial Coal consumption excluding coke plants, Jan. 1989 - Dec. 2013



Source: Monthly estimates based on EIA, *Quarterly Coal Report*, Table 32.

Non-combined heat and power industrial coal consumption is estimated as a function of coal-weighted industrial production and the previous month's other industrial coal consumption (Equation 36). Indices for six major industry groups are used as the basis for calculating the coal weighted index: food manufacturing, NAICS 311; paper manufacturing, NAICS 322; chemical manufacturing, NAICS 325; petroleum and coal products, NAICS 324; non-metallic mineral products manufacturing, NAICS 327; and primary metal manufacturing, NAICS 331. The indices are weighted by the proportions of coal consumed in the industry groups they represent. A trend variable, TIME, which counts the number of months from January 1975 – present, is included in the equation.

CLXCPUS = a0 + a1 * QSIC_CL (36)
+ a2 * TIME
+ a3 * CLXCPUS(-1)
+ monthly dummy variables

where

CLXCPUS = industrial coal consumption, excluding combined heat and power plants, million short tons per day

QSIC_CL = coal-weighted industrial production index, index, 2007=100

CLXCPUS(-1) = prior month industrial coal consumption, excluding combined heat and power plants, million short tons per day

Industrial coal consumption (excluding coke plants) in Equation 37 is the sum of non-combined heat and power industrial coal consumption, combined heat and power industrial coal consumption, and synfuel plant coal consumption. Consumption of coal at synfuel plants was not originally included in industrial coal surveys, but it is now included. Therefore, in the forecast period, to avoid double counting, it is now assumed to be equal to zero. Industrial coal consumption at combined heat and power plants is passed to the coal module directly from the electricity generation and fuel consumption modules in STEO.

$$CLYCPUS = CLXCPUS + CLCGCON + CLFCPUS \quad (37)$$

where

CLYCPUS = industrial coal consumption (excluding coke plants), million short tons per day
CLXCPUS = industrial coal consumption, excluding combined heat and power plants, million short tons per day
CLCGCON = industrial coal consumption at combined heat and power plants, million short tons per day
CLFCPUS = synfuel plant coal consumption, million short tons per day, and is assumed to equal zero in the forecast.

Retail and general industry coal consumption is defined in Equation 38 as the sum of commercial / institutional sector consumption and industrial sector coal consumption.

$$CLZCPUS = CLYCPUS + CLHCPUS \quad (38)$$

where

CLZCPUS = retail and general industry coal consumption, million short tons per day
CLYCPUS = industrial coal consumption (excluding coke plants), million short tons per day
CLHCPUS = commercial / institutional coal consumption, million short tons per day

Total coal consumption is defined in Equation 39 as the sum of coal consumption in the electric power sector, coke plant sector, and the retail and general industry sector.

$$CLTCPUS = CLEPCON + CLKCPUS + CLZCPUS \quad (39)$$

where

CLTCPUS = total coal consumption, million short tons per day
CLEPCON = electric power sector coal consumption, million short tons per day
CLKCPUS = coke plant coal consumption, million short tons per day
CLZCPUS = retail and general industry coal consumption, million short tons per day

Non-power section coal consumption is defined in Equation 40 as total coal consumption less electric power sector coal consumption.

$$CLOTCON = CLTCPUS - CLEPCON \quad (40)$$

where

CLOTCON = non-electric power sector coal consumption, million short tons per day

CLTCPUS = total coal consumption, million short tons per day
CLEPCON = electric power sector coal consumption, million short tons per day

9. Coal Balance

A. Introduction

The coal supply and balance section of the coal module contains ten equations all of which are identities. Final values for coal production, as well as other components of supply, are calculated in this section.

Historically, in any given period, the actual amount of coal supplied to the end-use sectors does not equal what was actually delivered and consumed by the end-use sectors because of measurement error, coal lost during distribution, or survey error. This discrepancy is calculated as production plus imports plus waste coal supplied minus the change in producer and distributor stocks minus consumption minus exports minus the change in consumer stocks. In the forecast period, we assume that coal supply and demand are in equilibrium, i.e. there is no imbalance or the discrepancy is equal to zero. To achieve this, we take forecasted demand values as given and we readjust the major supply component (production) to account for the difference.

B. Coal Balance Equations

The coal supply and demand forecasts are balanced through a set if seven identities. Forecasted coal production in each region is proportionally adjusted up or down so that total U.S. production equals the sum of estimated total coal use, net exports, and inventory change.

1. Coal Supply (Initial Values)

The initial value for net coal supplied is the sum of the initial value for coal production, net imports (imports minus exports), and primary (producer and distributor) inventory change (Equation 41).

$$CLNSPUSX = CLPRPUSX + (CLIMPUS - CLEXPUS) + CLSD\_DRAW \tag{41}$$

where

CLNSPUSX = net coal supplied (initial value), million short tons per day
CLPRPUSX = total coal production (initial value), million short tons per day
CLIMPUS = total coal imports, million short tons per day
CLEXPUS = total coal exports, million short tons per day
CLSD_DRAW = primary stock withdrawals, million short tons per day

The initial value for total coal supplied is defined as the sum of the initial value for net coal supplied, waste coal supplied, and secondary (end use sectors) inventory change (Equation 42). Waste coal estimates are calculated in the STEO identity module by applying annual growth rates based on the Annual Energy Outlook (AEO) projections to the latest waste coal supply data available from the Power Plant Operations Report (EIA-923) and the Quarterly Coal Consumption and Quality Report for Manufacturing and Transformation/Processing Coal Plants and Commercial and Institutional Coal Users

(EIA-3). The waste coal forecasts are prepared outside of the STEO models and entered into the STEO identity modules which, in turn, pass the values to the coal module.

$$CLTSPUSX = CLNSPUSX + CLWCPUS + CLST\_DRAW \tag{42}$$

where

CLTSPUSX = total coal supplied (initial value), million short tons per day
CLNSPUSX = net coal supplied (initial value), million short tons per day
CLWCPUS = waste coal supplied, million short tons per day
CLST_DRAW = secondary stock withdrawals, million short tons per day

The coal supply / demand imbalance is calculated in Equation 43 as the difference between the initial value of coal supplied and total coal consumption.

$$CLRESID = CLTSPUSX - CLTCPUS \tag{43}$$

where

CLRESID = coal supply / demand imbalance, million short tons per day
CLTSPUSX = total coal supplied (initial value), million short tons per day
CLTCPUS = total coal consumption, million short tons per day

2. Coal Production

The coal supply / demand imbalance is allocated to the initial production estimates by applying it proportionally to each of the three production regions by their shares of total production, as shown in Equations 44 through 46.

$$CLPRPAR = CLPRPARX – [CLRESID * (CLPRPARX / CLPRPUSX)] \tag{44}$$
$$CLPRPIR = CLPRPIRX – [CLRESID * (CLPRPIRX / CLPRPUSX)] \tag{45}$$
$$CLPRPWR = CLPRPARX – [CLRESID * (CLPRPWRX / CLPRPUSX)] \tag{46}$$

where

CLPRPAR = Appalachian region coal production, million short tons per day
CLPRPARX = Appalachian region coal production (initial value), million short tons per day
CLRESID = coal supply / demand imbalance, million short tons per day
CLPRPUSX = total coal production (initial value), million short tons per day
CLPRPIR = Interior region coal production, million short tons per day
CLPRPIRX = Interior region coal production (initial value), million short tons per day
CLPRPWR = Western region coal production, million short tons per day
CLPRPWRX = Western region coal production (initial value), million short tons per day

Total production is calculated as the sum of regional production in Equation 47.

CLPRPUS = CLPRPAR + CLPRPIR + CLPRPWR (47)

where

CLPRPUS = total coal production, million short tons per day
CLPRPAR = Appalachian region coal production, million short tons per day
CLPRPIR = Interior region coal production, million short tons per day
CLPRPWR = Western region coal production, million short tons per day

3. Coal Supply

The value for net coal supplied is the sum of the coal production, net imports (imports minus exports), and primary (producer and distributor) inventory change (Equation 48).

CLNSPUS = CLPRPUS + (CLIMPUS – CLEXPUS) + CLSD_DRAW (48)

where

CLNSPUS = net coal supplied, million short tons per day
CLPRPUS = total coal production, million short tons per day
CLIMPUS = total coal imports, million short tons per day
CLEXPUS = total coal exports, million short tons per day
CLSD_DRAW = primary stock withdrawals, million short tons per day

The value for total coal supplied is the sum of net coal supplied, waste coal supplied and, secondary (end use sectors) inventory change (Equation 49).

CLTSPUS = CLNSPUS + CLWCPUS + CLST_DRAW (49)

where

CLTSPUS = total coal supplied, million short tons per day
CLNSPUS = net coal supplied, million short tons per day
CLWCPUS = waste coal supplied, million short tons per day
CLST_DRAW = secondary stock withdrawals, million short tons per day

The coal supply / demand imbalance is calculated in Equation 50 as the difference between total coal supplied and total coal consumption. In the forecast period the value of the imbalance is zero.

CLAJPUS = CLTSPUS - CLTCPUS (50)

where

CLAJPUS = coal supply / demand imbalance, million short tons per day
CLTSPUS = total coal supplied, million short tons per day

CLTCPUS = total coal consumption, million short tons per day

10. Coal Prices

A. Introduction

The coal prices section of the coal module contains two regression equations. The first equation is for a production-weighted, composite national spot price and the second is for an average price for coal delivered to the electric power sector.

EIA reports weekly spot prices, in dollars per short ton, for 5 domestic coal commodity regions in the *Coals News and Markets (CNM)* report. The 5 regions are Central Appalachia (CAPP), Northern Appalachia (NAPP), Illinois Basin (ILB), Powder River Basin (PRB), and Uinta Basin (UIB). The historical data for the spot prices is proprietary and cannot be released by EIA, and since all data series in the *STEO* are published, a methodology to utilize these prices in the STEO model was developed.

Monthly estimates for each regional coal price are created by averaging the weekly estimates. When a week extends into a new month, the price is allocated on a daily basis and incorporated into the appropriate months. The prices are then converted from dollars per ton to dollars per million Btu (MMBtu), using the Btu per ton information provided in the *CNM* report. Monthly proxies for coal production from each of the 5 commodity regions are developed using EIA data, and a composite spot price is calculated based on the prices and their corresponding production.

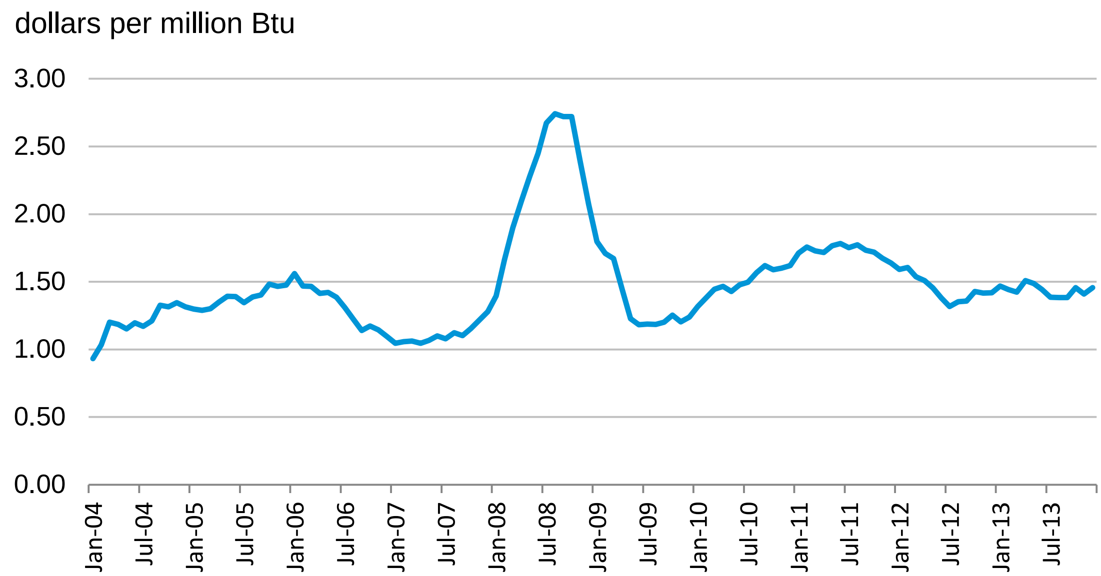
Prices for coal delivered to the electric power sector are reported in the *EPM* in dollars per ton and dollars per MMBtu. The *STEO* model uses the latter, so price comparisons to other power sector fuels such as natural gas and petroleum, which are also reported in dollars per MMBtu, are appropriate.

B. Coal Price Equations

1. Composite Spot Price

The composite spot price of coal has increased by 20% over the last 10 years from $1.20 per MMBtu in 2004 to $1.44 per MMBtu in 2013 as shown in Figure 26. PRB spot prices saw the largest increase over this period (67%), but the region's influence on the composite spot price is tempered by the fact that its price per MMBtu is roughly a half to a third of the other regional spot prices.

Figure 26. Composite spot price, Jan. 2004 - Dec. 2013



Source: monthly estimates based on EIA, *Coal News and Markets Report*.

The composite spot price of coal is estimated as a function of coal production, electric power sector coal stocks (inventories), and total coal exports (Equation 51).

$$
\begin{aligned}
CLSPUUS = & \ a0 + a1 * CLPRPUS \\
& + a2 * CLPS\_EP \\
& + a3 * CLEXPUS \\
& + \text{monthly dummy variables}
\end{aligned} \tag{51}
$$

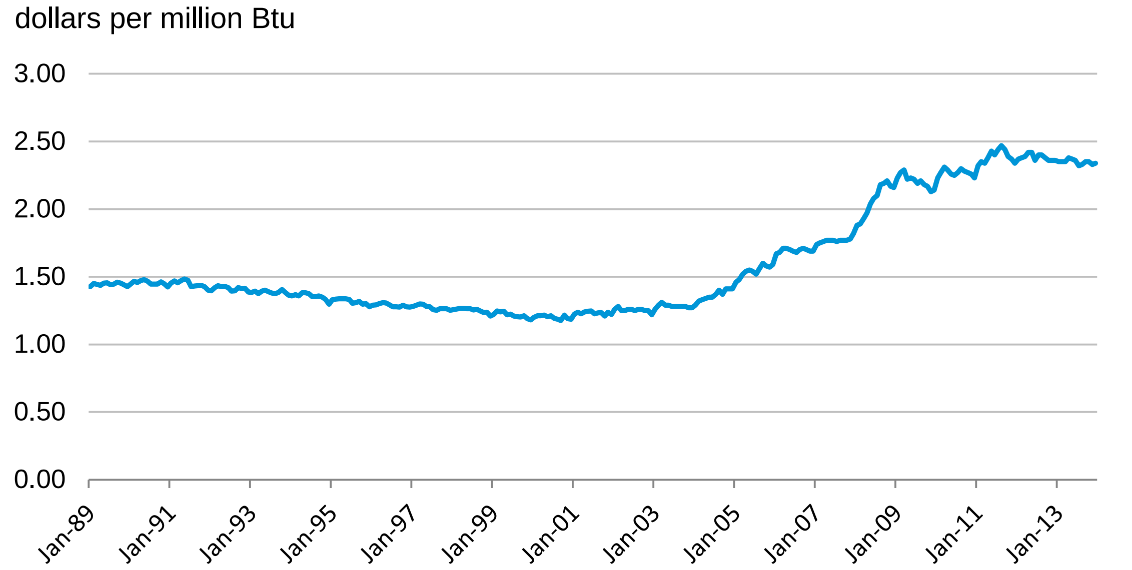
where

CLSPUUS = production-weighted, composite spot coal price, dollars per million Btu
CLPRPUS = total coal production, million short tons per day
CLPS_EP = total electric power sector coal stocks, million short tons
CLEXPUS = total coal exports, million short tons per day

2. Electric Power Sector Coal Price

The price of coal delivered to the electric power sector has increased by nearly 73% over the last 10 years from $1.36 per MMBtu in 2004 to $2.35 per MMBtu in 2013 as seen in Figure 27. During the same time, the natural gas prices to the power sector fell 27% from $5.97 per MMBtu (2010) to $4.35 per MMBtu (2013). In April 2012, the two prices were only $0.29 apart with the natural gas price at $2.71 per MMBtu and the coal price at $2.42 per MMBtu. That month was also the first time since EIA began collecting the data that generation from natural gas-fired plants was virtually equal to generation from coal-fired plants, with each fuel providing 32% of total generation.

Figure 27. Electric power sector coal price, Jan. 1989 - Dec. 2013



Source: EIA, *Electric Power Monthly*, Table ES2.B

The price of coal delivered to the electric power sector, as shown in Equation 52, is estimated as a function of the composite spot coal price, the retail diesel fuel price, and power sector coal stocks (inventories). The resulting prices are passed to several other STEO modules.

CLEUDUS = a0 + a1 * CLSPUUS (52)
+ a2 * DSRTUUS
+ a3 * CLPS_EP
+ monthly dummy variables

where

CLEUDUS = power sector coal price, dollars per million Btu
CLSPUUS = production-weighted composite spot coal price, dollars per million Btu
DSRTUUS = diesel fuel retail price, cents per gallon
CLPS_EP = total electric power sector coal stocks, million short tons

11. Short Ton Transformations

A. Introduction

The short ton transformation section of the coal module contains 21 equations, all of which are identities. The variables computed in this section are all that are generally reported in graphs, figures, and tables published in the *STEO*.

All energy flows (production, consumption, trade, and inventory changes) for all fuels (coal, electricity, natural gas, petroleum, and renewables) are modelled in the *STEO* on a per day basis. Fuels such as petroleum (barrels per day) are generally reported and aggregated in this manner, while others fuels such as electricity (kilowatt-hours per day) and natural gas (cubic feet per day) are sometimes reported on a per day basis. As coal is not generally reported in daily terms by the coal industry, major concepts of coal supply and demand are converted to the standard domestic units (short tons). Inventories (stocks) are modelled in short tons, so conversion is not necessary.

B. Short Ton Transformation Equations

1. Coal Supply and Trade

Four coal production variables (total, Appalachian, Interior, and Western) are converted to short tons in Equations 53 through 56.

$$CLPRPUS\_TON = CLPRPUS * ZSAJQUS \quad (53)$$
$$CLPRPAR\_TON = CLPRPAR * ZSAJQUS \quad (54)$$
$$CLPRPIR\_TON = CLPRPIR * ZSAJQUS \quad (55)$$
$$CLPRPWR\_TON = CLPRPWR * ZSAJQUS \quad (56)$$

where

CLPRPUS_TON = total coal production, million short tons
CLPRPUS = total coal production, million short tons per day
CLPRPAR_TON = Appalachian region coal production, million short tons
CLPRPAR = Appalachian region coal production, million short tons per day
CLPRPIR_TON = Interior region coal production, million short tons
CLPRPIR = Interior region coal production, million short tons per day
CLPRPWR_TON = Western region coal production, million short tons
CLPRPWR = Western region coal production, million short tons per day
ZSAJQUS = number of days in the reference month

Two stock (inventory) change variables are converted to short tons in Equations 57 through 58.

$$CLST\_DRAW\_TON = CLST\_DRAW * ZSAJQUS \quad (57)$$

CLSD_DRAW_TON = CLSD_DRAW * ZSAJQUS (58)

where

CLST_DRAW_TON = secondary stock withdrawals, million short tons
CLST_DRAW = secondary stock withdrawals, million short tons per day
CLSD_DRAW_TON = primary stock withdrawals, million short tons
CLSD_DRAW = primary stock withdrawals, million short tons per day
ZSAJQUS = number of days in the reference month

Four coal trade variables, imports, total exports, steam coal exports and metallurgical exports are converted to short tons (Equations 59 through 62).

CLIMPUS_TON = CLIMPUS * ZSAJQUS (59)
CLEXPUS_TON = CLEXPUS * ZSAJQUS (60)
CLEXPSC_TON = CLEXPSC * ZSAJQUS (61)
CLEXPMC_TON = CLEXPMC * ZSAJQUS (62)

where

CLIMPUS_TON = total coal imports, million short tons
CLIMPUS = total coal imports, million short tons per day
CLEXPUS_TON = total coal exports, million short tons
CLEXPUS = total coal exports, million short tons per day
CLEXPSC_TON = steam coal exports, million short tons
CLEXPSC = steam coal exports, million short tons per day
CLEXPMC_TON = metallurgical coal exports, million short tons
CLEXPMC = metallurgical coal exports, million short tons per day
ZSAJQUS = number of days in the reference month

Equation 63 shows the conversion to short tons of waste coal supplied.

CLWCPUS_TON = CLWCPUS * ZSAJQUS (63)

where

CLWCPUS_TON = waste coal supplied, million short tons
CLWCPUS = waste coal supplied, million short tons per day
ZSAJQUS = number of days in the reference month

Equations 64 and 65 show the conversion of net supply and total supply to short tons.

CLNSPUS_TON = CLNSPUS * ZSAJQUS (64)
CLTSPUS_TON = CLTSPUS * ZSAJQUS (65)

where

CLNSPUS_TON = net coal supply, million short tons
CLNSPUS = net coal supply, million short tons per day
CLTSPUS_TON = total coal supply, million short tons
CLTSPUS = total coal supply, million short tons per day
ZSAJQUS = number of days in the reference month

2. Coal Demand

Four coal consumption sector variables (coke plant consumption, electric power sector consumption, industrial sector consumption, and commercial / institutional sector consumption) are converted to short tons in Equations 66 through 69.

$$CLKCPUS\_TON = CLKCPUS * ZSAJQUS \tag{66}$$
$$CLEPCON\_TON = CLEPCON * ZSAJQUS \tag{67}$$
$$CLYCPUS\_TON = CLYCPUS * ZSAJQUS \tag{68}$$
$$CLHCPUS\_TON = CLHCPUS * ZSAJQUS \tag{69}$$

where
CLKCPUS_TON = coke plant coal consumption, million short tons
CLKCPUS = coke plant coal consumption, million short tons per day
CLEPCON_TON = electric power sector coal consumption, million short tons
CLEPCON = electric power sector coal consumption, million short tons per day
CLYCPUS_TON = industrial sector coal consumption, million short tons
CLYCPUS = industrial sector coal consumption, million short tons per day
CLHCPUS_TON = commercial / institutional consumption, million short tons
CLHCPUS = commercial / institutional consumption, million short tons per day
ZSAJQUS = number of days in the reference month

Three aggregated coal demand variables are converted to short tons in Equations 70 through 72.

$$CLZCPUS\_TON = CLZCPUS * ZSAJQUS \tag{70}$$
$$CLOTCON\_TON = CLOTCON * ZSAJQUS \tag{71}$$
$$CLTCPUS\_TON = CLTCPUS * ZSAJQUS \tag{72}$$

where
CLZCPUS_TON = retail and general industry coal consumption, million short tons
CLZCPUS = retail and general industry coal consumption, million short tons per day
CLOTCON_TON = coal consumption excluding the electric power sector, million short tons
CLOTCON = coal consumption excluding the electric power sector, million short tons per day
CLTCPUS_TON = total coal consumption, million short tons
CLTCPUS = total coal consumption, million short tons per day
ZSAJQUS = number of days in the reference month

3. Coal Discrepancy (Supply / Demand Imbalance)

The coal supply / demand imbalance is converted to short tons in Equation 73.

CLAJPUS_TON = CLAJPUS * ZSAJQUS (73)

where

CLAJPUS_TON = coal supply / demand imbalance, million short tons
CLAJPUS = coal supply / demand imbalance, million short tons per day
ZSAJQUS = number of days in the reference month

12. 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 2010. Dynamic forecasts were then generated for the period January 2011 through December 2012 using each regression equation. The forecasts were 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 were calculated for each regression equation. The mean absolute error (MAE) and root mean squared error (RMSE) statistics 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) normalizes the error to values between zero and one. This statistic can be used to compare the reliability of forecasts across different series.

The 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. Coal Production

Table 2 provides a comparison of the out-of-sample dynamic forecasts and actual coal production by region for each coal production regression equation for the years 2011 and 2012. A forecast for total coal production is calculated as the sum of the 3 individual production forecasts. The interior region forecast differed by 0.1% in both years, below in 2011, and above in 2012. Both the Appalachian and Western region production forecasts were lower than actual for both years.

Table 2. Actual and out-of-sample coal production forecasts, annual totals (million short tons)

	2011		2012	
	Actual	Forecast	Actual	Forecast
Appalachian Production (CLPRPARX)	337.232	313.590	294.139	287.206
Interior Production (CLPRPIRX)	170.763	170.660	179.587	179.810
Western Production (CLPRPWRX)	587.633	582.117	542.673	531.348
Total (CLPRPUS)	1095.628	1066.367	1016.399	998.364

Figure 28 through Figure 30 show the monthly actual and forecasted values for each region's production.

Figure 28. CLPRPARX, Appalachian coal production out-of-sample forecast versus actual, January 2011 – December 2012

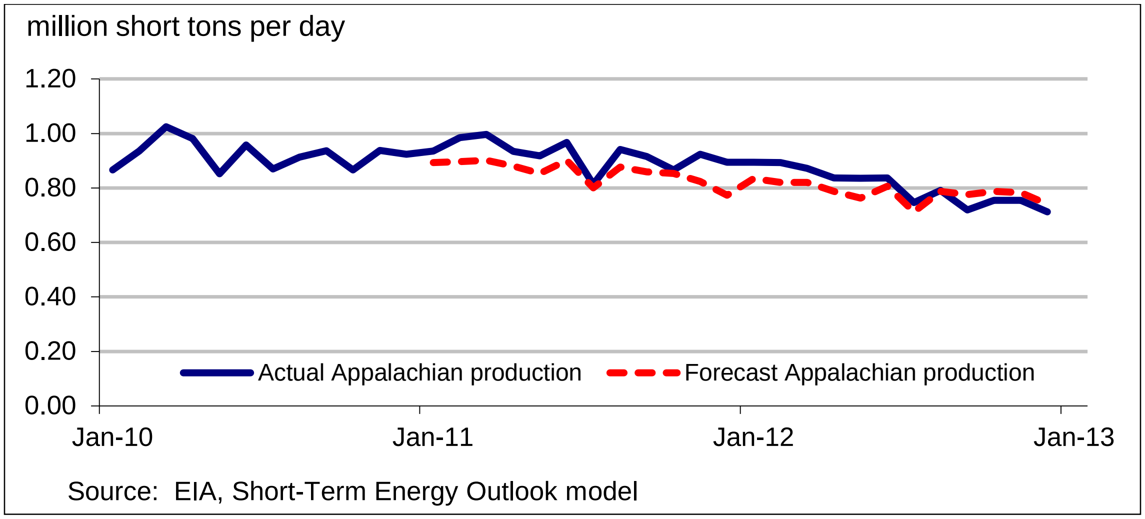


Figure 29. CLPRPIRX, Interior coal production out-of-sample forecast versus actual, January 2011 – December 2012

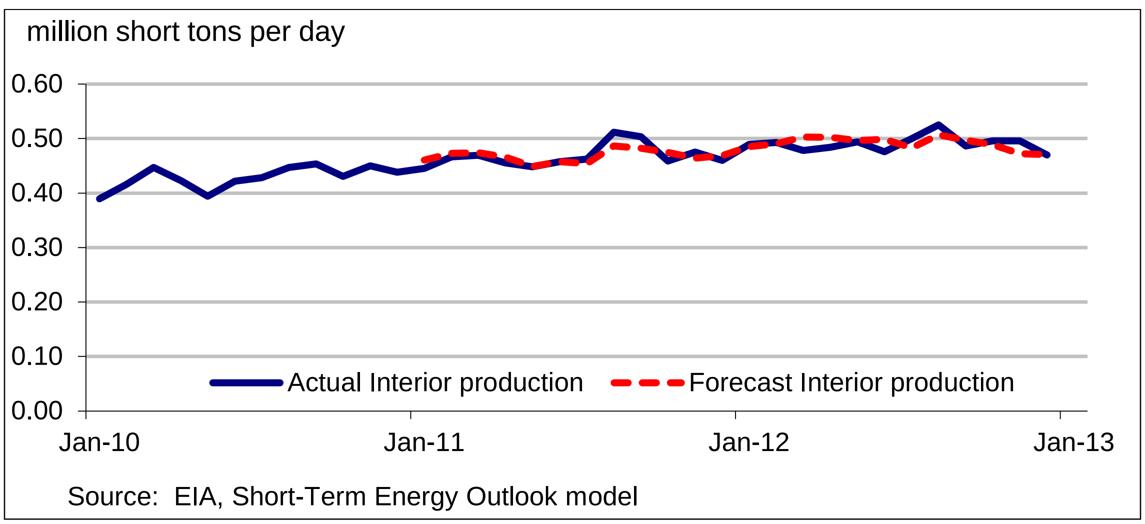
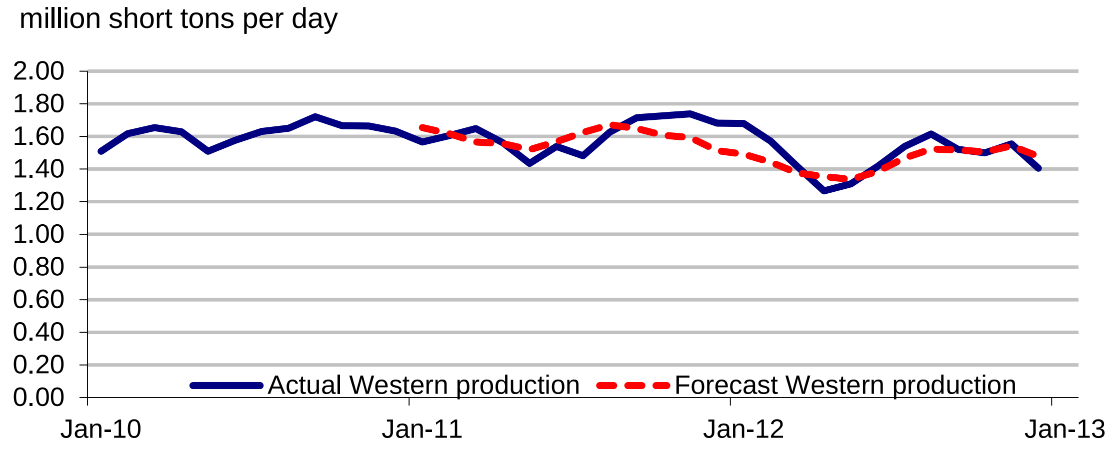


Figure 30. CLPRPWRX, Western coal production out-of-sample forecast versus actual, January 2011 – December 2012



Source: EIA, Short-Term Energy Outlook model

The difficulty in forecasting coal production also appears in Table 3, which reports summary forecast error statistics for each regression equation. Although the MAPE and Theil inequality coefficient are greatest for Appalachian production, most of the forecast error occurs in the covariance proportion, which implies unsystematic forecast error. The observed deviations between forecast and actual production could result from several structural trends occurring during this time. For example, Appalachian production was highly affected by the rise in coal prices experienced in 2011 and 2012. However, at the same time there was a significant drop in natural gas prices, with significant switching to that fuel for power generation, particularly in regions supplied with Appalachian coal (Midwest, Southeast, and the Middle Atlantic).

Table 3. Coal production out-of-sample simulation error statistics

	Appalachian Production	Interior Production	Western Production
Root mean squared error	0.069	0.018	0.077
Mean absolute error	0.060	0.015	0.061
Means absolute percent error	7.03	3.17	3.96
Theil inequality coefficient	0.041	0.019	0.025
Bias proportion	0.103	0.011	0.002
Variance proportion	0.352	0.354	0.155
Covariance proportion	0.545	0.606	0.842

B. Coal Trade

Table 4 provides a comparison of the out-of-sample dynamic forecasts and actual coal trade (imports, steam coal exports, and metallurgical coal exports). A forecast for total exports is calculated as the sum of the 2 individual export forecasts. The forecast error for imports was much larger in 2011 than in 2012 (nearly double). The largest forecast error (ton-wise) was for metallurgical coal exports in 2011 (11.0 million short tons, or 6%). The model correctly forecast declines in coal imports and increases in coal exports, but the forecasted increase in exports (total) was 18.1 million short tons (14%) lower than the actual increase. The 125.7 million short tons of coal exports in 2012 was the largest amount of coal ever exported and illustrates the volatility associated with the U.S. role as a “swing” supplier of coal in the world market, meaning that it has the ability to supply the market when there is an uptick in world demand (and U.S. exports) for coal worldwide. The ability of domestic production to compete with other major coal exporting countries, however, is hindered due to factors including production and transportation costs.

Table 4. Actual and out-of-sample coal trade forecasts, annual totals (million short tons)

	2011		2012	
	Actual	Forecast	Actual	Forecast
Coal imports (CLIMPUS)	13.088	16.371	9.159	10.500
Steam coal exports (CLEXPSC)	37.647	40.247	55.870	46.073
Metallurgical coal exports (CLEXPMC)	69.532	58.510	69.876	61.565
Total coal exports (CLEXPUS)	107.179	98.757	125.746	107.638

Figure 31 through Figure 33 show the monthly actual and forecasted values for imports and exports.

Figure 31. CLIMPUS, coal imports out-of-sample forecast versus actual, January 2011 – December 2012

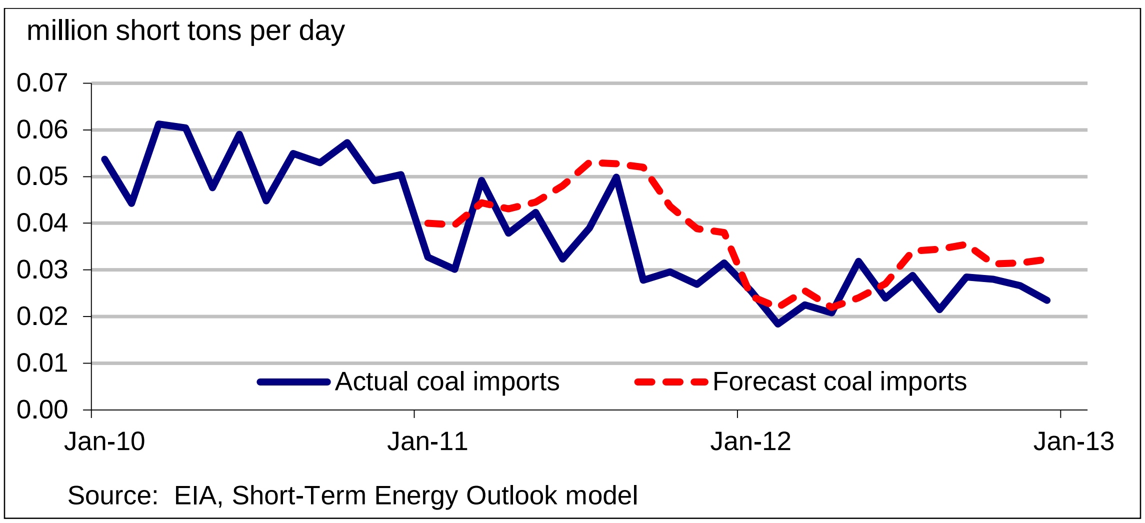


Figure 32. CLEXPSC, steam coal exports out-of-sample forecast versus actual, January 2011 – December 2012

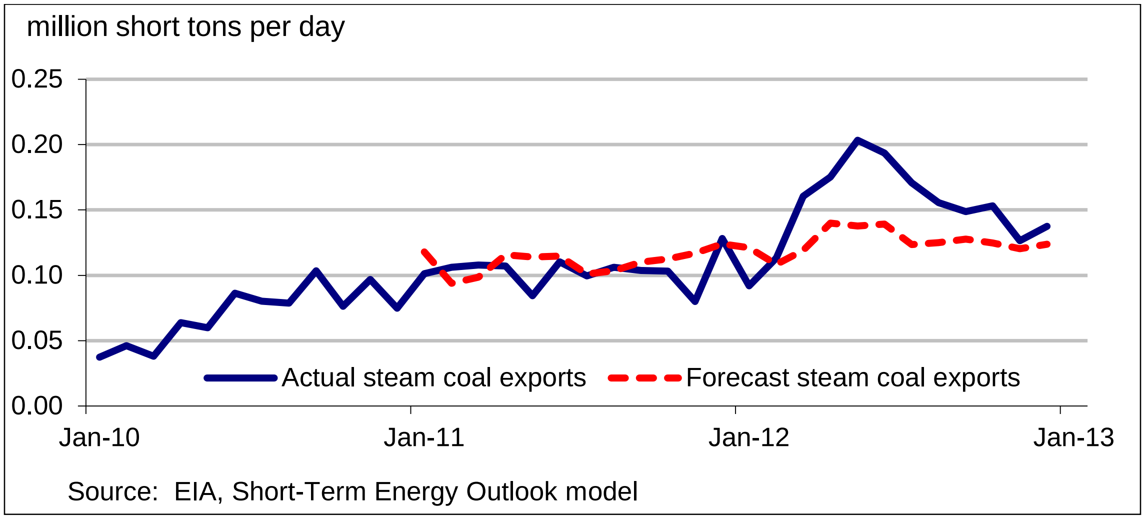
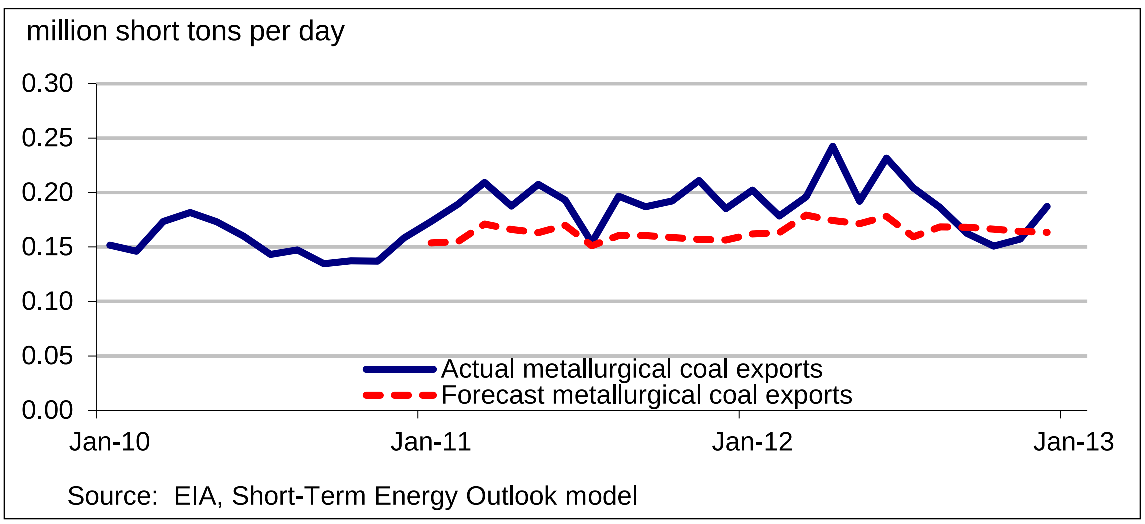


Figure 33. CLEXPMC, metallurgical coal exports out-of-sample forecast versus actual, January 2011 – December 2012



The over-prediction of imports and under-prediction of metallurgical exports are also revealed in Table 5, which reports summary forecast error statistics for each regression equation. The bias proportions of the Theil inequality coefficient are the highest for these forecasts. The high variance proportions for metallurgical and steam exports shows that the equations for these items did not accurately capture the fluctuations in each series. The inability to capture the fluctuations in the export forecasts is due in part to the United States' role as a swing supplier in the international coal market. Driven by worldwide demand for coal, exports were at record levels in 2011 and 2012, and it was nearly impossible to forecast this increase.

Table 5. Coal trade out-of-sample simulation error statistics

	Imports	Steam Coal Exports	Metallurgical Coal Exports
Root mean squared error	0.009	0.023	0.026
Mean absolute error	0.007	0.018	0.021
Means absolute percent error	24.84	16.96	10.90
Theil inequality coefficient	0.111	0.097	0.076
Bias proportion	0.242	0.037	0.338
Variance proportion	0.064	0.471	0.266
Covariance proportion	0.695	0.492	0.396

C. Coal Inventories (Stocks)

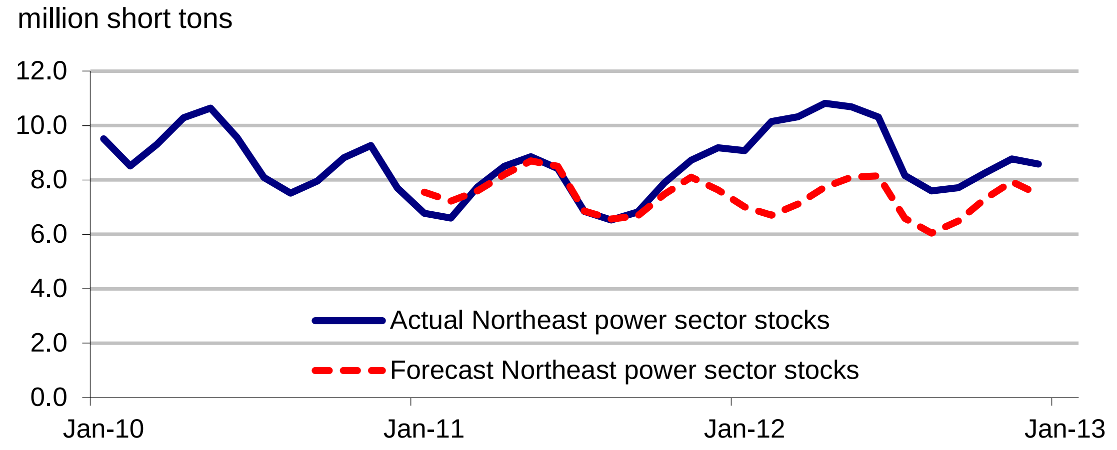
Table 6 provides a comparison of the out-of-sample dynamic forecasts and actual values for end-of-year coal stocks for the years 2011 and 2012. A forecast for total electric power sector stocks is calculated as a sum of the 4 regional forecasts. A forecast for total secondary stocks is created by summing the electric power sector forecast with the forecasts of the other end-use (secondary) sectors.

Table 6. Actual and out-of-sample coal inventory forecasts, end of year values (million short tons)

	2011		2012	
	Actual	Forecast	Actual	Forecast
Power Sector Inventories (Stocks)				
Northeast (CLPS_EP_NE)	9.189	7.632	8.582	7.472
Midwest (CLPS_EP_MW)	65.806	66.543	66.693	67.958
South (CLPS_EP_SO)	77.015	69.289	87.323	76.137
West (CLPS_EP_WE)	20.376	21.492	22.517	21.364
Total (CLPS_EP)	172.387	164.956	185.116	172.932
Coke Plant (CLSKPUS)	2.610	1.957	2.522	1.929
Industrial (CLSOPUS)	4.455	4.770	4.475	4.562
Commercial / Institutional (CLSHPUS)	0.603	0.556	0.583	0.557
Total Secondary (CLSTPUS)	180.054	172.239	192.696	179.980

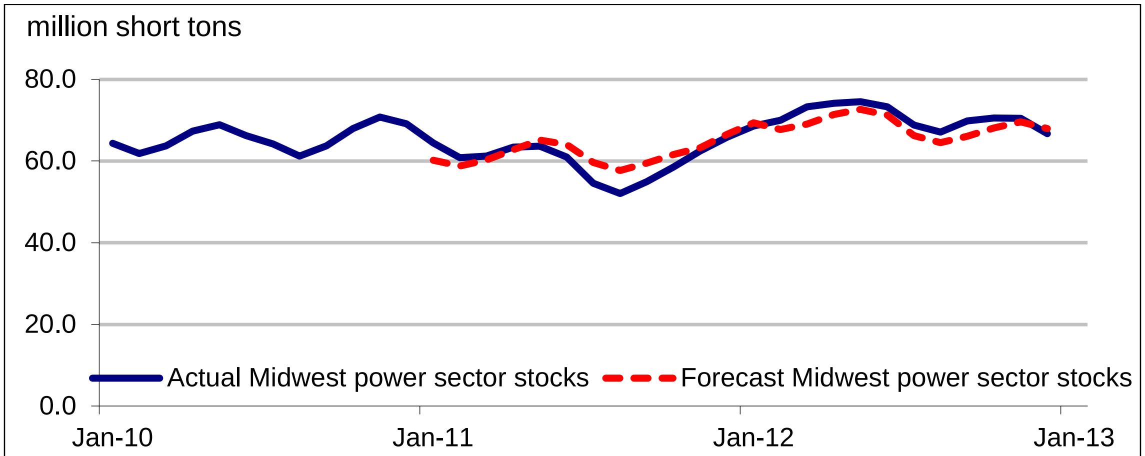
Figure 34 through Figure 40 show the monthly actual and forecasted values for the estimated coal stock series.

Figure 34. CLPS_EP_NE, Northeast power sector stocks out-of-sample forecast versus actual, January 2011 – December 2012



Source: EIA, Short-Term Energy Outlook model

Figure 35. CLPS_EP_MW, Midwest power sector stocks out-of-sample forecast versus actual, January 2011 – December 2012



Source: EIA, Short-Term Energy Outlook model

Figure 36. CLPS_EP_SO, South power sector stocks out-of-sample forecast versus actual, January 2011 – December 2012

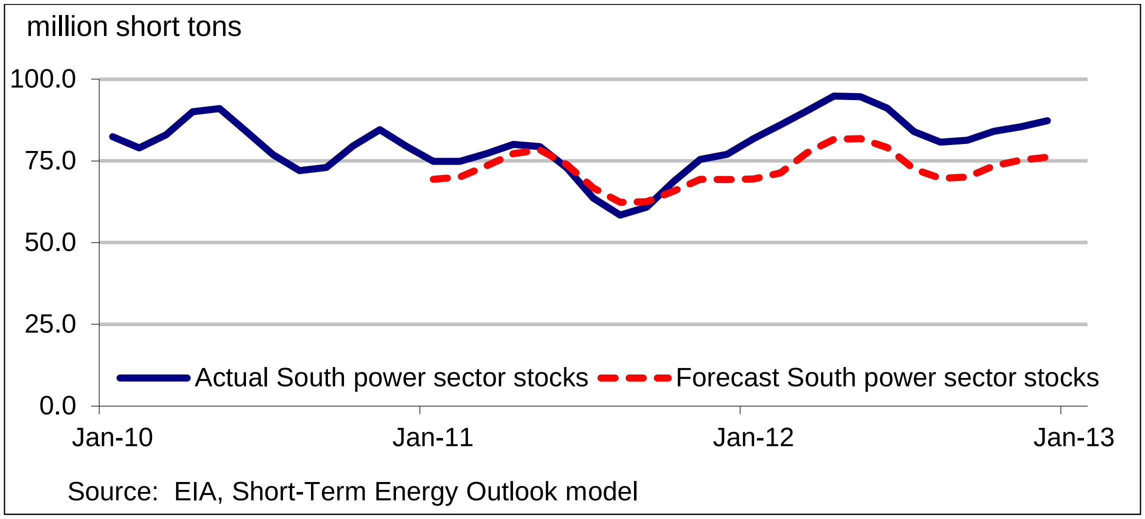


Figure 37. CLPS_EP_WE, West power sector stocks out-of-sample forecast versus actual, January 2011 – December 2012

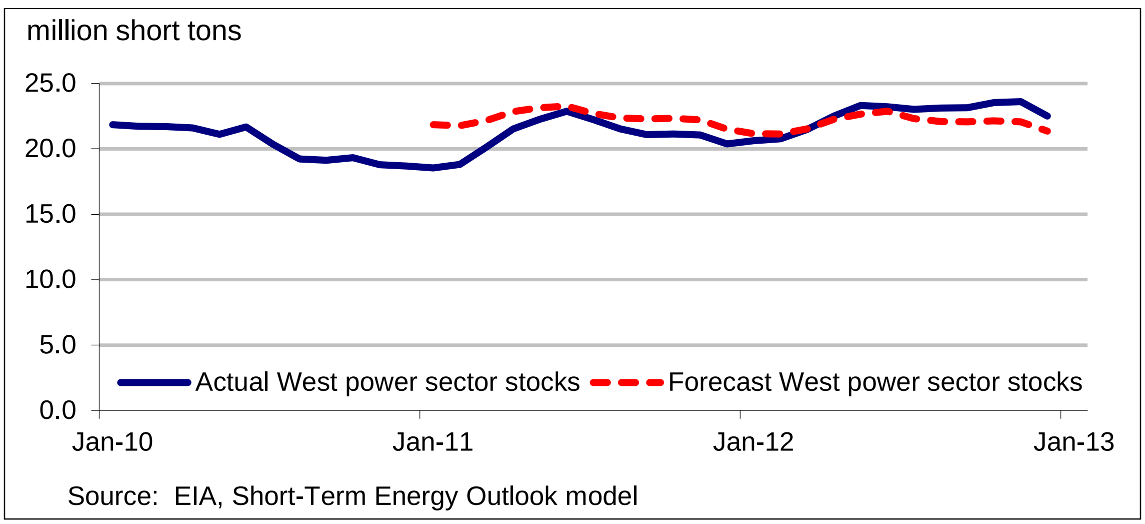
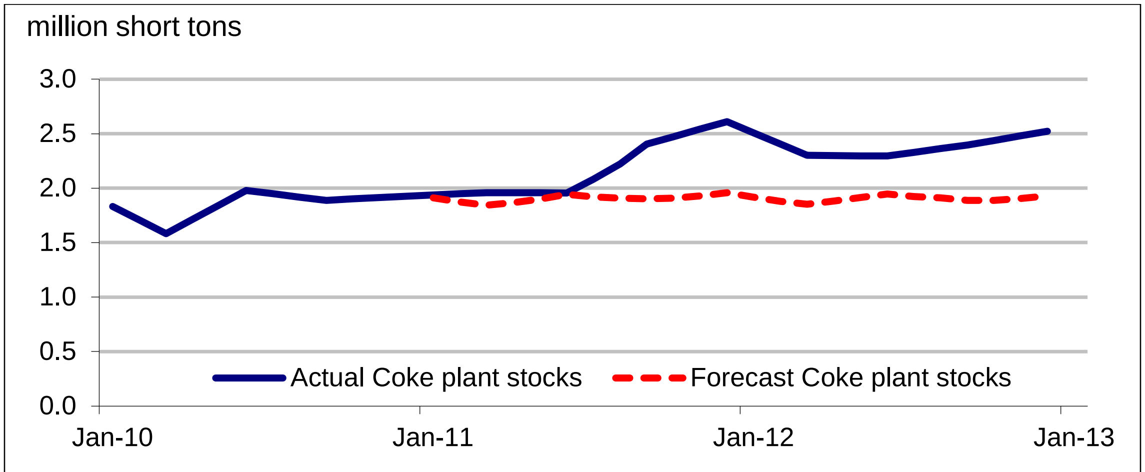
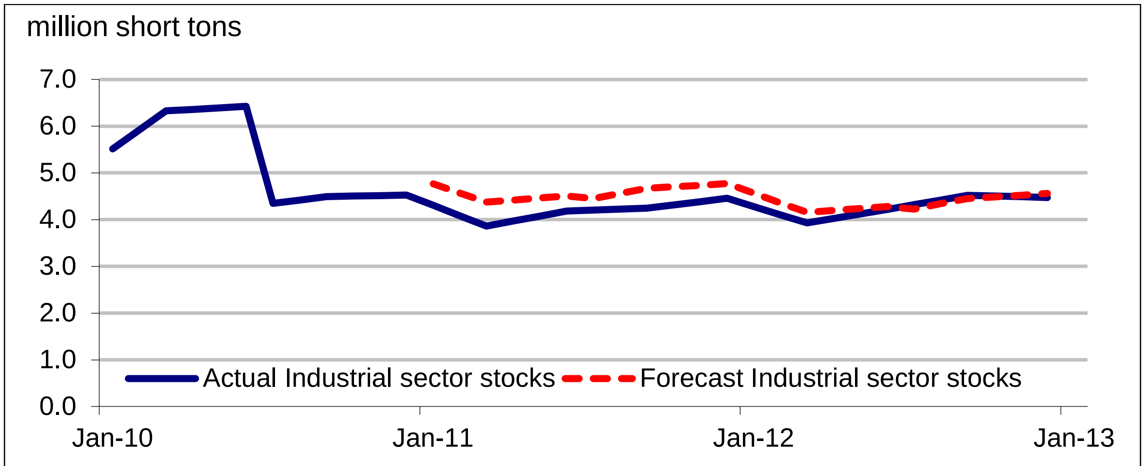


Figure 38. CLSKPUS, coke plant stocks out-of-sample forecast versus actual, January 2011 – December 2012



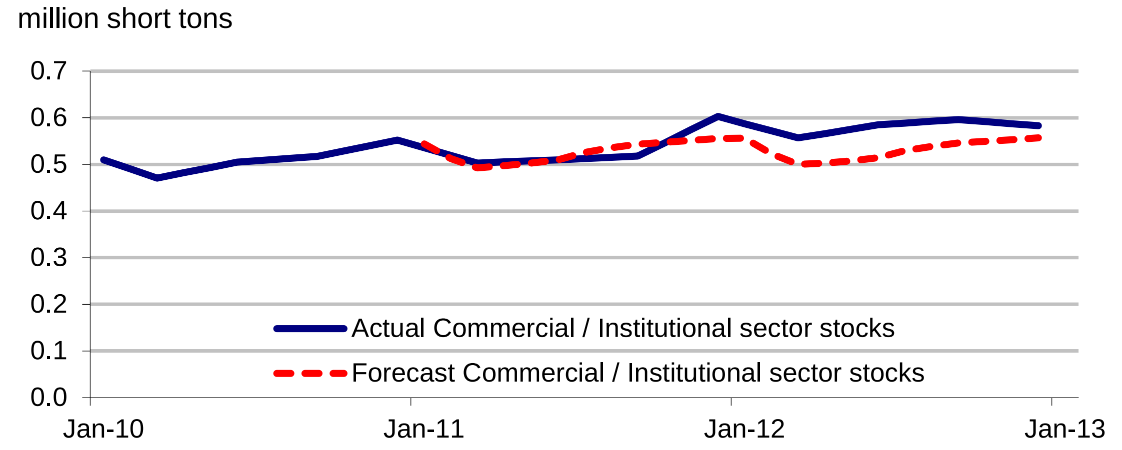
Source: EIA, Short-Term Energy Outlook model

Figure 39. CLSOPUS, industrial sector (excluding coke plants) stocks out-of-sample forecast versus actual, January 2011 – December 2012



Source: EIA, Short-Term Energy Outlook model

Figure 40. CLSHPUS, Commercial / Institutional sector stocks out-of-sample forecast versus actual, January 2011 – December 2012



Source: EIA, Short-Term Energy Outlook model

The under-prediction of Northeast and South region power sector stocks are shown in the large errors and Theil inequality coefficient bias proportion in Table 7. The increased usage of natural gas, due to falling prices, to generate power in these regions led to a build in power sector coal stocks. Gas-fired generation increased in the Middle Atlantic (Northeast), South Atlantic (South), and East South Central (South) regions in 2011 and 2012.

The under-prediction of coke plant stocks is shown in the large errors and Theil inequality coefficient bias proportion in Table 8. The large increase in coke plant stocks in 2011, the largest net percentage change in nearly 10 years, was hard to forecast, but the decline in stocks in 2012 was captured in part by the equation.

Table 7. Power sector coal stocks out-of-sample simulation error statistics

	Northeast	Midwest	South	West
Root mean squared error	1.179	5.187	7.057	2.176
Mean absolute error	0.803	3.672	5.653	1.781
Means absolute percent error	9.076	6.224	6.848	8.954
Theil inequality coefficient	0.073	0.040	0.045	0.050
Bias proportion	0.221	0.107	0.425	0.388
Variance proportion	0.044	0.278	0.095	0.167
Covariance proportion	0.735	0.614	0.481	0.445

Table 8. Non-power sector secondary coal stocks out-of-sample simulation error statistics

	Coke Plants	Industrial	Commercial Institutional
Root mean squared error	0.399	0.611	0.032
Mean absolute error	0.328	0.387	0.024

Means absolute percent error	13.96	7.73	4.39
Theil inequality coefficient	0.097	0.068	0.030
Bias proportion	0.559	0.000	0.172
Variance proportion	0.368	0.480	0.119
Covariance proportion	0.073	0.520	0.709

D. Coal Coke Sector

Table 9 provides a comparison of the out-of-sample dynamic forecasts and actual values for raw steel production and components of the coal coke sector for the years 2011 and 2012.

Table 9. Actual and out-of-sample coal coke sector forecasts, annual values (million short tons)

	2011		2012	
	Actual	Forecast	Actual	Forecast
Raw Steel Production (RSPRPUS_SA)	95.707	97.875	97.814	96.049
Coal Coke Consumption (CCTCPUS)	15.825	15.653	15.472	16.772
Coal Coke Net Imports (CCNIPUS)	0.448	0.558	0.161	0.287
Coal Coke Exports (CCEXPUS)	0.970	1.193	0.974	1.245
Coal Coke Production (CCPRPUS)	15.421	15.030	15.172	15.228

Figure 41 through Figure 45 show the monthly actual and forecasted values for the estimated coal coke sector series.

Figure 41. RSPRPUS_SA, raw steel production (seasonally adjusted) out-of-sample forecast versus actual, January 2011 – December 2012

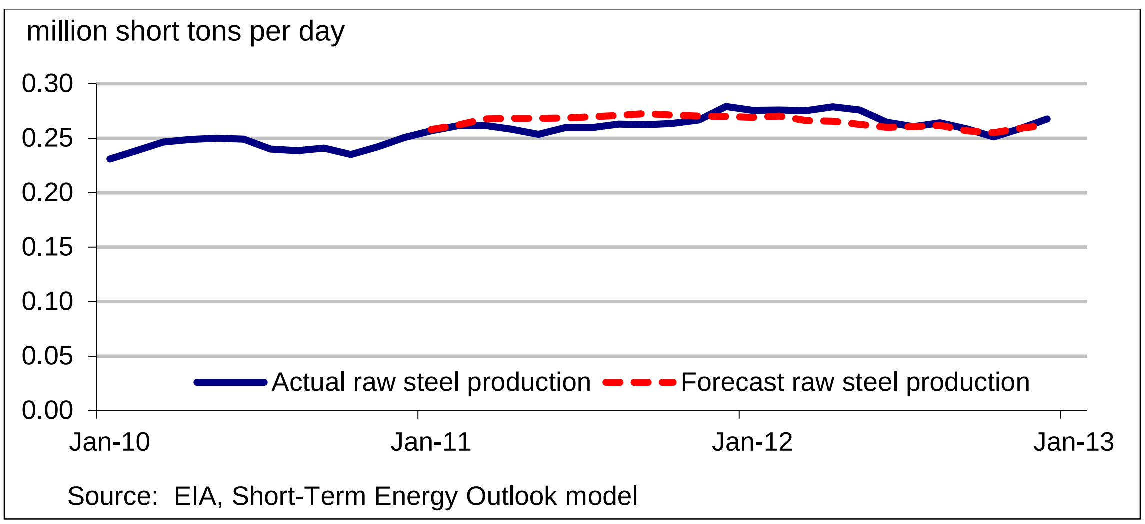


Figure 42. CCTCPUS, coal coke consumption out-of-sample forecast versus actual, January 2011 – December 2012

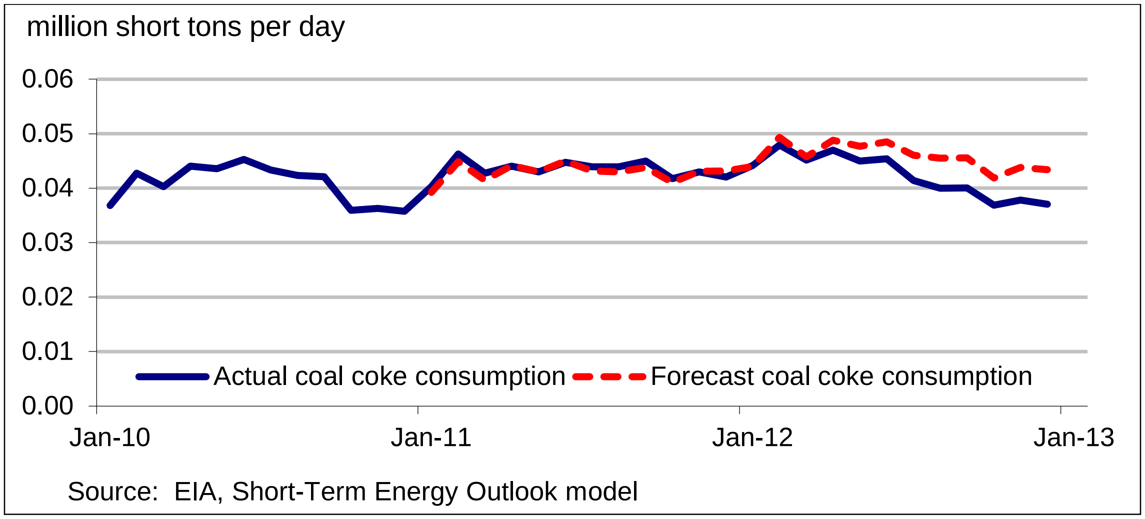


Figure 43. CCNIPUS, coal coke net imports out-of-sample forecast versus actual, January 2011 – December 2012

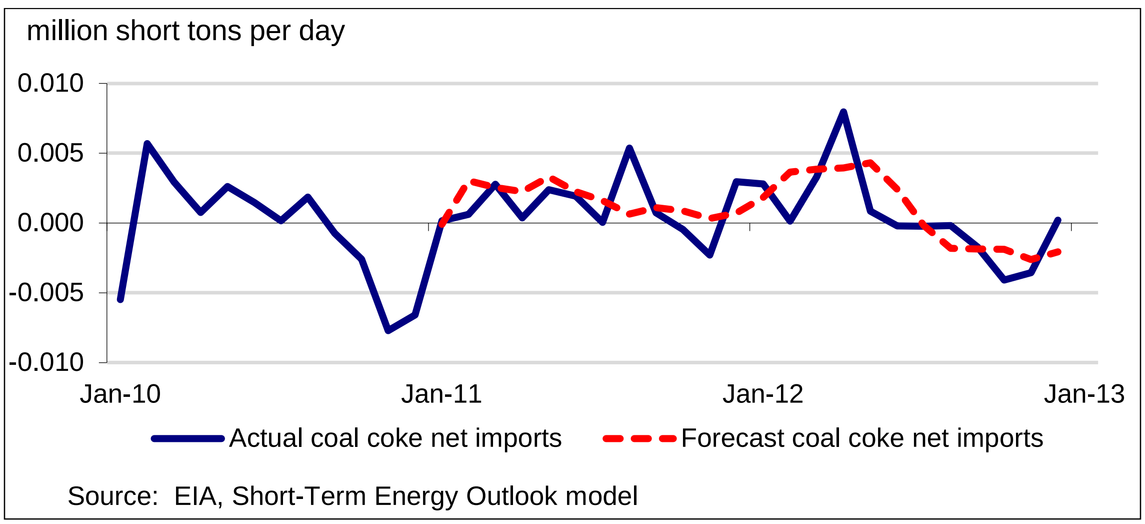


Figure 44. CCEXPUS, coal coke exports out-of-sample forecast versus actual, January 2011 – December 2012

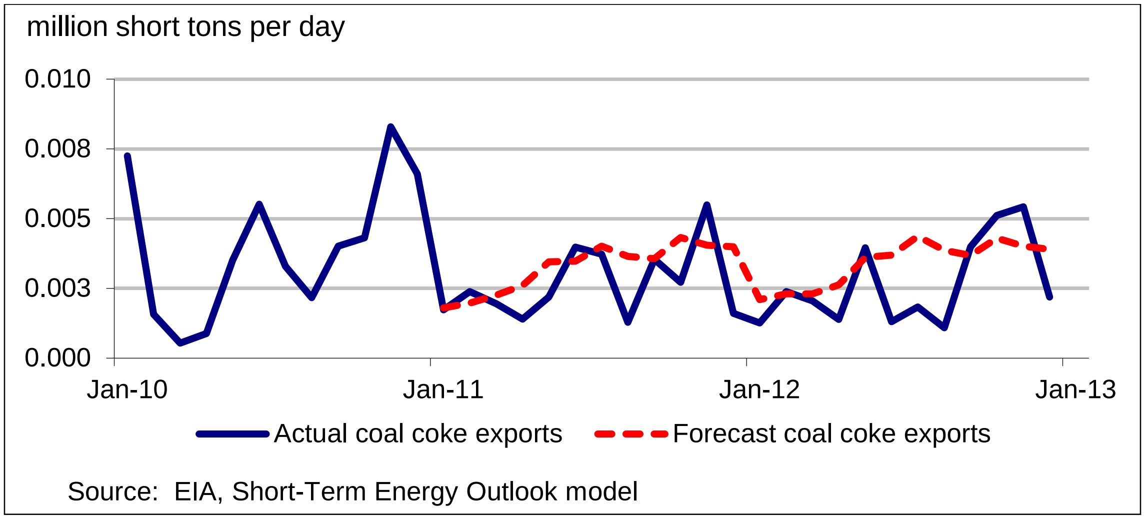
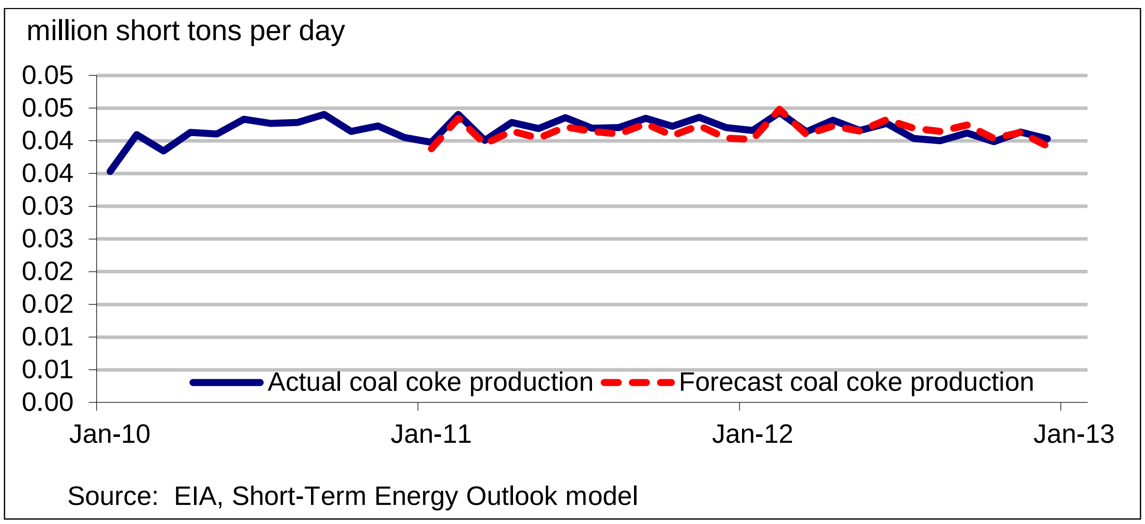


Figure 45. CCPRPUS, coal coke production out-of-sample forecast versus actual, January 2011 – December 2012



Coal coke production was the only sector that did not have most of the forecast error occurring in the covariance proportion. Table 10 also shows that the variance proportion was insignificant for both raw steel production and coal coke consumption.

Table 10. Coal coke sector out-of-sample simulation error statistics

	Raw Steel Production	Coal Coke Consumption	Coal Coke Net Imports	Coal Coke Exports	Coal Coke Production
Root mean squared error	0.007	0.004	0.002	0.002	0.002
Mean absolute error	0.006	0.003	0.002	0.001	0.002
Means absolute percent error	2.19	8.05	304.0	76.8	3.70

Theil inequality coefficient	0.013	0.047	0.423	0.248	0.022
Bias proportion	0.003	0.204	0.078	0.055	0.498
Variance proportion	0.032	0.000	0.150	0.345	0.016
Covariance proportion	0.965	0.796	0.772	0.600	0.486

E. Coal Consumption

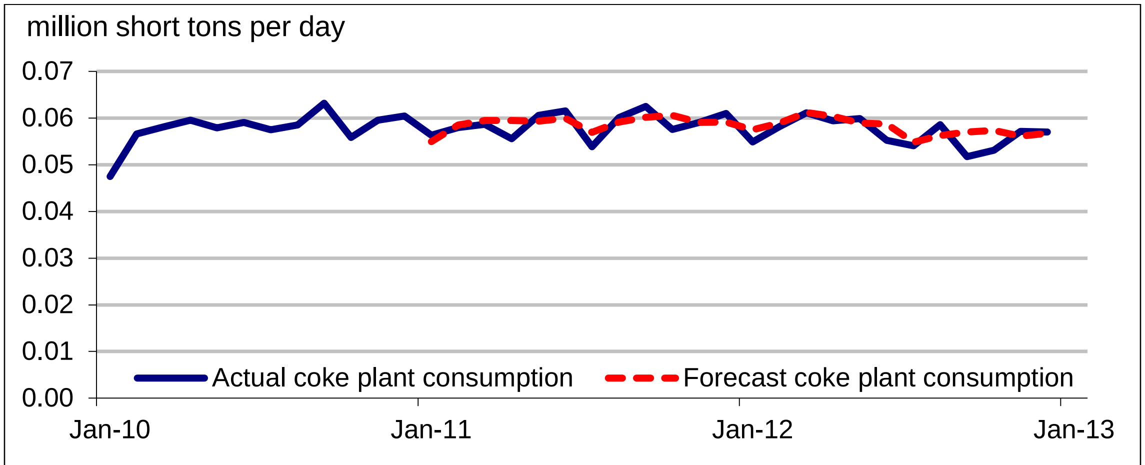
Table 11 provides a comparison of the out-of-sample dynamic forecasts and actual values for non-power-related coal consumption for the years 2011 and 2012.

Table 11. Actual and out-of-sample coal consumption forecasts, annual values (million short tons)

	2011		2012	
	Actual	Forecast	Actual	Forecast
Coke Plant Consumption (CLKCPUS)	21.434	21.494	20.751	21.163
Industrial Sector Consumption (CLXCPUS)	23.919	24.207	22.773	23.787
Commercial / Institutional Consumption (CLHCNONCHP)	1.125	1.203	0.595	0.725

Figure 46 through Figure 48 show the monthly actual and forecasted values for the estimated coal consumption series.

Figure 46. CLKCPUS, coke plant consumption out-of-sample forecast versus actual, January 2011 – December 2012



Source: EIA, Short-Term Energy Outlook model

Figure 47. CLXCPUS, industrial coal consumption out-of-sample forecast versus actual, January 2011 – December 2012

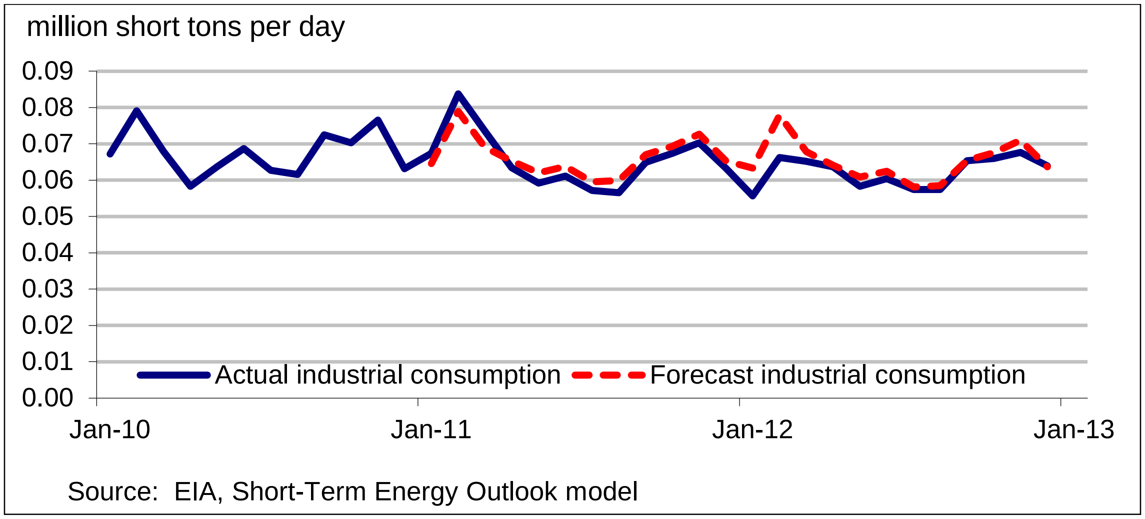
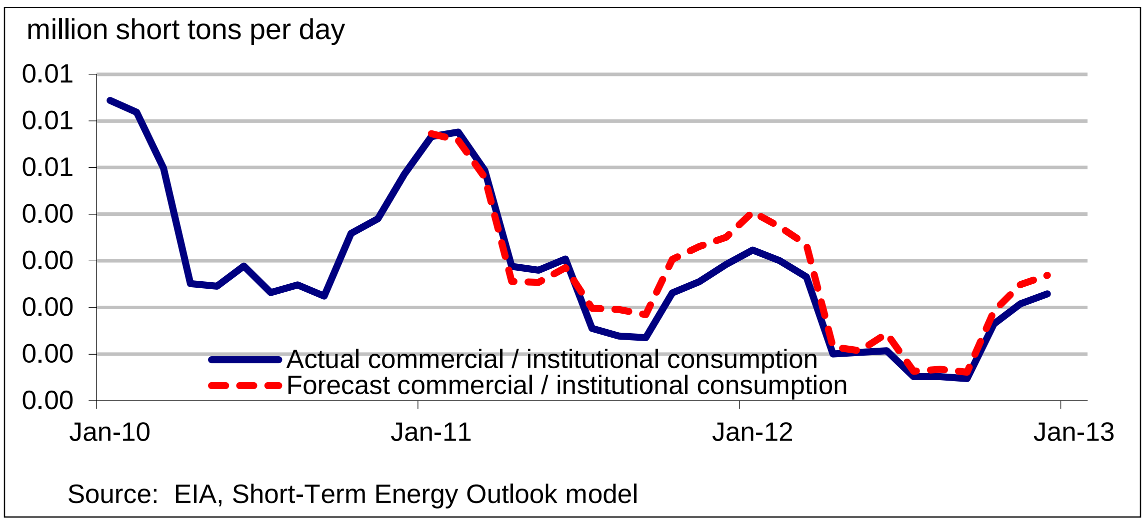


Figure 48. CLHCNONCHP, commercial / institutional consumption out-of-sample forecast versus actual, January 2011 – December 2012



The majority of the forecast error occurred in the covariance proportion for all three sectors. Table 12 also shows that the bias proportion was insignificant for coke plant consumption. The largest errors were found in the commercial/institutional sector. As shown in Figure 48, the trend in consumption of coal in this sector is downward, but it seemed to accelerate downward in 2012 faster than forecasted. This movement was a result of lower natural gas prices and the decision of several institutions, particularly colleges and university campuses to cease or significantly curtail their usage of coal at heating plants in 2011 and 2012.

Table 12. Non-power sector coal consumption out-of-sample simulation error statistics

	Coke Plants	Industrial	Commercial Institutional
Root mean squared error	0.003	0.003	0.0004
Mean absolute error	0.002	0.003	0.0003
Means absolute percent error	3.72	3.90	15.7
Theil inequality coefficient	0.022	0.025	0.063
Bias proportion	0.111	0.024	0.286
Variance proportion	0.119	0.020	0.025
Covariance proportion	0.769	0.956	0.688

F. Coal Prices

Table 13 provides a comparison of the out-of-sample dynamic forecasts and actual values for coal prices for the years 2011 and 2012.

Table 13. Actual and out-of-sample coal price forecasts, annual averages (dollars per million Btu)

	2011		2012	
	Actual	Forecast	Actual	Forecast
Composite Spot Price (CLSPUUS)	1.73	1.66	1.45	1.42
Electric Power Sector Price (CLEUDUS)	2.39	2.39	2.38	2.50

Figure 49 and Figure 50 show the monthly actual and forecasted values for coal prices.

Figure 49. CLSPUUS, composite spot price out-of-sample forecast versus actual, January 2011 – December 2012

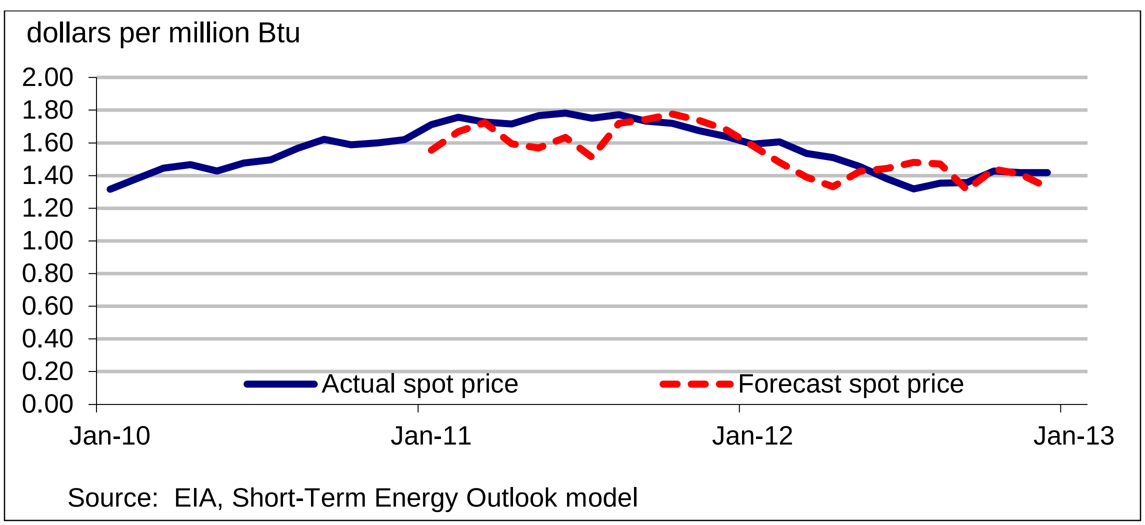
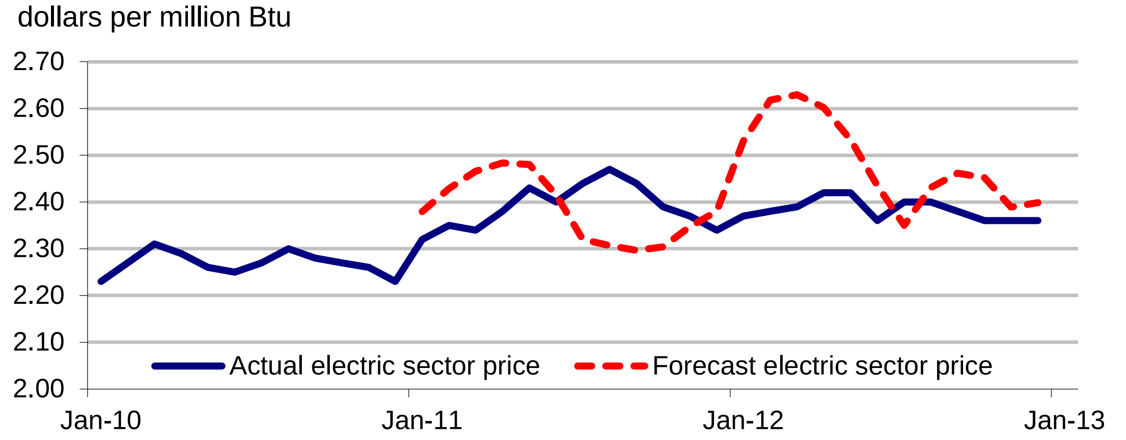


Figure 50. CLEUDUS, electric power sector coal price out-of-sample forecast versus actual, January 2011 – December 2012



Source: EIA, Short-Term Energy Outlook model

The majority of the forecast error occurred in the covariance proportion for both prices, but Table 14 also shows that the variance proportion was high for the power sector price. The high variance proportion shows that the equation for the power sector price did not accurately capture the fluctuations in the series. A higher degree of seasonality was forecast for power sector coal prices than actually occurred. This tempering of seasonal effects could possibly be attributed to lesser demands for coal-fired generation (and therefore consumption of coal) due to increased reliance on natural gas-fired generation. Reduced usage of coal also led to increases in power sector coal inventories, which in turn would also have the effect of lowering coal prices.

Table 14. Coal prices out-of-sample simulation error statistics

	Spot Price	Power Sector Price
Root mean squared error	0.093	0.106
Mean absolute error	0.075	0.087
Means absolute percent error	4.83	3.68
Theil inequality coefficient	0.030	0.023
Bias proportion	0.034	0.002
Variance proportion	0.059	0.443
Covariance proportion	0.907	0.556

Appendix A. Variable Definitions, Units, and Sources

Table A1. Variable Definitions, Units, and Sources

Variable Name	Units	ıition	History	Forecast
APR	Integer	= 1 if April, 0 otherwise	-	-
AUG	Integer	= 1 if August, 0 otherwise	-	-
CCEXPUS	MMTD	Coal coke exports	Census	Eq.28
CCIMPUS	MMTD	Coal coke imports	Census	Eq.30
CCNIPUS	MMTD	Coal coke net imports	Census	Eq.27
CCPRPUS	MMTD	Coal coke production	QCR	Eq.29
CCSDPUS	MMST	Coal coke stocks	QCR	Eq.32
CCTCPUS	MMTD	Coal coke consumption	QCR	Eq.26
CLAJPUS	MMTD	Coal supply demand imbalance	MER	Eq.50
CLAJPUS_TON	MMST	Coal supply demand imbalance	MER	Eq.73
CLCECON	MMTD	Commercial / institutional coal consumption, combined heat and power	EPM	STEO
CLCGCON	MMTD	Industrial coal consumption, combined heat and power	EPM	STEO
CLEP_CON_MW	MTD	Power sector coal consumption, Midwest	EPM	STEO
CLEP_CON_NE	MTD	Power sector coal consumption, Northeast	EPM	STEO
CLEP_CON_SO	MTD	Power sector coal consumption, South	EPM	STEO
CLEPCON	MMTD	Power sector coal consumption	EPM	STEO
CLEPCON_TON	MMST	Power sector coal consumption	EPM	STEO
CLEUDUS	DMMBTU	Power sector coal price	EPM	Eq.52
CLEXPMC	MMTD	Metallurgical coal exports	Census	Eq.7
CLEXPMC_TON	MMST	Metallurgical coal exports	Census	Eq.62
CLEXPSC	MMTD	Steam coal exports	Census	Eq.6
CLEXPSC_TON	MMST	Steam coal exports	Census	Eq.61
CLEXPUS	MMTD	Total coal exports	Census	Eq.8
CLEXPUS_TON	MMST	Total coal exports	Census	Eq.60
CLFCPUS	MMTD	Industrial coal consumption, synfuels	MER	Eq.37
CLHCNONCHP	MMTD	Commercial / institutional coal consumption, excluding combined heat and power	MER	Eq.34
CLHCPUS	MMTD	Commercial / institutional coal consumption	MER	Eq.35
CLHCPUS_TON	MMST	Commercial / institutional coal consumption	MER	Eq.69
CLIMPUS	MMTD	Total coal imports	Census	Eq.5
CLIMPUS_TON	MMST	Total coal imports	Census	Eq.59
CLKCPUS	MMTD	Coke plant coal consumption	MER	Eq.33
CLKCPUS_TON	MMST	Coke plant coal consumption	MER	Eq.66
CLNSPUS	MMTD	Net coal supply	MER	Eq.48
CLNSPUS_TON	MMST	Net coal supply	MER	Eq.64
CLOTCON	MMTD	Coal consumption excluding power sector	MER	Eq.40
CLOTCON_TON	MMST	Coal consumption excluding power sector	MER	Eq.71
CLPRPAR	MMTD	Appalachian coal production	MSHA	Eq.1
CLPRPAR_TON	MMST	Appalachian coal production	MSHA	Eq.54
CLPRPIR	MMTD	Interior coal production	MSHA	Eq.2

CLPRPIR_TON	MMST	Interior coal production	MSHA	Eq.55
CLPRPUS	MMTD	Total coal production	MSHA	Eq.47
CLPRPUS_TON	MMST	Total coal production	MSHA	Eq.53
CLPRPWR	MMTD	Western coal production	MSHA	Eq.3
CLPRPWR_TON	MMST	Western coal production	MSHA	Eq.56
CLPS_EP	MMST	Power sector coal stocks, United States	EPM	Eq.14
CLPS_EP_MW	MMST	Power sector coal stocks, Midwest	EPM	Eq.10
CLPS_EP_NE	MMST	Power sector coal stocks, Northeast	EPM	Eq.9
CLPS_EP_SO	MMST	Power sector coal stocks, South	EPM	Eq.11
CLPS_EP_US	MMST	Power sector coal stocks, United States	EPM	Eq.13
CLPS_EP_WE	MMST	Power sector coal stocks, West	EPM	Eq.12
CLPS_TOT	MMST	Total coal stocks	MER	Eq.21
CLRESID	MMTD	Coal supply demand imbalance	MER	Eq.43
CLSD_DRAW	MMTD	Stock change, Producer / distributor stocks	MER	Eq.23
CLSD_DRAW_TON	MMST	Stock change, Producer / distributor stocks	MER	Eq.58
CLSDPUS	MMST	Producer / distributor coal stocks	MER	Eq.23a
CLSHPUS	MMST	Commercial / institutional coal stocks	MER	Eq.17
CLSKPUS	MMST	Coke plant coal stocks	MER	Eq.19
CLSOPUS	MMST	Other industrial coal stocks	MER	Eq.18
CLSPUUS	DMMBTU	Coal spot price	CNM	Eq.51
CLST_DRAW	MMTD	Stock change, Total end-use sector stocks	MER	Eq.22
CLST_DRAW_TON	MMST	Stock change, Total end-use sector stocks	MER	Eq.57
CLSTPUS	MMST	Total end-use sector coal stocks	MER	Eq.20
CLTCPUS	MMTD	Total coal consumption	MER	Eq.39
CLTCPUS_TON	MMST	Total coal consumption	MER	Eq.72
CLTSPUS	MMTD	Total coal supply	MER	Eq.49
CLTSPUS_TON	MMST	Total coal supply	MER	Eq.65
CLWCPUS	MMTD	Waste coal supplied	MER	Eq.42
CLWCPUS_TON	MMST	Waste coal supplied	MER	Eq.63
CLXCPUS	MMTD	Industrial coal consumption, excluding combined heat and power & synfuels	MER	Eq.36
CLYCPUS	MMTD	Industrial coal consumption	MER	Eq.37
CLYCPUS_TON	MMST	Industrial coal consumption	MER	Eq.68
CLZCPUS	MMTD	Retail & general industry consumption	MER	Eq.38
CLZCPUS_TON	MMST	Retail & general industry consumption	MER	Eq.70
COKEBAL	MMTD	Stock change, Coal coke stocks	QCR	Eq.30
DEC	Integer	= 1 if December, 0 otherwise	-	-
DSRTUUS	CPG	Diesel fuel retail price	PMM	STEO
FEB	Integer	= 1 if February, 0 otherwise	-	-
FOREX_WORLD	Index	Real U.S. Dollar Exchange Rate	GI	GI
I87RXUS	$BIL	Real Fixed Investment	GI	GI
JAN	Integer	= 1 if January, 0 otherwise	-	-
JUL	Integer	= 1 if July, 0 otherwise	-	-
JUN	Integer	= 1 if June, 0 otherwise	-	-
KRDRXUS	$BIL	Business Inventory Change	GI	GI
MAR	Integer	= 1 if March, 0 otherwise	-	-
MAY	Integer	= 1 if May, 0 otherwise	-	-
NOV	Integer	= 1 if November, 0 otherwise	-	-
OCT	Integer	= 1 if October, 0 otherwise	-	-
QSIC_CL	Index	Coal-weighted industrial production index	GI	GI

RGDPQ_WORLD	Index	World Oil-Consumption Weighted GDP	GI	GI
RSPRPUS	MMTD	Raw steel production	AISI	Eq.25
RSPRPUS_SA	MMTD	Raw steel production seasonally adjusted	AISI	Eq.24
SEP	Integer	= 1 if September, 0 otherwise	-	-
TIME	Integer	Counts the number of months from January 1975 – Present	-	-
ZO331IUS	Index	Indus. Production Index: Primary Metals (NAICS 331)	GI	GI
ZSAJQUS	Integer	Number of days in a month	-	-
ZWCD_MW	CDD	Cooling degree days, Midwest	NOAA	NOAA
ZWCD_NE	CDD	Cooling degree days, Northeast	NOAA	NOAA
ZWCD_SO	CDD	Cooling degree days, South	NOAA	NOAA
ZWCD_WE	CDD	Cooling degree days, West	NOAA	NOAA
ZWCN_MW	CDD	Cooling degree days normal, Midwest	NOAA	NOAA
ZWCN_NE	CDD	Cooling degree days normal, Northeast	NOAA	NOAA
ZWCN_SO	CDD	Cooling degree days normal, South	NOAA	NOAA
ZWCN_WE	CDD	Cooling degree days normal, West	NOAA	NOAA
ZWHD_ENC	HDD	Heating degree days, East North Central	NOAA	NOAA
ZWHD_MAC	HDD	Heating degree days, Middle Atlantic	NOAA	NOAA
ZWHD_NE	HDD	Heating degree days, Northeast	NOAA	NOAA
ZWHD_SO	HDD	Heating degree days, South	NOAA	NOAA
ZWHD_WE	HDD	Heating degree days, West	NOAA	NOAA
ZWHDPUS	HDD	Heating degree days, U.S.	NOAA	NOAA
ZWHN_NE	HDD	Heating degree days normal, Northeast	NOAA	NOAA
ZWHN_SO	HDD	Heating degree days normal, South	NOAA	NOAA
ZWHN_WE	HDD	Heating degree days normal, West	NOAA	NOAA
ZWHNPUS	HDD	Heating degree days normal, U.S.	NOAA	NOAA

Table A2. Units key

$BIL	Billion chained 2009 dollars
CDD	Cooling degree days
CPG	Cents per gallon
DMMBTU	Dollars per million BTU
HDD	Heating degree days
Index	Index value
Integer	Number = 0 or 1
MMST	Million short tons
MMTD	Million short tons per day
MTD	Thousand short tons per day

Table A3. Sources key

AISI	American Iron and Steel Institute
Census	Bureau of the Census
CNM	Coal News and Markets
EPM	Electric Power Monthly
GI	IHS-Global Insight
MER	Monthly Energy Review
MSHA	Mine Safety and Health Administration
NOAA	National Oceanic and Atmospheric Organization
PMM	EIA Petroleum Marketing Monthly
QCR	Quarterly Coal Report
STEO	Short-Term Energy Outlook Model

Appendix B. Eviews Model Program File

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********************* Coal Production Equations ******************************
:EQ_CLPRPAR
:EQ_CLPRPIR
:EQ_CLPRPWR

@IDENTITY CLPRPUSX = CLPRPARX + CLPRPIRX + CLPRPWRX

********************* Coal Trade Equations ******************************
:EQ_CLIMPUS
:EQ_CLEXPSC
:EQ_CLEXPMC

@IDENTITY CLEXPUS = CLEXPMC + CLEXPSC

********************* Coal Stock Equations ******************************
:EQ_CLPS_EP_NE
:EQ_CLPS_EP_MW
:EQ_CLPS_EP_SO
:EQ_CLPS_EP_WE

@IDENTITY CLPS_EP_US = CLPS_EP_NE + CLPS_EP_MW + CLPS_EP_SO + CLPS_EP_WE

@IDENTITY CLPS_EP_NEW = CLPS_EP_US

@IDENTITY CLPS_EP = CLPS_EP_US

:EQ_CLSKPUSX
:EQ_CLSOPUSX
:EQ_CLSHPUS

@IDENTITY CLSOPUS = CLSOPUSX

@IDENTITY CLSKPUS = CLSKPUSX

@IDENTITY CLSTPUS = CLPS_EP + CLSOPUS + CLSKPUS + CLSHPUS

@IDENTITY CLPS_TOT = CLSTPUS + CLSDPUS

@IDENTITY CLST_DRAW = (CLSTPUS(-1) - CLSTPUS) / ZSAJQUS

@IDENTITY CLSD_DRAW = (CLSDPUS (-1) - CLSDPUS) / ZSAJQUS

********************* Coal Coke & Raw Steel Equations ******************************
:EQ_RSPRPUS_SA
```

```
@IDENTITY RSPRPUS = RSPRPUS_SA * RSPRPUS_SF

:EQ_CCTCPUS
:EQ_CCNIPUS
:EQ_CCPRPUS
:EQ_CCEXPUS

@IDENTITY CCIMPUS = CCNIPUS + CCEXPUS

@IDENTITY COKEBAL = CCTCPUS - CCPRPUS - CCNIPUS

@IDENTITY CCSDPUS = CCSDPUS(-1) - (COKEBAL * ZSAJQUS)

********************** Coal Consumption Equations *******************************
:EQ_CLKCPUS
:EQ_CLHCNONCHP

@IDENTITY CLHCPUS = CLCECON + CLHCNONCHP

:EQ_CLXCPUS

@IDENTITY CLYCPUS = CLFCPUS + CLXCPUS + CLCGCON

@IDENTITY CLZCPUS = CLYCPUS + CLHCPUS

@IDENTITY CLTCPUS = CLEPCON + CLKCPUS + CLZCPUS

@IDENTITY CLOTCON = CLTCPUS - CLEPCON

*************** Coal Supply and Balance *******************************************

@IDENTITY CLNSPUSX = CLPRPUSX + CLIMPUS - CLEXPUS + CLSD_DRAW

@IDENTITY CLTSPUSX = CLNSPUSX + CLWCPUS + CLST_DRAW

@IDENTITY CLRESID = CLTSPUSX - CLTCPUS

@IDENTITY CLPRPAR = CLPRPARX - (CLPRPARX / CLPRPUSX) * CLRESID

@IDENTITY CLPRPIR = CLPRPIRX - (CLPRPIRX / CLPRPUSX) * CLRESID

@IDENTITY CLPRPWR = CLPRPWRX - (CLPRPWRX / CLPRPUSX) * CLRESID

@IDENTITY CLPRPUS = CLPRPAR + CLPRPIR + CLPRPWR

@IDENTITY CLNSPUS = CLPRPUS + CLIMPUS - CLEXPUS + CLSD_DRAW

@IDENTITY CLTSPUS = CLNSPUS + CLWCPUS + CLST_DRAW
```

```
@IDENTITY CLAJPUS = CLTSPUS - CLTCPUS

********************** Coal Price Equations *******************************
:EQ_CLSPUUS
:EQ_CLEUDUS

 ----    Million Short Ton Variables for Dynamic Tables --------------------------------------------

@IDENTITY CLPRPUS_TON = CLPRPUS * ZSAJQUS
@IDENTITY CLPRPAR_TON = CLPRPAR * ZSAJQUS
@IDENTITY CLPRPIR_TON = CLPRPIR * ZSAJQUS
@IDENTITY CLPRPWR_TON = CLPRPWR * ZSAJQUS
@IDENTITY CLST_DRAW_TON = CLST_DRAW * ZSAJQUS
@IDENTITY CLSD_DRAW_TON = CLSD_DRAW * ZSAJQUS
@IDENTITY CLIMPUS_TON = CLIMPUS * ZSAJQUS
@IDENTITY CLEXPUS_TON = CLEXPUS * ZSAJQUS
@IDENTITY CLEXPSC_TON = CLEXPSC * ZSAJQUS
@IDENTITY CLEXPMC_TON = CLEXPMC * ZSAJQUS
@IDENTITY CLWCPUS_TON = CLWCPUS * ZSAJQUS
@IDENTITY CLNSPUS_TON = CLNSPUS * ZSAJQUS
@IDENTITY CLTSPUS_TON = CLTSPUS * ZSAJQUS
@IDENTITY CLKCPUS_TON = CLKCPUS * ZSAJQUS
@IDENTITY CLEPCON_TON = CLEPCON * ZSAJQUS
@IDENTITY CLZCPUS_TON = CLZCPUS * ZSAJQUS
@IDENTITY CLYCPUS_TON = CLYCPUS * ZSAJQUS
@IDENTITY CLHCPUS_TON = CLHCPUS * ZSAJQUS
@IDENTITY CLTCPUS_TON = CLTCPUS * ZSAJQUS
@IDENTITY CLOTCON_TON = CLOTCON * ZSAJQUS
@IDENTITY CLAJPUS_TON = CLAJPUS * ZSAJQUS
```

Appendix C. Regression Results

Table 15. CLPRPARX, Appalachian region coal production, regression results

Dependent Variable: CLPRPARX
Method: Least Squares
Date: 11/17/14 Time: 11:23
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.250244	0.113466	2.205444	0.0290
CLEXPUS	0.017311	0.112255	0.154210	0.8777
CLPS_EP_NE+CLPS_EP_SO	-0.000699	0.000406	-1.722304	0.0871
(CLEPCON_NE+CLEPCON_SO)/1000	0.090961	0.055357	1.643182	0.1025
D10ON	-0.053494	0.021014	-2.545626	0.0120
JAN	0.100007	0.023063	4.336354	0.0000
FEB	0.056827	0.023269	2.442155	0.0158
MAR	0.077553	0.024901	3.114459	0.0022
APR	0.053634	0.026407	2.031056	0.0441
MAY	0.027829	0.023753	1.171624	0.2433
JUN	0.070373	0.023510	2.993290	0.0032
JUL	-0.076532	0.024849	-3.079926	0.0025
AUG	0.066814	0.024979	2.674804	0.0083
SEP	0.023387	0.023376	1.000491	0.3187
OCT	0.055211	0.024808	2.225518	0.0276
NOV	0.035564	0.024210	1.468970	0.1440
CLPRPARX(-1)	0.647633	0.063346	10.22368	0.0000

R-squared	0.839016	Mean dependent var	0.989428
Adjusted R-squared	0.821252	S.D. dependent var	0.139913
S.E. of regression	0.059153	Akaike info criterion	-2.718362
Sum squared resid	0.507368	Schwarz criterion	-2.394355
Log likelihood	237.1873	Hannan-Quinn criter.	-2.586810
F-statistic	47.23183	Durbin-Watson stat	2.518292
Prob(F-statistic)	0.000000		

Table 16. CLPRPIRX, Interior region coal production, regression results

Dependent Variable: CLPRPIRX
Method: Least Squares
Date: 11/17/14 Time: 11:11
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.393733	0.056839	6.927198	0.0000
CLEXPSC	0.288550	0.058733	4.912942	0.0000
CLPS_EP_MW+CLPS_EP_SO	-0.000301	8.26E-05	-3.640116	0.0004
(CLEPCON_MW+CLEPCON_SO)/1000	-0.039371	0.013773	-2.858563	0.0049
JAN	0.024536	0.007122	3.445059	0.0007
FEB	0.018942	0.007305	2.592875	0.0105
MAR	0.008806	0.007811	1.127461	0.2614
APR	-0.000657	0.008399	-0.078275	0.9377
MAY	-0.003987	0.007574	-0.526387	0.5994
JUN	0.013110	0.007085	1.850452	0.0663
JUL	0.012326	0.007701	1.600647	0.1116
AUG	0.038273	0.007579	5.049979	0.0000
SEP	0.012939	0.007293	1.774045	0.0782
OCT	-0.000169	0.007717	-0.021862	0.9826
NOV	0.000754	0.007511	0.100449	0.9201
D10ON	0.037850	0.005784	6.544178	0.0000
CLPRPIRX(-1)	0.252521	0.076812	3.287499	0.0013

R-squared	0.827149	Mean dependent var	0.427762
Adjusted R-squared	0.808076	S.D. dependent var	0.041548
S.E. of regression	0.018202	Akaike info criterion	-5.075600
Sum squared resid	0.048038	Schwarz criterion	-4.751593
Log likelihood	428.1236	Hannan-Quinn criter.	-4.944048
F-statistic	43.36718	Durbin-Watson stat	2.229390
Prob(F-statistic)	0.000000		

Table 17. CLPRPWRX, Western region coal production, regression results

Dependent Variable: CLPRPWRX
Method: Least Squares
Date: 11/17/14 Time: 11:18
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.085373	0.112476	0.759033	0.4491
CLEPCON_US/1000	0.154045	0.037446	4.113808	0.0001
CLPS_EP_US	9.67E-06	0.000303	0.031901	0.9746
D08ON	0.028139	0.016297	1.726608	0.0864
JAN	0.045018	0.025430	1.770245	0.0788
FEB	0.025969	0.025168	1.031837	0.3039
MAR	0.042450	0.027085	1.567307	0.1192
APR	0.082135	0.029198	2.813066	0.0056
MAY	0.031169	0.027009	1.154032	0.2504
JUN	0.037542	0.026199	1.432981	0.1540
JUL	0.025072	0.027791	0.902179	0.3684
AUG	0.047511	0.026976	1.761219	0.0803
SEP	0.057211	0.025590	2.235686	0.0269
OCT	0.077169	0.027431	2.813229	0.0056
NOV	0.094340	0.026329	3.583112	0.0005
CLPRPWRX(-1)	0.648141	0.056912	11.38851	0.0000

R-squared	0.703790	Mean dependent var	1.578121
Adjusted R-squared	0.673358	S.D. dependent var	0.112845
S.E. of regression	0.064494	Akaike info criterion	-2.550943
Sum squared resid	0.607286	Schwarz criterion	-2.245996
Log likelihood	222.6264	Hannan-Quinn criter.	-2.427130
F-statistic	23.12626	Durbin-Watson stat	2.064261
Prob(F-statistic)	0.000000		

Table 18. CLIMPUS, coal imports, regression results

Dependent Variable: CLIMPUS
Method: Least Squares
Date: 11/17/14 Time: 11:27
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.007836	0.016079	-0.487366	0.6267
(CLEPCON_SO)/1000	0.024036	0.014430	1.665748	0.0979
D09ON	-0.006587	0.002600	-2.532960	0.0124
JAN	-0.011805	0.004199	-2.811236	0.0056
FEB	-0.002772	0.004171	-0.664520	0.5074
MAR	0.004963	0.004536	1.094237	0.2756
APR	-0.000366	0.004933	-0.074186	0.9410
MAY	-0.000695	0.004246	-0.163631	0.8702
JUN	-0.002466	0.004379	-0.563030	0.5743
JUL	-0.001740	0.004736	-0.367401	0.7138
AUG	-0.004727	0.004665	-1.013102	0.3127
SEP	-0.000436	0.004245	-0.102707	0.9183
OCT	-0.003069	0.004672	-0.656904	0.5123
NOV	-0.001548	0.004510	-0.343230	0.7319
CLIMPUS(-1)	0.762761	0.050163	15.20568	0.0000

R-squared	0.855569	Mean dependent var	0.061909
Adjusted R-squared	0.841813	S.D. dependent var	0.027147
S.E. of regression	0.010797	Akaike info criterion	-6.131075
Sum squared resid	0.017137	Schwarz criterion	-5.845186
Log likelihood	511.6171	Hannan-Quinn criter.	-6.015000
F-statistic	62.19883	Durbin-Watson stat	2.521724
Prob(F-statistic)	0.000000		

Table 19. CLEXPSC, steam coal exports, regression results

Dependent Variable: CLEXPSC
Method: Least Squares
Date: 11/17/14 Time: 11:35
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.063044	0.106239	0.593419	0.5539
CLPRPUS	0.007792	0.012257	0.635750	0.5260
CLTCPUS-CLKCPUS	-0.025245	0.010908	-2.314282	0.0221
FOREX_WORLD	-0.000182	0.000520	-0.349645	0.7271
RGDPQ_WORLD	0.000400	0.000269	1.485331	0.1397
D0809	0.047932	0.019506	2.457327	0.0152
D1101	0.030113	0.019457	1.547628	0.1240
D1303	0.088477	0.019606	4.512829	0.0000
D1304	-0.038413	0.020432	-1.880030	0.0622
JAN	-0.010122	0.007395	-1.368722	0.1733
FEB	-0.023223	0.007281	-3.189544	0.0018
MAR	-0.011036	0.008642	-1.276995	0.2037
APR	0.000782	0.009417	0.083031	0.9339
MAY	-0.007490	0.008097	-0.925015	0.3565
JUN	0.003829	0.007161	0.534724	0.5937
JUL	-0.003060	0.007672	-0.398840	0.6906
AUG	0.003998	0.007572	0.528065	0.5983
SEP	-0.001470	0.007593	-0.193598	0.8468
OCT	-0.010523	0.008102	-1.298794	0.1961
NOV	-0.008496	0.007795	-1.089992	0.2776
CLEXPSC(-1)	0.649974	0.063733	10.19833	0.0000

R-squared	0.793020	Mean dependent var	0.082170
Adjusted R-squared	0.763661	S.D. dependent var	0.038053
S.E. of regression	0.018499	Akaike info criterion	-5.021765
Sum squared resid	0.048253	Schwarz criterion	-4.621521
Log likelihood	427.7629	Hannan-Quinn criter.	-4.859259
F-statistic	27.01129	Durbin-Watson stat	2.376053
Prob(F-statistic)	0.000000		

Table 20. CLEXPMC, metallurgical coal exports, regression results

Dependent Variable: CLEXPMC
Method: Least Squares
Date: 11/17/14 Time: 11:47
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.052638	0.057570	-0.914326	0.3621
RGDPQ_WORLD	0.000819	0.000295	2.776755	0.0062
FOREX_WORLD	5.21E-05	0.000405	0.128597	0.8979
D08ON	0.011062	0.005928	1.866189	0.0640
JAN	0.005588	0.007367	0.758418	0.4494
FEB	0.002876	0.007367	0.390422	0.6968
MAR	0.017898	0.007365	2.430079	0.0163
APR	0.002031	0.007451	0.272557	0.7856
MAY	0.002435	0.007403	0.328913	0.7427
JUN	0.010807	0.007380	1.464272	0.1453
JUL	-0.012891	0.007562	-1.704809	0.0904
AUG	0.008923	0.007491	1.191130	0.2355
SEP	0.002168	0.007495	0.289247	0.7728
OCT	0.000424	0.007492	0.056565	0.9550
NOV	-0.000553	0.007487	-0.073854	0.9412
CLEXPMC(-1)	0.670616	0.061528	10.89932	0.0000

R-squared	0.881058	Mean dependent var	0.113194
Adjusted R-squared	0.868838	S.D. dependent var	0.052697
S.E. of regression	0.019085	Akaike info criterion	-4.986299
Sum squared resid	0.053178	Schwarz criterion	-4.681352
Log likelihood	419.8903	Hannan-Quinn criter.	-4.862486
F-statistic	72.09936	Durbin-Watson stat	2.320169
Prob(F-statistic)	0.000000		

Table 21. CLPS_EP_NE, electric power sector stocks - Northeast, regression results

Dependent Variable: CLPS_EP_NE
Method: Least Squares
Date: 11/17/14 Time: 19:32
Sample: 2010M01 2014M06
Included observations: 54

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.026803	0.581964	-0.046055	0.9635
(ZWCD_NE-ZWCN_NE)/ZSAJQUS*(APR+MAY+JUN+JUL+AUG+SEP)	-0.262727	0.169527	-1.549761	0.1293
D1001	2.021296	0.572932	3.527984	0.0011
JAN	-0.174014	0.363623	-0.478556	0.6349
FEB	0.108607	0.346795	0.313173	0.7558
MAR	0.805742	0.350256	2.300439	0.0269
APR	1.043359	0.346706	3.009352	0.0046
MAY	1.055146	0.346982	3.040922	0.0042
JUN	0.308669	0.344247	0.896649	0.3754
JUL	-0.512127	0.549155	-0.932573	0.3568
AUG	0.010479	0.371804	0.028185	0.9777
SEP	0.700533	0.375405	1.866070	0.0696
OCT	1.201052	0.371416	3.233710	0.0025
NOV	1.059372	0.364060	2.909884	0.0059
CLPS_EP_NE(-1)	0.944897	0.060137	15.71231	0.0000

R-squared	0.897686	Mean dependent var	8.066685
Adjusted R-squared	0.860957	S.D. dependent var	1.374260
S.E. of regression	0.512440	Akaike info criterion	1.730867
Sum squared resid	10.24120	Schwarz criterion	2.283362
Log likelihood	-31.73341	Hannan-Quinn criter.	1.943943
F-statistic	24.44126	Durbin-Watson stat	1.128789
Prob(F-statistic)	0.000000		

Table 22. CLPS_EP_MW, electric power sector stocks - Midwest, regression results

Dependent Variable: CLPS_EP_MW
Method: Least Squares
Date: 11/17/14 Time: 19:47
Sample (adjusted): 2001M02 2014M06
Included observations: 161 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.480759	0.926830	-0.518713	0.6048
(ZWCD_MW-ZWCN_MW)/ZSAJQUS*(APR+MAY+JUN+JUL+AUG+SEP)	-0.424742	0.112582	-3.772744	0.0002
D0201	5.331683	1.480285	3.601796	0.0004
D0601	5.139550	1.499107	3.428409	0.0008
D0912	-4.071399	1.487086	-2.737837	0.0070
D1112	4.851976	1.473042	3.293848	0.0012
D1201	7.130965	1.480060	4.818025	0.0000
JAN	-2.757520	0.616316	-4.474201	0.0000
FEB	0.026279	0.571124	0.046013	0.9634
MAR	2.935324	0.573394	5.119205	0.0000
APR	4.014719	0.570901	7.032251	0.0000
MAY	3.697159	0.568477	6.503624	0.0000
JUN	0.685105	0.568280	1.205577	0.2300
JUL	-0.982604	0.583172	-1.684931	0.0942
AUG	-0.354032	0.578324	-0.612170	0.5414
SEP	2.810527	0.580043	4.845381	0.0000
OCT	3.627845	0.578613	6.269904	0.0000
NOV	3.109400	0.577633	5.383006	0.0000
CLPS_EP_MW(-1)	0.983299	0.013728	71.62884	0.0000

R-squared	0.975711	Mean dependent var	58.22623
Adjusted R-squared	0.972632	S.D. dependent var	8.522868
S.E. of regression	1.409952	Akaike info criterion	3.635436
Sum squared resid	282.2910	Schwarz criterion	3.999080
Log likelihood	-273.6526	Hannan-Quinn criter.	3.783090
F-statistic	316.9068	Durbin-Watson stat	1.067814
Prob(F-statistic)	0.000000		

Table 23. CLPS_EP_SO, electric power sector stocks - South, regression results

Dependent Variable: CLPS_EP_SO
Method: Least Squares
Date: 11/17/14 Time: 20:14
Sample (adjusted): 2001M02 2014M06
Included observations: 161 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.321253	0.826771	-1.598088	0.1122
(ZWCD_SO-ZWCN_SO)/ZSAJQUS*(APR+MAY+JUN+JUL+AUG+SEP)	-0.600548	0.173076	-3.469853	0.0007
(ZWHD_SO-ZWHN_SO)/ZSAJQUS*(JAN+FEB+MAR+OCT+NOV+DEC)	-0.639386	0.090546	-7.061443	0.0000
D0903	6.687702	1.938642	3.449684	0.0007
JAN	-0.257604	0.733330	-0.351280	0.7259
FEB	1.625003	0.724466	2.243037	0.0264
MAR	4.042724	0.733984	5.507918	0.0000
APR	6.230789	0.720812	8.644123	0.0000
MAY	2.867657	0.719714	3.984440	0.0001
JUN	-1.285863	0.723756	-1.776652	0.0777
JUL	-4.016895	0.732769	-5.481800	0.0000
AUG	-1.377194	0.738266	-1.865442	0.0641
SEP	1.764121	0.736318	2.395868	0.0179
OCT	5.117426	0.735142	6.961142	0.0000
NOV	4.237482	0.732200	5.787330	0.0000
CLPS_EP_SO(-1)	0.996936	0.009705	102.7244	0.0000

R-squared	0.987426	Mean dependent var	64.03786
Adjusted R-squared	0.986126	S.D. dependent var	15.83574
S.E. of regression	1.865290	Akaike info criterion	4.178798
Sum squared resid	504.4996	Schwarz criterion	4.485024
Log likelihood	-320.3932	Hannan-Quinn criter.	4.303138
F-statistic	759.1321	Durbin-Watson stat	1.039688
Prob(F-statistic)	0.000000		

Table 24. CLPS_EP_WE, electric power sector stocks - West, regression results

Dependent Variable: CLPS_EP_WE
Method: Least Squares
Date: 11/17/14 Time: 20:32
Sample (adjusted): 2001M02 2014M06
Included observations: 161 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.445024	0.216530	-2.055251	0.0416
(ZWCD_WE-ZWCN_WE)/ZSAJQUS*(APR+MAY+JUN+JUL+AUG+SEP)	0.078152	0.064757	1.206846	0.2294
(ZWHD_WE-ZWHN_WE)/ZSAJQUS*(JAN+FEB+MAR+OCT+NOV+DEC)	-0.014415	0.029388	-0.490483	0.6245
JAN	0.331681	0.185771	1.785430	0.0763
FEB	0.677165	0.182252	3.715537	0.0003
MAR	1.092191	0.181293	6.024449	0.0000
APR	1.389879	0.186632	7.447148	0.0000
MAY	1.086481	0.187379	5.798318	0.0000
JUN	0.897798	0.186446	4.815323	0.0000
JUL	0.207785	0.191238	1.086527	0.2790
AUG	0.333094	0.189934	1.753732	0.0816
SEP	0.573257	0.189748	3.021145	0.0030
OCT	0.740625	0.185568	3.991138	0.0001
NOV	0.598100	0.186134	3.213283	0.0016
CLPS_EP_WE(-1)	0.989362	0.009969	99.24635	0.0000

R-squared	0.985764	Mean dependent var	16.83726
Adjusted R-squared	0.984399	S.D. dependent var	3.757763
S.E. of regression	0.469363	Akaike info criterion	1.413658
Sum squared resid	32.16405	Schwarz criterion	1.700745
Log likelihood	-98.79944	Hannan-Quinn criter.	1.530227
F-statistic	722.1139	Durbin-Watson stat	1.513406
Prob(F-statistic)	0.000000		

Table 25. CLSKPUSX, Coke plant coal stocks, regression results

Dependent Variable: CLSKPUSX
Method: Least Squares
Date: 11/17/14 Time: 21:08
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.031486	0.071266	-0.441808	0.6593
CLKCPUS	1.442195	0.941354	1.532043	0.1276
JAN	-0.059939	0.033731	-1.776956	0.0776
FEB	-0.062876	0.033878	-1.855965	0.0654
MAR	-0.058602	0.033936	-1.726872	0.0863
APR	0.001142	0.033890	0.033700	0.9732
MAY	0.003052	0.033807	0.090291	0.9282
JUN	0.011735	0.033845	0.346740	0.7293
JUL	-0.041572	0.034375	-1.209373	0.2284
AUG	-0.040034	0.034439	-1.162463	0.2469
SEP	-0.038088	0.034514	-1.103570	0.2716
OCT	-0.017960	0.034542	-0.519952	0.6039
NOV	-0.008187	0.034367	-0.238227	0.8120
CLSKPUSX(-1)	0.986017	0.014519	67.91083	0.0000

R-squared	0.970110	Mean dependent var	1.950985
Adjusted R-squared	0.967485	S.D. dependent var	0.485633
S.E. of regression	0.087569	Akaike info criterion	-1.950313
Sum squared resid	1.134925	Schwarz criterion	-1.683484
Log likelihood	171.9754	Hannan-Quinn criter.	-1.841976
F-statistic	369.5001	Durbin-Watson stat	0.661516
Prob(F-statistic)	0.000000		

Table 26. CLSOPUSX, Other industrial coal stocks, regression results

Dependent Variable: CLSOPUSX
Method: Least Squares
Date: 11/17/14 Time: 21:29
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.122690	0.160572	0.764078	0.4460
CLYCPUS	1.409474	0.829619	1.698943	0.0914
JAN	-0.229482	0.082375	-2.785830	0.0060
FEB	-0.260915	0.083833	-3.112336	0.0022
MAR	-0.249934	0.082977	-3.012079	0.0031
APR	-0.009959	0.083511	-0.119255	0.9052
MAY	0.000562	0.083361	0.006737	0.9946
JUN	-0.002412	0.083080	-0.029032	0.9769
JUL	-0.094957	0.084228	-1.127385	0.2614
AUG	0.068000	0.084314	0.806510	0.4212
SEP	0.068308	0.084047	0.812733	0.4177
OCT	-0.004729	0.083915	-0.056353	0.9551
NOV	-0.009278	0.084008	-0.110438	0.9122
CLSOPUSX(-1)	0.944166	0.026462	35.68000	0.0000

R-squared	0.916715	Mean dependent var	4.908198
Adjusted R-squared	0.909399	S.D. dependent var	0.710500
S.E. of regression	0.213860	Akaike info criterion	-0.164533
Sum squared resid	6.768953	Schwarz criterion	0.102296
Log likelihood	27.32720	Hannan-Quinn criter.	-0.056197
F-statistic	125.3099	Durbin-Watson stat	1.446514
Prob(F-statistic)	0.000000		

Table 27. CLSHPUS, Commercial / institutional sector coal stocks, regression results

Dependent Variable: CLSHPUS
Method: Least Squares
Date: 11/17/14 Time: 22:28
Sample: 2008M01 2014M06
Included observations: 78

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.363751	0.052766	6.893664	0.0000
CLHCPUS	-1.250584	3.748475	-0.333625	0.7398
D11ON	0.013139	0.012975	1.012634	0.3151
JAN	0.000481	0.019421	0.024745	0.9803
FEB	-0.034456	0.018973	-1.816097	0.0741
MAR	-0.046292	0.017885	-2.588255	0.0120
APR	-0.038612	0.020867	-1.850415	0.0689
MAY	-0.034762	0.021153	-1.643352	0.1053
JUN	-0.029699	0.019680	-1.509055	0.1363
JUL	-0.017240	0.021267	-0.810663	0.4206
AUG	-0.013151	0.021186	-0.620770	0.5370
SEP	-0.009546	0.021864	-0.436600	0.6639
OCT	-0.007144	0.020129	-0.354899	0.7239
NOV	-0.003552	0.018776	-0.189199	0.8505
CLSHPUS(-1)	0.340685	0.056889	5.988646	0.0000

R-squared	0.590266	Mean dependent var	0.514575
Adjusted R-squared	0.499214	S.D. dependent var	0.044840
S.E. of regression	0.031732	Akaike info criterion	-3.891953
Sum squared resid	0.063435	Schwarz criterion	-3.438739
Log likelihood	166.7861	Hannan-Quinn criter.	-3.710523
F-statistic	6.482739	Durbin-Watson stat	0.452199
Prob(F-statistic)	0.000000		

Table 28. RSPRPUS_SA, Raw steel production, regression results

Dependent Variable: RSPRPUS_SA
Method: Least Squares
Date: 11/18/14 Time: 09:39
Sample: 2009M01 2014M06
Included observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.05572	0.033516	1.662478	0.1016
ZO331IUS	0.001376	0.000296	4.644484	0.0000
I87RXUS	-5.43E-05	1.41E-05	-3.85152	0.0003
KRDRXUS	-3.79E-05	1.42E-05	-2.66248	0.0099
@TREND(2008:12)	0.000368	1.80E-04	2.040316	0.0457
RSPRPUS_SA(-1)	0.703471	0.070387	9.994353	0.0000

R-squared	0.986169	Mean dependent var	0.243880
Adjusted R-squared	0.985016	S.D. dependent var	0.036442
S.E. of regression	0.004461	Akaike info criterion	-7.900500
Sum squared resid	0.001194	Schwarz criterion	-7.701440
Log likelihood	266.7164	Hannan-Quinn criter.	-7.821840
F-statistic	855.6137	Durbin-Watson stat	1.532678
Prob(F-statistic)	0.000000		

Table 29. CCTCPUS, Coal coke consumption, regression results

Dependent Variable: CCTCPUS
Method: Least Squares
Date: 11/18/14 Time: 09:51
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.002830	0.002114	-1.338424	0.1828
RSPRPUS	0.067745	0.024902	2.720458	0.0073
RSPRPUS(-1)	-0.036218	0.025770	-1.405439	0.1620
JAN	0.000837	0.001349	0.620555	0.5359
FEB	0.005245	0.001315	3.990348	0.0001
MAR	-0.002789	0.001261	-2.211442	0.0285
APR	0.002919	0.001274	2.291690	0.0233
MAY	-0.000479	0.001259	-0.380194	0.7044
JUN	0.002091	0.001265	1.653012	0.1005
JUL	-0.001263	0.001273	-0.992095	0.3228
AUG	-5.82E-05	0.001297	-0.044850	0.9643
SEP	0.001244	0.001296	0.959984	0.3386
OCT	-0.001982	0.001263	-1.568589	0.1189
NOV	0.002034	0.001261	1.613085	0.1089
CCTCPUS(-1)	0.864838	0.038948	22.20518	0.0000

R-squared	0.902411	Mean dependent var	0.046868
Adjusted R-squared	0.893116	S.D. dependent var	0.009776
S.E. of regression	0.003196	Akaike info criterion	-8.565849
Sum squared resid	0.001501	Schwarz criterion	-8.279960
Log likelihood	708.8337	Hannan-Quinn criter.	-8.449774
F-statistic	97.09361	Durbin-Watson stat	1.272124
Prob(F-statistic)	0.000000		

Table 30. CCNIPUS, Coal coke net imports, regression results

Dependent Variable: CCNIPUS
Method: Least Squares
Date: 11/18/14 Time: 10:00
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.013940	0.002567	-5.429684	0.0000
CCTCPUS	0.651947	0.100328	6.498138	0.0000
CCTCPUS(-1)	-0.299356	0.112977	-2.649710	0.0089
JAN	-0.000694	0.001568	-0.442645	0.6587
FEB	-0.001100	0.001691	-0.650584	0.5163
MAR	0.001359	0.001577	0.861265	0.3905
APR	-0.000644	0.001619	-0.397899	0.6913
MAY	0.001571	0.001562	1.005332	0.3164
JUN	-0.001341	0.001607	-0.834673	0.4053
JUL	-0.000516	0.001591	-0.324606	0.7459
AUG	-0.001481	0.001587	-0.933076	0.3523
SEP	-0.001393	0.001600	-0.871046	0.3851
OCT	0.000681	0.001590	0.427954	0.6693
NOV	-0.001598	0.001606	-0.994996	0.3214
CCNIPUS(-1)	0.364556	0.076596	4.759458	0.0000

R-squared	0.684970	Mean dependent var	0.003366
Adjusted R-squared	0.654967	S.D. dependent var	0.006865
S.E. of regression	0.004032	Akaike info criterion	-8.100892
Sum squared resid	0.002390	Schwarz criterion	-7.815004
Log likelihood	671.1723	Hannan-Quinn criter.	-7.984817
F-statistic	22.83018	Durbin-Watson stat	2.154503
Prob(F-statistic)	0.000000		

Table 31. CCPRPUS, Coal coke production, regression results

Dependent Variable: CCPRPUS
Method: Least Squares
Date: 11/18/14 Time: 10:10
Sample: 2001M01 2013M12
Included observations: 156

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.67E-05	0.000749	0.102295	0.9187
CCTCPUS	0.185300	0.027383	6.766990	0.0000
CCTCPUS(-1)	-0.042188	0.025901	-1.628815	0.1056
CCNIPUS	-0.109130	0.022076	-4.943284	0.0000
JAN	0.000879	0.000381	2.304789	0.0226
FEB	0.004775	0.000412	11.57921	0.0000
MAR	-0.001840	0.000385	-4.772217	0.0000
APR	0.002691	0.000393	6.841294	0.0000
MAY	0.000475	0.000381	1.247857	0.2142
JUN	0.002623	0.000389	6.742105	0.0000
JUL	0.000596	0.000380	1.569736	0.1187
AUG	0.001311	0.000381	3.442982	0.0008
SEP	0.002436	0.000384	6.346431	0.0000
OCT	-5.42E-05	0.000379	-0.143113	0.8864
NOV	0.002291	0.000383	5.980927	0.0000
CCPRPUS(-1)	0.819891	0.028763	28.50509	0.0000

R-squared	0.969551	Mean dependent var	0.043598
Adjusted R-squared	0.966288	S.D. dependent var	0.005230
S.E. of regression	0.000960	Akaike info criterion	-10.96178
Sum squared resid	0.000129	Schwarz criterion	-10.64898
Log likelihood	871.0189	Hannan-Quinn criter.	-10.83473
F-statistic	297.1888	Durbin-Watson stat	1.450324
Prob(F-statistic)	0.000000		

Table 32. CCEXPUS, Coal coke exports, regression results

Dependent Variable: CCEXPUS
Method: Least Squares
Date: 11/18/14 Time: 14:09
Sample: 2009M01 2014M06
Included observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004422	0.001744	2.534645	0.0144
CCPRPUS	0.044884	0.079244	0.566406	0.5736
CCTCPUS	-0.035455	0.057157	-0.620316	0.5378
@TREND(2008:12)	-3.06E-05	1.12E-05	-2.725353	0.0088
APR	-0.001895	0.000862	-2.199619	0.0324
AUG	-0.001412	0.000906	-1.558201	0.1254
FEB	-0.001978	0.000875	-2.259140	0.0282
JAN	-0.001234	0.000861	-1.433972	0.1577
JUL	-0.000798	0.000908	-0.878214	0.3839
JUN	-0.000281	0.000860	-0.326497	0.7454
MAR	-0.001864	0.000864	-2.156736	0.0358
MAY	-0.001118	0.000861	-1.298334	0.2000
NOV	0.001384	0.000898	1.541122	0.1295
OCT	-0.000153	0.000895	-0.171164	0.8648
SEP	-0.000533	0.000903	-0.590207	0.5577

R-squared	0.431637	Mean dependent var	0.002920
Adjusted R-squared	0.275616	S.D. dependent var	0.001663
S.E. of regression	0.001415	Akaike info criterion	-10.08661
Sum squared resid	0.000102	Schwarz criterion	-9.588965
Log likelihood	347.8582	Hannan-Quinn criter.	-9.889969
F-statistic	2.766532	Durbin-Watson stat	1.890008
Prob(F-statistic)	0.004051		

Table 33. CLKCPUS, Coke plant coal consumption, regression results

Dependent Variable: CLKCPUS
Method: Least Squares
Date: 11/18/14 Time: 14:19
Sample: 2000M01 2014M06
Included observations: 174

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001628	0.001380	1.179614	0.2400
CCPRPUS	1.310533	0.085612	15.30780	0.0000
CCNIPUS	0.041770	0.026902	1.552695	0.1225
D0812	-0.009874	0.002197	-4.495311	0.0000
D0010+D0901	-0.004864	0.001565	-3.106945	0.0022
D0810	0.011666	0.002195	5.315616	0.0000
D0504+D0507	0.002327	0.001564	1.487791	0.1388
JAN	-0.000961	0.000807	-1.191736	0.2352
FEB	-0.003043	0.000920	-3.307119	0.0012
MAR	0.002683	0.000810	3.313551	0.0011
APR	-0.000247	0.000810	-0.304483	0.7612
MAY	0.000142	0.000809	0.176042	0.8605
JUN	-0.001583	0.000818	-1.934677	0.0549
JUL	-0.002435	0.000822	-2.964419	0.0035
AUG	-6.98E-05	0.000828	-0.084323	0.9329
SEP	-0.000525	0.000827	-0.634425	0.5267
OCT	0.001085	0.000847	1.281424	0.2020
NOV	-0.002036	0.000814	-2.500138	0.0135
CLKCPUS(-1)	0.041659	0.058939	0.706810	0.4807

R-squared	0.947909	Mean dependent var	0.061922
Adjusted R-squared	0.941860	S.D. dependent var	0.008754
S.E. of regression	0.002111	Akaike info criterion	-9.380637
Sum squared resid	0.000691	Schwarz criterion	-9.035683
Log likelihood	835.1154	Hannan-Quinn criter.	-9.240703
F-statistic	156.6975	Durbin-Watson stat	1.992079
Prob(F-statistic)	0.000000		

Table 34. CLHCNONCHP, Commercial / Institutional coal consumption (excluding combined heat and power), regression results

Dependent Variable: CLHCNONCHP
Method: Least Squares
Date: 11/30/14 Time: 08:03
Sample: 2008M01 2014M06
Included observations: 78

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001026	0.000486	-2.113773	0.0387
ZWHD_ENC	1.30E-06	9.11E-07	1.428593	0.1583
ZWHD_MAC	1.52E-07	1.13E-06	0.133687	0.8941
D0801	-0.000891	0.000331	-2.689468	0.0093
D10	0.000115	9.46E-05	1.212038	0.2302
D1203	0.000944	0.000361	2.611368	0.0114
JAN	0.000136	0.000192	0.705749	0.4831
FEB	-0.000402	0.000167	-2.400084	0.0195
MAR	-0.000787	0.000196	-4.024274	0.0002
APR	-0.001693	0.000306	-5.527719	0.0000
MAY	0.000815	0.000411	1.985832	0.0516
JUN	0.001416	0.000479	2.954536	0.0045
JUL	0.000281	0.000489	0.574411	0.5678
AUG	0.001069	0.000487	2.196262	0.0319
SEP	0.000833	0.000457	1.823430	0.0732
OCT	0.001736	0.000333	5.204385	0.0000
NOV	0.000545	0.000226	2.409054	0.0191
CLHCNONCHP(-1)	0.954797	0.030456	31.35033	0.0000

R-squared	0.977706	Mean dependent var	0.002909
Adjusted R-squared	0.971389	S.D. dependent var	0.001670
S.E. of regression	0.000283	Akaike info criterion	-13.30628
Sum squared resid	4.79E-06	Schwarz criterion	-12.76242
Log likelihood	536.9448	Hannan-Quinn criter.	-13.08856
F-statistic	154.7795	Durbin-Watson stat	2.201719
Prob(F-statistic)	0.000000		

Table 35. CLXCPUS, Industrial coal consumption, regression results

Dependent Variable: CLXCPUS
Method: Least Squares
Date: 11/18/14 Time: 10:54
Sample: 2001M01 2014M06
Included observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.041249	0.009225	4.471226	0.0000
QSIC_CL	0.000118	4.77E-05	2.477383	0.0144
TIME	-6.32E-05	1.04E-05	-6.060382	0.0000
D0004+D0207+D0802	-0.011228	0.002262	-4.962667	0.0000
D0102	0.014496	0.003235	4.480368	0.0000
D0901	0.009923	0.003266	3.038191	0.0028
JAN	0.002342	0.001251	1.872041	0.0632
FEB	0.017973	0.001306	13.75811	0.0000
MAR	-0.000222	0.001228	-0.180356	0.8571
APR	0.001847	0.001196	1.543914	0.1248
MAY	0.000794	0.001255	0.632363	0.5282
JUN	0.004396	0.001332	3.301041	0.0012
JUL	-0.000842	0.001318	-0.638732	0.5240
AUG	0.001997	0.001455	1.373083	0.1719
SEP	0.008891	0.001424	6.243447	0.0000
OCT	0.007194	0.001246	5.774883	0.0000
NOV	0.009289	0.001213	7.654729	0.0000
CLXCPUS(-1)	0.569533	0.057826	9.849137	0.0000

R-squared	0.919846	Mean dependent var	0.073937
Adjusted R-squared	0.910384	S.D. dependent var	0.010181
S.E. of regression	0.003048	Akaike info criterion	-8.644291
Sum squared resid	0.001338	Schwarz criterion	-8.301224
Log likelihood	718.1875	Hannan-Quinn criter.	-8.505000
F-statistic	97.20858	Durbin-Watson stat	2.037004
Prob(F-statistic)	0.000000		

Table 36. CLSPUUS, Coal spot price, regression results

Dependent Variable: CLSPUUS
Method: Least Squares
Date: 11/18/14 Time: 11:04
Sample: 2004M01 2014M06
Included observations: 126

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.394009	0.300604	-1.310721	0.1928
CLPRPUS	0.681990	0.093387	7.302819	0.0000
CLPS_EP	-0.004582	0.000716	-6.403328	0.0000
CLEXPUS	0.970175	0.220527	4.399349	0.0000
D07	-0.092807	0.046903	-1.978678	0.0505
D0801+D0802+D0803	0.432199	0.081231	5.320626	0.0000
D0804+D0805+D0806	0.986894	0.083729	11.78678	0.0000
D0807+D0808+D0809	1.420654	0.082681	17.18228	0.0000
D0810+D0811+D0812	1.065134	0.087465	12.17784	0.0000
D09ON	0.489861	0.059670	8.209471	0.0000
JAN	-0.062846	0.055272	-1.137037	0.2581
FEB	-0.059518	0.056275	-1.057631	0.2927
MAR	-0.041654	0.055760	-0.747033	0.4567
APR	-0.006501	0.054303	-0.119722	0.9049
MAY	0.076177	0.054399	1.400346	0.1644
JUN	-0.019630	0.054603	-0.359500	0.7199
JUL	-0.035344	0.055423	-0.637715	0.5250
AUG	-0.137050	0.057423	-2.386680	0.0188
SEP	-0.113346	0.056812	-1.995085	0.0486
OCT	0.027862	0.054599	0.510301	0.6109
NOV	-0.013449	0.055044	-0.244332	0.8075

R-squared	0.895742	Mean dependent var	1.475455
Adjusted R-squared	0.875883	S.D. dependent var	0.344700
S.E. of regression	0.121439	Akaike info criterion	-1.227805
Sum squared resid	1.548469	Schwarz criterion	-0.755091
Log likelihood	98.35171	Hannan-Quinn criter.	-1.035756
F-statistic	45.10589	Durbin-Watson stat	1.335732
Prob(F-statistic)	0.000000		

Table 37. CLEUDUS, Electric power sector coal price, regression results

Dependent Variable: CLEUDUS
Method: Least Squares
Date: 03/14/16 Time: 15:52
Sample: 2004M01 2014M06
Included observations: 126

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.230292	0.090535	-2.543681	0.0124
DSRTUUS	0.002165	0.000195	11.11661	0.0000
CLSPUUS	0.393036	0.054468	7.215918	0.0000
CLPS_EP	0.006558	0.000443	14.80736	0.0000
D08	-0.519453	0.058128	-8.936429	0.0000
D0811	0.321703	0.137340	2.342387	0.0210
D0812	0.505169	0.137526	3.673270	0.0004
D1001+D1002+D1003	0.075378	0.075095	1.003763	0.3178
JAN	0.124043	0.055210	2.246759	0.0267
FEB	0.136144	0.055226	2.465209	0.0153
MAR	0.081240	0.055065	1.475351	0.1431
APR	0.021719	0.054593	0.397841	0.6915
MAY	-0.001211	0.054688	-0.022150	0.9824
JUN	0.010215	0.054586	0.187139	0.8519
JUL	0.050391	0.055796	0.903131	0.3685
AUG	0.096429	0.055903	1.724947	0.0874
SEP	0.072355	0.055853	1.295468	0.1979
OCT	0.012128	0.055862	0.217111	0.8285
NOV	-0.038612	0.057113	-0.676060	0.5005

R-squared	0.905674	Mean dependent var	2.020159
Adjusted R-squared	0.889806	S.D. dependent var	0.364757
S.E. of regression	0.121083	Akaike info criterion	-1.246549
Sum squared resid	1.568734	Schwarz criterion	-0.818855
Log likelihood	97.53257	Hannan-Quinn criter.	-1.072790
F-statistic	57.07583	Durbin-Watson stat	0.364402
Prob(F-statistic)	0.000000		

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