**An empirical analysis of gas consumption to generate Electricity in United States**

**Econometrics Project (Phase I)**

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**Fall 2014**

**I. Introduction:** A recent report of Federation of Indian Chambers of Commerce and Industry (FICCI) says "There is strong correlation between power consumption and the GDP of the country. Power shortages currently cost India a GDP loss of $68 billion (0.4 per cent of total GDP)" [1]. Thus in modern world generating sufficient amount of energy is very much important for sustainable development. Excess electricity generation is also not encouraged due to loss of time, man power and raw material cost for electricity production. Though electricity generation and distribution is a time consuming process, we need accurate forecast about how much electricity required for uninterrupted industrial production and household use.

Electricity is mainly generated from fossil fuel, nuclear electric power and renewable energy. We should make sure about supplying enough raw materials timely to generate required amount of electricity. From the case study of Bangladesh electricity sector in [2], we can learn that inadequate raw material supply is one of the main reason behind electricity crisis in Bangladesh. Thus how much raw material are required to generate demanded electricity is also a very important factor to know for electricity generating companies. According to US energy information administration report [3], 40.693 quadrillion Btu fossil fuel has been used between January to June 2014 which is more than 81% of total energy used in US. Coal, crude oil and natural gas are main sources of fossil fuel in United States. Earlier coal were mostly used for fossil fuel due to low price. But recently natural gas consumption to generate electricity increases significantly and in near future trend shows that natural gas consumption for electricity generation will increase more (Figure 1).

Figure 1: Fossil fuel consumption for generation electricity in US

Electricity generation and distribution is a huge industry in United States. In this project, we will do some empirical analysis on natural gas consumption for electricity generation in US. In section II, we will discuss about some background study and literature review. In section III, we will propose a mathematical model for total natural gas consumption in US for electricity generation and then in subsequent sections we will do some empirical analysis of our proposed model.

**II. Background and Literature review:** In 2011, Himadri Shekhar Dey *et al.* [4], proposed a model to predict gas consumption in Bangladesh. They used two economic factor price and income as a function of total gas demand for electricity generation in Bangladesh. They used previous year’s gas demand as an input of current year’s gas demand which is called autoregressive model. Elasticity has been used in their model for smoothing. Finally they predicted the gas demand of Bangladesh until 2025along with some statistical test.

In 2014, Richard Cebula and Nate Herder [5] proposed a mathematical model to predict the economic factor electricity demand in United States as a function of cooling degree day, electricity price, per capita income, efficiency of electricity use by state and peak electricity generation capacity of each state. They proposed two log models and one linear regression model equation for estimating electricity load. According to their findings electricity consumption increases with the increase of cooling degree days, per capita real disposable income and the peak summer electricity capacity, but consumption decreases due to increasing electricity price and more efficiency score.

In 2013, Sergio Ramos *et al.* [6] proposed four mathematical models to forecast electricity based on Halt-Winters exponential smoothing and an artificial neural network and then test these two models with known forecasting results. In two of their models they considered weekends and national holiday for forecasting electricity. Their result shows that considering national holidays and weekends for forecasting electricity gives more accurate result. Finally they compare both models performance with each other and find out neural network model is better than Halt-Winters exponential smoothing.

Sometime, we need data of electricity supply for smaller area to more accurate prediction of electricity consumption but we don’t have that data. In this case if a larger region electricity consumption data is available including that sub region then we can extract the data of our required small region from bigger region data using bus load distribution factor and decoupled extended kanlman filter neural network technique [7].

In fall 2013, Adriatik Hajdari and Paul Kaefer submitted a natural gas demand consumption model for Alaska as an econometrics project of this course. They used wind, local natural gas price, cooling degree day, local natural gas production, local oil production, heating degree day, unemployment rate, gross domestic product of Japan, real gross domestic product of US, natural gas production of US as a factor to forecast the natural gas consumption of Alaska. Their model combines Ronal H. Brown *et al.* [8] and [Jiří Vondráček](http://www.sciencedirect.com/science/article/pii/S0306261907001183) *et al.* [9] models.

**III. Modeling Process and Data Issues:** I have taken ideas from all of the papers and project discussed in section II to find an economic model for natural gas consumption in United States. At first I have tried to model [4], because of simplicity. They use only two economic factor to find out natural gas consumption in Bangladesh. Adriatik Hajdari and Paul Kaefer’s model uses too many factors (18 factors) which is very difficult to implement in a short time period. Richard Cebula and Nate Herder [5] proposed three models and one of them is linear regression model. But I have to collect 48 states data for all factors which is also not feasible within short time period. Thus I come up with my own model taking ideas from all of those models. I have used six factors (population, gross domestic product, unemployment rate, coal consumption, oil price and natural gas price of US) in my econometrics model.

Population is a major factor for natural gas consumption because normally when population increases we need more electricity for those extra people. Thus we need more natural gas to generate extra electricity.

Gross domestic product (GDP) is an indicator of economic growth for every country. If a country’s total production increases it requires more electricity to maintain its growth. Thus we include GDP as an economic factor to model gas consumption in US. There are two types of GDP data available: real and nominal GDP. Nominal GDP is the adjusted real GDP considering inflation. We will use nominal GDP in our model thus we need not to worry about collecting CPI (Consumer Price Index) data for GDP. In [5], Richard Cebula and Nate Herder used CPI data to find nominal GDP for their econometric model. Per capita income is not used in our model because it’s related to GDP and population.

Unemployment rate is directly related to any kind of consumption. From our prior knowledge we know when unemployment of a country increases it reduces any kind of consumption and vice versa. Thus I have used unemployment rate as a factor to design an economic model for natural gas consumption.

Coal is the main competitor of natural gas in United States due to its low price and availability. But recently we found lots of environmental issues about coal mining. In near past there were some protest in coal mine areas in Bangladesh for environmental issues which make the authority stop mining for several years. Currently coal is the cheapest fossil fuel available for electricity generation in US. Thus when coal consumption will drop for some reason (economical, environmental or political), we can expect to fill up the gap by natural gas. Because natural gas has the second lowest price among all fossil fuels in US market. Thus coal supply is an important economic factor to model natural gas consumption in US.

More than 81% of electricity in US generated by fossil fuel [3]. Two types of fossil fuels are mainly used other than natural gas. One is coal and other is crude oil. But crude oil price has been increased recently which makes other substitute more lucrative to generate electricity. Thus oil price is an important economic factor to model natural gas consumption.

Finally, the economic factor natural gas price is directly related to natural gas consumption. From the general theory of economics when price of some economic good goes up people consume that item less and vice versa considering other factors constant. Thus natural gas price in US is an important economic factor to model natural gas consumption in US.

Considering all economic factors our economic model for natural gas consumption to generate electricity is given below:

*NGC=β1+ β2\*POP+ β3\*GDP+ β4\*UMEMP+ β5\*COALC+ β6\*OILP+ β7\*NGP*

Where (data sources are in parenthesis):

NGC = Total natural gas consumption for generating electricity in United States from 1949 to 2011, measured in trillion BTU [10]. The British thermal unit (BTU or Btu) is a traditional unit of energy equal to about 1055 joules. It is the amount of energy needed to cool or heat one pound of water by one degree Fahrenheit [14]. The unit trillion means we have to multiply with 1000,000,000,000 (12 zeros) for every entry of natural gas consumption in our table to get the original amount.

POP = Total number of people lived in United States from 1949 to 2011 [12], measured in million. The unit billion means we have to multiply each entry of population by 1000,000 (6 zeros) to get the original amount.

GDP = Gross Domestic Product of United States between 1949 and 2011 [12, 13], measured in billion. Nominal GDP is used to get better result. The unit billion means we have to multiply each entry of GDP by 1000,000,000 (9 zeros) to get the original amount.

UMEMP = Unemployment rate in United States between 1949 and 2011 [11], measured in percentage (%).

COALC = Total coal (one of the fossil fuel alternatives of natural gas) consumption in United States to generate electricity between 1949 and 2011 [10], measured in trillion BTU.

OILP = Oil price per million BTU in United States between 1949 and 2011 [10].

NGP = Natural gas price per million BTU in United States between 1949 and 2011 [10].

From our econometric model of natural gas consumption for electricity section in US, we want to do the following tests:

1. Testing the estimated model for overall significance: To perform the test our null and alternative hypothesis are given below:

H0: *β2* = 0 and *β3* = 0 and *β4* = 0 and *β5* = 0 and *β6* = 0 and *β7* = 0 vs

H1: *β2* ≠ 0 or *β3* ≠ 0 or *β4* ≠ 0 or *β5* ≠ 0 or *β6* ≠ 0 or *β7* = 0.

1. Testing statistical significance of the estimated coefficient on *GDP* using the *t-test*: According to our common knowledge, if GDP grows then people have more purchasing capability and thus they will consume more electricity. So, Electricity Companies will need more natural gas to produce extra electricity. Thus, *a priori*, we expect the effect of GDP to be positive on natural gas consumption. Thus we should use a one-tailed test. So our null and alternative hypothesis are: H0: *β3* ≤ 0 vs H1: *β3* > 0.
2. Testing the statistical significance of the estimated coefficient on *GDP* using the *F-test*: This time we will do two tailed test, thus our null and alternative hypothesis are:

H0: *β3* = 0 vs H1: *β3* ≠ 0.

1. Testing whether the estimated coefficients on population, GDP, and unemployment rate are jointly statistically significant: Our null hypothesis and alternative hypothesis for the test are: H0: *β2* = *β3* = *β4* = 0 vs H1: *β2* ≠ 0 or *β3* ≠ 0 or *β4* ≠ 0.
2. Testing whether the sum of estimated coefficients on population, GDP, and unemployment rate equal to zero: Our null hypothesis and alternative hypothesis for the test are: H0: *β2* + *β3* + *β4* + 0 vs H1: *β2* + *β3* + *β4* ≠ 0.
3. Testing whether the estimated coefficients on coal consumption, oil price, and natural gas price are jointly statistically significant: Our null hypothesis and alternative hypothesis for the test is given below:

H0: *β5* = *β6* = *β7* = 0 vs H1: *β5* ≠ 0 or *β6* ≠ 0 or *β7* ≠ 0.

1. Testing whether the sum of estimated coefficients on coal consumption, oil price, and natural gas price equal to zero: Our null hypothesis and alternative hypothesis for the test are: H0: *β5* + *β6* + *β7* + 0 vs H1: *β5* + *β6* + *β7* ≠ 0.
2. In 1970, US government started energy efficiency program which significantly reduces electricity consumption between 1970 and 2003 [15]. Thus we will test, if this cause a structural break in regression line. In this case our null hypothesis and alternative hypothesis are:

H0: No structural break in 1970 (model is stable) vs

H1: Structural break in 1970 (model is unstable).

1. At the end of 2003, US attacked Iraq which is one of the largest oil producing countries in the world. Thus we will test, if this cause a structural break in regression line for subsequent years. In this case we will set our break point in 2005 because the effect of war will take couple of years to hit the oil market though every country has their reserve purchase of oil for few years. So, our null hypothesis and alternative hypothesis are:

H0: No structural break in 2005 (model is stable) vs

H1: Structural break in 2005 (model is unstable).

My data sources for this project are given below:

1. US Energy Information Administration (EIA)
2. Bureau of Labor Statistics (BLS)
3. Bureau of Economic Analysis (BEA)

Sample residual of our economic model is uncorrelated with US population, US gross domestic product, US unemployment rate, coal consumption in US electricity sector, price of oil in US, and price of natural gas in US (see Table 2 in Appendix for test result). Our residual mean is also zero (see Figure 1 of Appendix). Based on above two tests we can conclude that our sample data is unbiased and consistent. Efficiency and normality test are out of scope for this project.

**IV Econometric Analysis:** According to the estimated coefficients of Table 1, if population of United States increase (decrease) by 1 million then natural gas consumption for electricity generation increase (decrease) by 89.9 trillion BTU on an average holding other factors constant. This result satisfies our prior knowledge and expectation about population growth and consumption. When population will increase we will need more electricity for growing population and we need more natural gas to generate electricity.

According to Table1, on an average 1 billion dollar increase (decrease) in GDP cause natural gas consumption decrease (increase) by 0.05 trillion BTU holding other factors constant. This result goes against our prior expectation. From common knowledge GDP increase of a country means more production and nowadays production is heavily depend on electricity. Thus we would need more natural gas for electricity generation. We can explain this unexpected result from Marvin J. [Horowitz](http://search.proquest.com/econlit/indexinglinkhandler/sng/au/Horowitz,+Marvin+J/$N?accountid=100)’s work about changing in electricity consumption from 1970 to 2003 in United States [15]. In 1970, US government took some initiatives to reduce electricity consumption by increasing efficiency. According to the findings of his paper, residential sector reduces electricity consumption by 4.4 percent, in commercial sector by 8.1 percent, and industrial sector by 11.8 percent between 1970 and 2003. This reduction results are relative to per capita income which is directly related to GDP. Though considering Horowitz’s work, everything makes sense, still we 2will test the significance of GDP in hypothesis testing part.

According to Table 1, one percentage point (100 basis point) increase (decrease) of unemployment rate in US is expected to decrease (increase) natural gas consumption for electricity generation by about 150.7 trillion BTU holding other factors constant. From common knowledge, we know when unemployment rate increase then people force to cut their consumption. Thus it makes sense.

According to Table 1, on an average 1 trillion BTU coal consumption for electricity generation decrease (increase) has the effect of increasing (decreasing) natural gas consumption by about 0.35 trillion BTU holding other factors constant. Natural gas is the cheapest alternative of coal in US electricity section, thus reduction of coal supply positively impact on natural gas demand for electricity generation.

According to Table 1, on an average the increase (decrease) of 1 dollar in oil price per million BTU cause natural gas consumption to increase (decrease) by about 42.5 trillion BTU for electricity generation in US holding other factors constant. When oil price became costly electricity companies searches for alternative sources like natural gas to reduce production cost. Thus our findings from the model goes with general concept of demand for any item and price of alternative.

According to Table 1, when natural gas price increase (decrease) on an average by 1 dollar per million BTU then it’s consumption decrease (increase) by about 17.9 trillion BTU holding other factors constant which also goes with the common knowledge of price and demand of economics. The mean systematic effect of determinants of the natural gas consumption for electricity sector in US is about -11832.8 trillion BTU.

**Hypothesis testing results defined in previous section:**

1. Testing the estimated model for overall significance: To perform the test our null and alternative hypothesis are given below:

H0: *β2* = 0 and *β3* = 0 and *β4* = 0 and *β5* = 0 and *β6* = 0 and *β7* = 0 vs

H1: *β2* ≠ 0 or *β3* ≠ 0 or *β4* ≠ 0 or *β5* ≠ 0 or *β6* ≠ 0 or *β7* = 0.

Alternatively, H0: R2 = 0 vs H1: R2 ≠ 0.

From the regression output (Table 1 in Appendix), we find the necessary F-statistic to be 275.71 with a p-value of zero. This leads us to reject the null hypothesis in the favor of alternative hypothesis at nearly any level of significance and conclude that the estimated model is overall statistically significant.

1. Testing statistical significance of the estimated coefficient on *GDP* using the *t-test*: Our null and alternative hypothesis for this test are: H0: *β3* ≤ 0 vs H1: *β3* > 0.

From the result of regression output (Table 1 in Appendix), we see that t-statistic associated with the estimated coefficient on US GDP is -1.09 with a p-value of 0.28/2=0.14.Thus can’t reject the null hypothesis with 5% level of significance, which means that the estimated coefficient on US GDP is statistically significantly negative.

1. Testing the statistical significance of the estimated coefficient on *GDP* using the *F-test*: Our null and alternative hypothesis are: H0: *β3* = 0 vs H1: *β3* ≠ 0.

The result shows (Table3 in Appendix), we have F-value of 1.19 with p-value 0.28 which concludes that we can’t reject the null hypothesis with 5% level of significance. That means the estimated coefficient of US GDP is statistically significantly less than zero.

1. Testing whether the estimated coefficients on population, GDP, and unemployment rate are jointly statistically significant: Our null hypothesis and alternative hypothesis for the test are: H0: *β2* = *β3* = *β4* = 0 vs H1: *β2* ≠ 0 or *β3* ≠ 0 or *β4* ≠ 0.

According to test result (Table 4 in Appendix), F-statistic is 85.68 with p-value of zero, meaning we can reject the null hypothesis in favor of alternative hypothesis at high level of confidence. Thus we can conclude that US GDP, US unemployment rate and US population are jointly statistically significant.

1. Testing whether the sum of estimated coefficients on population, GDP, and unemployment rate equal to zero: Our null hypothesis and alternative hypothesis for the test are: H0: *β2* + *β3* + *β4* + 0 vs H1: *β2* + *β3* + *β4* ≠ 0.

The test result shows (Table 5 in Appendix), high p-value of 0.1 leads us not to reject the null hypothesis and conclude that the sum of the estimated effects of GDP, unemployment rate and population on natural gas consumption is not statistically significantly different from zero.

1. Testing whether the estimated coefficients on coal consumption, oil price, and natural gas price are jointly statistically significant: Our null hypothesis and alternative hypothesis for the test is given below:

H0: *β5* = *β6* = *β7* = 0 vs H1: *β5* ≠ 0 or *β6* ≠ 0 or *β7* ≠ 0.

From the test result (Table 6 in Appendix), we can see F-statistics is 39.6 with p-value of zero, which means we can reject the null hypothesis in favor of alternative hypothesis at high level of confidence. Thus we can conclude that coal consumption, oil price, and natural gas price are jointly statistically significant with any level of significance.

1. Testing whether the sum of estimated coefficients on coal consumption, oil price, and natural gas price equal to zero: Our null hypothesis and alternative hypothesis for the test are: H0: *β5* + *β6* + *β7* + 0 vs H1: *β5* + *β6* + *β7* ≠ 0.

From the test result (Table 7 in Appendix), we can observe F-statistics is 0.14 with p-value of 0.7 which leads us not to reject the null hypothesis and conclude that the sum of estimated effects of coal consumption, oil price, and natural gas price is not statistically significantly different from zero.

1. Our null hypothesis and alternative hypothesis for testing break point at 1970 are:

H0: No structural break in 1970 (model is stable) vs

H1: Structural break in 1970 (model is unstable).

The test result shows (Table 8 in Appendix), very low p-value (0.0008) which leads us to reject the null hypothesis in favor of alternative hypothesis. Thus it appears that there is a statistically significant break in 1970 so that estimating the model over the entire period is not appropriate.

1. Our null hypothesis and alternative hypothesis for testing break point at 2005 are:

H0: No structural break in 2005 (model is stable) vs

H1: Structural break in 2005 (model is unstable).

The test result shows (Table 9 in Appendix), high p-value of 0.08. Thus we can’t reject the null hypothesis with 5% level of significant which means that there is no statistically significant break in 2005.

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**Appendix:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dependent Variable: US\_NG\_CON | | |  |  |
| Method: Least Squares | | |  |  |
| Date: 10/13/14 Time: 21:32 | | |  |  |
| Sample: 1949 2011 | | |  |  |
| Included observations: 63 | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | -11832.79 | 1041.346 | -11.36297 | 0.0000 |
| US\_POP | 89.92054 | 6.898528 | 13.03474 | 0.0000 |
| US\_GDP | -0.047739 | 0.043677 | -1.093012 | 0.2791 |
| US\_UNEMP | -150.7452 | 36.96679 | -4.077854 | 0.0001 |
| US\_COAL\_CON | -0.352826 | 0.042221 | -8.356712 | 0.0000 |
| US\_OIL\_PR | 42.47535 | 38.59321 | 1.100591 | 0.2758 |
| US\_NG\_PR | -17.87042 | 79.96424 | -0.223480 | 0.8240 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.967257 | Mean dependent var | | 3656.365 |
| Adjusted R-squared | 0.963748 | S.D. dependent var | | 1881.935 |
| S.E. of regression | 358.3172 | Akaike info criterion | | 14.70515 |
| Sum squared resid | 7189910. | Schwarz criterion | | 14.94328 |
| Log likelihood | -456.2123 | Hannan-Quinn criter. | | 14.79881 |
| F-statistic | 275.7123 | Durbin-Watson stat | | 0.729757 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Table 1:** Estimation result of our linear regression model

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | US\_POP | US\_GDP | US\_UNEMP | US\_COAL\_CON | US\_OIL\_PR | US\_NG\_PR |
| RESID | 6.52E-15 | 1.14E-14 | -6.12E-16 | 4.31E-14 | -1.07E-15 | 5.93E-15 |

**Table 2:** Correlation between RESID and Xi = {US\_POP, US\_GDP, US\_UNEMP, US\_COAL\_CON, US\_OIL\_PR, US\_NG\_PR}



**Figure 1:** RESID stats

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Redundant Variables Test | | |  |  |
| Equation: EQ03 | | |  |  |
| Specification: US\_NG\_CON C US\_POP US\_GDP US\_UNEMP | | | | |
| US\_COAL\_CON US\_OIL\_PR US\_NG\_PR | | | |  |
| Redundant Variables: US\_GDP | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  | Value | df | Probability |  |
| t-statistic | 1.093012 | 56 | 0.2791 |  |
| F-statistic | 1.194674 | (1, 56) | 0.2791 |  |
| Likelihood ratio | 1.329873 | 1 | 0.2488 |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Table 3:** F-statistics test for US\_GDP

|  |  |  |  |
| --- | --- | --- | --- |
| Wald Test: | |  |  |
| Equation: EQ03 | |  |  |
|  |  |  |  |
|  |  |  |  |
| Test Statistic | Value | df | Probability |
|  |  |  |  |
|  |  |  |  |
| F-statistic | 85.68382 | (2, 56) | 0.0000 |
| Chi-square | 171.3676 | 2 | 0.0000 |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| Null Hypothesis: C(2)=C(3)=C(4) | | |  |

**Table 4:** Wald test on US\_POP, US\_GDP and US\_UNEMP (part1)

|  |  |  |  |
| --- | --- | --- | --- |
| Wald Test: | |  |  |
| Equation: EQ03 | |  |  |
|  |  |  |  |
|  |  |  |  |
| Test Statistic | Value | Df | Probability |
|  |  |  |  |
|  |  |  |  |
| t-statistic | -1.679382 | 56 | 0.0986 |
| F-statistic | 2.820325 | (1, 56) | 0.0986 |
| Chi-square | 2.820325 | 1 | 0.0931 |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| Null Hypothesis: C(2)+C(3)+C(4)=0 | | | |

**Table 5:** Wald test on US\_POP, US\_GDP and US\_UNEMP (part2)

|  |  |  |  |
| --- | --- | --- | --- |
| Wald Test: | |  |  |
| Equation: EQ03 | |  |  |
|  |  |  |  |
|  |  |  |  |
| Test Statistic | Value | df | Probability |
|  |  |  |  |
|  |  |  |  |
| F-statistic | 39.60604 | (3, 56) | 0.0000 |
| Chi-square | 118.8181 | 3 | 0.0000 |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| Null Hypothesis: C(5)=C(6)=C(7)=0 | | | |

**Table 6:** Wald test on US\_COAL\_CON, US\_OIL\_PR and US\_NG\_PR (part1)

|  |  |  |  |
| --- | --- | --- | --- |
| Wald Test: | |  |  |
| Equation: EQ03 | |  |  |
|  |  |  |  |
|  |  |  |  |
| Test Statistic | Value | df | Probability |
|  |  |  |  |
|  |  |  |  |
| t-statistic | 0.378359 | 56 | 0.7066 |
| F-statistic | 0.143156 | (1, 56) | 0.7066 |
| Chi-square | 0.143156 | 1 | 0.7052 |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| Null Hypothesis: C(5)+C(6)+C(7)=0 | | | |

**Table 7:** Wald test on US\_COAL\_CON, US\_OIL\_PR and US\_NG\_PR (part2)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Chow Breakpoint Test: 1970 | | | |  |
| Null Hypothesis: No breaks at specified breakpoints | | | | |
| Varying regressors: All equation variables | | | |  |
| Equation Sample: 1949 2011 | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| F-statistic | 4.363570 |  | Prob. F(7,49) | 0.0008 |
| Log likelihood ratio | 30.52366 |  | Prob. Chi-Square(7) | 0.0001 |
| Wald Statistic | 30.54499 |  | Prob. Chi-Square(7) | 0.0001 |
|  |  |  |  |  |
|  |  |  |  |  |

**Table 8:** Chow breakpoint test for 1970

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Chow Breakpoint Test: 2005 | | | |  |
| Null Hypothesis: No breaks at specified breakpoints | | | | |
| Varying regressors: All equation variables | | | |  |
| Equation Sample: 1949 2011 | | | |  |
|  |  |  |  |  |
|  |  |  |  |  |
| F-statistic | 1.958648 |  | Prob. F(7,49) | 0.0802 |
| Log likelihood ratio | 15.54268 |  | Prob. Chi-Square(7) | 0.0296 |
| Wald Statistic | 13.71054 |  | Prob. Chi-Square(7) | 0.0566 |
|  |  |  |  |  |
|  |  |  |  |  |

**Table 9:** Chow breakpoint test for 2005