Correlation Study on Economy Growth and Petroleum Consumption-Taking US, China and Japan as examples

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Abstract. Petroleum is the world’s most important primary energy. The global petroleum market fluctuation will threaten China’s energy security. China’s petroleum foreign dependency reached 67.4% in 2017. General speaking, quick petroleum price rising and high dependence on foreign petroleum are likely to have an adverse impact on the economy. However we will seek the truth by using data. The paper has analyzed the correlation between GDP growth of 3 countries (US, China and Japan) and 2 independent variables (international petroleum price rising and dependence on foreign petroleum) by using the econometric model. As for US, international petroleum price rising has no remarkable effect on GDP growth. The dependence on foreign petroleum is positively correlated with GDP growth: 0.14249. As for China, both international petroleum price rising and dependence on foreign petroleum have a negative correlation with the GDP growth: -0.02669 and -0.24123 respectively. As for Japan, both international petroleum price rising and dependence on foreign petroleum have no significant impact on its GDP growth. The conclusion illustrates that US and Japan have been well rewarded from their reasonable investment and exploration on the overseas petroleum resources.

1. Introduction
US, China and Japan are three largest economies in the world, and plenty of petroleum have consumed to achieve their economy growth. Petroleum is the world’s most important primary energy. It is no wonder that the energy geopolitics is among the hot research spots for scholars. In terms of the supply and demand pattern, the world petroleum market pattern is characterized by the separation of demand and supply sides, i.e. western countries control the global petroleum supply and developing countries become main demand-sides. However, it is still a mystery that what impact will be exerted to GDP growth when international petroleum price and dependence on foreign petroleum changes. Positive or negative? For different countries, the effects may be different. US, China and Japan are taken for detailed analysis by using the econometric model in the paper.

2. Variables In Econometric Model
Let’s take a look at the GDP growth of the three target countries. In the last 45 years (1965-2009), the Chinese average GDP has achieved 0.091 growth rate while US GDP being 0.029 and Japan 0.037. Especially since 1980, China’s GDP has been in pretty high and relatively stable growth. US’s GDP growth was also relatively stable for the past 39 years. And Japan’s GDP growth was comparatively
stable in the last 45 years. But Japan’s GDP growth is in a slow downward trend when compared with that of US and China. According to the stationary test on the GDP growth of the above three countries, their GDP is in stable growth.

The first independent variable in the analyzed model is the fluctuation of international petroleum price. In the according recent 45 years, the average international petroleum price rising was 0.086 with the minimum being -0.486 and maximum 2.173 in Figure 1. The steadiness of data series of international petroleum price rising was proved by the stationary test.

![Figure 1. International Petroleum Price Rising(Data from [1])](image)

The second independent variable in the analyzed model is the dependence degree on international petroleum. As for dependence on foreign petroleum, China’s dependence on foreign petroleum was -0.001 while US 0.422 and Japan 0.997 over the past 45 years. There are two crucial points of time related to the change of dependence on foreign petroleum: before 1985, China was a net exporter of petroleum and its exports peaked in 1985; after 1985, degree of dependence on foreign petroleum kept increasing. By 1993, China has become a net importer and its degree of dependence upon import has been increasing year by year. By the end of 2008, China’s degree of dependence on foreign petroleum was 0.465. US’s degree of dependence on foreign petroleum was in a slow upward trend for the past 45 years, reaching a maximum of 0.6529 in 2005. Japan’s degree of dependence on foreign petroleum was more than 0.99 and changed little for the past 45 years in Figure 2. In line with the stationary test on dependence on foreign petroleum, results show that Chinese and American dependence on foreign petroleum is in non-stationary growth, while Japan’s dependence on foreign petroleum is in stationary trend.
Figure 2. Dependence on Foreign Petroleum of China, US and Japan

The data from 1965 to 2009 are listed in Table 1 [2]. The data series are non-stationary for American and Chinese dependence on foreign petroleum, the steadiness can also be achieved by calculating growth rate. By contrast, there is no need to do calculating for the stationary data series of Japan for dependence on foreign petroleum. After calculating growth rates respectively, growth rates are demonstrated to be stable upon the stationary test.

| Variables                          | N  | Average | Standard Error | Minimum | Maximum |
|------------------------------------|----|---------|----------------|---------|---------|
| China’s annual GDP growth          | 45 | 0.091   | 0.050          | -0.057  | 0.194   |
| US’s annual GDP growth             | 39 | 0.029   | 0.022          | -0.026  | 0.072   |
| Japan’s annual GDP growth          | 45 | 0.037   | 0.037          | -0.052  | 0.129   |
| International petroleum price rising | 45 | 0.086   | 0.406          | -0.486  | 2.173   |
| China’s dependence on foreign petroleum | 38 | -0.001 | 0.261          | -0.370  | 0.475   |
| US’s dependence on foreign petroleum | 45 | 0.422   | 0.146          | 0.156   | 0.653   |
| Japan’s dependence on foreign petroleum | 45 | 0.997   | 0.001          | 0.992   | 0.998   |

Then, multivariate regression model can be established to verify how GDP growth is affected by international petroleum price rising and dependence on foreign petroleum.

3. Effect On Us
Calculation Model [3]: \( Y = a_1 + a_2 \times X_1 + a_3 \times X_2 + e \)
X1 is international petroleum price rising, X2 is rate of dependence on foreign petroleum [4].
The model is significant under the significance level of 0.05 and R2 of the whole model after modulation is 0.2301, shown in Table 2.

Under the significance level of 0.05, dependence on foreign petroleum has a notable effect on GDP growth while international petroleum price rising has no significant impact on GDP growth, shown in Table 3.
After screening through stepwise method, the dependence on foreign petroleum is elected into the model. This variable has an obvious effect on GDP growth shown in Table 4, and R2 of the whole model after modulation is 0.2659.

Estimate rate of dependence on foreign petroleum is 0.14249, which implies that GDP growth is positively correlated to growth rate of dependence on foreign petroleum. GDP growth will increase by 0.14249 units with each unit increase in the rate of dependence on foreign petroleum shown in Table 5.

Table 2 Significance of the Model (enter)

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|--------|----|----------------|-------------|---------|--------|
| Model  | US | 3  | 0.00439 | 0.00150 | 4.57 | 0.0087 |
|        | China | 3 | 0.0114 | 0.0038 | 3.56 | 0.0251 |
|        | Japan | 3 | 0.0029 | 0.0009009 | 0.2659 |

Table 3 Model Parameter Estimates (enter)

| Variable | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|----------|----|--------------------|----------------|---------|------|----|
| Intercept | US | 1 | 0.02795 | 0.00359 | 7.6 | <.00009 |
|          | China | 1 | 0.09603 | 0.00570 | 16.92 | <.00009 |
|          | Japan | 1 | 0.05867 | 0.00491 | 10.13 | <.00009 |
| X1       | US | 1 | -0.00631 | 0.00719 | -0.89 | 0.3871 |
|          | China | 1 | -0.02462 | 0.0127 | -1.91 | 0.0630 |
|          | Japan | 1 | -0.01971 | 0.00859 | -1.29 | 0.0587 |
| X2       | US | 1 | 0.12229 | 0.05527 | 2.209 | 0.0341 |
|          | China | 1 | -0.00311 | 0.00452 | -0.689 | 0.4959 |
|          | Japan | 1 | 0.00982 | 0.00981 | 0.0923 | 0.656 |

Table 4 Significance of the Model (stepwise)

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|--------|----|----------------|-------------|---------|--------|
| Model  | US | 1  | 0.00399 | 0.00399 | 12.71 | 0.0012 |
|        | China | 1 | 0.0107 | 0.0055 | 5.16 | 0.011 |
|        | Japan | 1 | 0.00192 | 0.0098 | 9.32 | 0.043 |
| Error  | US | 35 | 0.01107 | 0.0003160 |         |       |
|        | China | 34 | 0.03565 | 0.00106 |         |       |
|        | Japan | 34 | 0.01976 | 0.00267 |         |       |
| Corrected total | US | 36 | 0.01506 | 0.004629 |         |       |
|        | China | 36 | 0.02654 | 0.00267 |         |       |
Table 5 Model Parameter Estimates (stepwise)

| Variable | Parameter Estimate | Standard Error | Type II SS | F Value | Pr > F |
|----------|--------------------|----------------|------------|---------|--------|
| Intercept |                    |                |            |         |        |
| US       | 0.02635            | 0.00314        | 0.02211    | 70.02   | <.0001 |
| China    | 0.09671            | 0.00560        | 0.31647    | 302.87  | <.0001 |
| Japan    | 0.00500            | 0.00476        | 0.15712    | 157.91  | <.0001 |
| X1       |                    |                |            |         |        |
| US       | 0.00003            | 0.00323        | 0.00087    | 4.62    | 0.0082 |
| China    | -0.02669           | 0.01232        | 0.00491    | 4.75    | 0.0372 |
| Japan    | 0.00001            | 0.00212        | 0.00091    | 5.76    | 0.0071 |
| X2       |                    |                |            |         |        |
| US       | 0.14249            | 0.04002        | 0.00403    | 12.67   | 0.0010 |
| China    | -0.24123           | 0.10767        | 0.00527    | 5.03    | 0.0317 |
| Japan    | 0.00013            | 0.00067        | 0.00627    | 4.93    | 0.0572 |

4. Effect on China
Calculation model: \( Y = a_1 + a_2 \times X_1 + a_3 \times X_2 + e \)

X1 is international petroleum price rising, X2 is growth rate of dependence on foreign petroleum, e is residual error, \( a_1-a_3 \) denotes parameter estimates.

The model is significant under the significance level of 0.05 but not significant under the significance level of 0.01. And R2 of the whole model after modulation is 0.177 shown in Table 2.

Under the significance level of 0.05, international petroleum price rising and dependence on foreign petroleum have no remarkable effect on GDP growth. But under the significance level of 0.1, GDP growth is influenced significantly by international petroleum price growth and dependence on foreign petroleum shown in Table 3.

After screening through stepwise method, international petroleum price rising and dependence on foreign petroleum are selected into the model. And these two variables have a significant influence on GDP growth shown in Table 4. R2 of the whole model after modulation is 0.2941.

The estimate of international petroleum price growth is -0.02669, which means that international petroleum price rising has negative relation with GDP growth. GDP growth will decrease by 0.02669 units while international petroleum price rising per unit. Growth rate of dependence on foreign petroleum is -0.24123, that is, there exists a negative correlation between dependence on foreign petroleum and GDP growth. GDP growth will decrease by 0.24123 units with each unit increase in dependence on foreign petroleum shown in Table 5.

5. Effect On Japan
Model: \( Y = a_1 + a_2 \times X_1 + a_3 \times X_2 + e \)

X1 is international petroleum price growth, X2 is dependence on foreign petroleum.

The model is not significant under the significance level of 0.05, and R2 of the whole model after modulation is 0.0394 shown in Table II. After screening through stepwise method, there is no significant variable into the model, which indicates that both X1 and X2 have no significant effects on GDP growth.

6. Conclusion
For US, international petroleum price rising has no remarkable influence on GDP growth. The dependence on foreign petroleum is positively correlated with GDP growth: when growth rate of dependence on foreign petroleum increases per unit, GDP growth will increase by 0.14249 units.

For China, both international petroleum price rising and dependence on foreign petroleum have a negative relation with the GDP growth. When international petroleum price growth increases per unit, GDP growth will decrease by 0.02669 units. When dependence on foreign petroleum increases per unit, GDP growth will decrease by 0.24123 units.

For Japan, both international petroleum price rising and dependence on foreign petroleum have no significant impact on GDP growth.
In general, quick petroleum price rising and high dependence on foreign petroleum are likely to have an adverse impact on the economy [5]. However, our analysis shows that both the rising price of international petroleum and heavy dependence on imported petroleum have a passive influence on China’s GDP but have little impact or even a positive effect on GDP of US and Japan, which indicates that the investment and exploration of overseas petroleum resources for many years has brought profitable returns to US and Japan.

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