Analysis on the Relation between Strengthening Internal Management and Economic Benefit of China's Petrochemical Enterprises under the Restriction of Market Environment

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Abstract. This paper studies the external impact of China's energy policy and market environment changes on the economic benefits of petrochemical enterprises, and the internal impact of internal control and management of petrochemical enterprises on their economic benefits. In 2010-2017, China's energy economic policy has been adjusted, the market environment has undergone major changes. This paper quantifies these two factors into indexes and combines them with the internal control index of enterprises to apply them to the economic benefit model of petrochemical enterprises. Regression analysis has been used for positive analysis. The study finds the changes of China's energy policy have played a guiding, regulating and promoting role in the development of petrochemical enterprises; the more restrictions the market environment imposes on petrochemical enterprises, the worse the economic benefits of petrochemical enterprises are. Strengthening internal control in petrochemical enterprises can offset some unfavorable factors and the economic benefits of downstream petrochemical enterprises are better than those of upstream ones. The paper reveals the effects of energy policy action index, market environment restriction index and internal control index on economic benefits of petrochemical enterprises. The policy recommendations are as follows: The governments should improve the market environment and formulate policies that will benefit upstream petrochemical enterprises, especially oil and gas extraction enterprises, in raising product prices and increasing profit margins.

1. Introduction
Searching the Scopus database for "petrochemical enterprises" and "Economic Benefit" found that, Some western enterprises pay attention to energy efficiency or energy conversion efficiency in the process of energy development and utilization. The government regulates and supervises energy enterprises for the purpose of environmental protection. The Emerald Group Publishing Limited (2008) proposed preferential tariff rates for products for energy efficiency and environmental protection purposes\cite{1}. Raymond et al. (2011) studied the role of energy models in policy design and the potential impact of energy policies on technology diffusion in a wide range of energy sectors \cite{2}. Mauricio (2008) assessed the contribution of the energy sector to sustainable development in Latin America and the Caribbean over the past 30 years and identified key areas for improvement \cite{3}. Lga et al. (2012) reviewed and assessed Latvia's existing energy efficiency policies and measures. They believed that the planned measures for improving energy efficiency in the industrial sector did not
meet the energy conservation goals set in the framework of Latvia's national energy plan. Latvia needed to formulate a common energy efficiency strategy for the industrial sector to achieve their energy efficiency goals [4]. Piotr (2013) discussed and evaluated the continuous coal policy issued by the government in the context of the transformation of the economic system in Poland from 1989 to 2006. Although the government invested billions of zloty into the coal industry in the form of direct subsidies and debt cancellation, the policy makers failed to make the coal mine develop economically healthily. The main reason was that successive governments were unable to confront the trade unions and were unwilling to market the coal industry. The most important thing in introducing the mechanism into the industry is the reluctance to promote economic freedom nationwide[5]. Matev et al. (2014) confirmed through case studies that the transition from environmentally unfriendly fossil fuel economy to sustainable and climate-friendly development requires a realistic approach based on exceptional knowledge of alternative possibilities for development, especially new opportunities for energy utilization and renewable energy development [6]. Nadine (2017) studied the policy risk and regulatory risk of investment in renewable energy projects in developed countries in Europe, and put forward the idea of improving risk management mechanism [7]. Margarita et al. (2019) studied energy conversion efficiency, believing that direct combustion of coal, petroleum and other fuels would emit large amounts of nitrogen oxides, sulfur oxides, carbon dioxide and fly ash to pollute the environment, among which coal combustion is one of the most harmful fuels to the environment. An advanced method to solve the environmental pollution problem of coal-fired enterprises is to process coal into fuel slurry containing water and waste flammable liquid, which is called "CWS" or "CWSP" containing petrochemical products [8].

Referring to China Knowledge Network (CNKI) and searching articles related to economic data and economic benefits of petrochemical enterprises under the title of the article, the article can be divided into two categories: One category of articles dealing with the topic of "economic operation" is mainly the data provided by China Petroleum and Chemical Industry Federation [9] and Zhao Zhiping et al. [10]. The other category is related to the topic of "economic efficiency". Five of them are academic research papers: Zhang Deyi (1993, 1994) discussed the ways to improve economic benefits of petrochemical enterprises from the perspective of new technology promotion [11], deep processing of crude oil [12]. Wang Yexiang (1997) put forward the Countermeasures of improving economic benefits of petrochemical enterprises from the aspects of optimizing resource allocation[13]. Dengkashan (2005) discussed ways and means to improve economic benefits from the perspective of power system of petrochemical enterprises [14]. Wang Guohua (2006) discussed the countermeasures to improve economic benefits from strengthening project management and controlling construction cost in petrochemical construction enterprises[15].

Referring to China Knowledge Network (CNKI), there are seven empirical methods introduced in the model articles related to "petrochemical enterprises": (1) Li Jindong (2004) used the "non-linear mathematical programming method" to establish the optimization model of boiler units, and optimized the heating and steam supply system of petrochemical enterprises, in order to improve economic efficiency [16].(2) Li Chufu et al. (2005) developed a graphical production planning optimization system for petrochemical enterprises by using the "graphical configuration tool library". The simplex method was used to optimize the production and operation process and realize the profit maximization of enterprises [17].(3) Longguan et al. (2006) used the "cost change analysis model" to analyze the change of production cost in petrochemical enterprises [18].(4) Yang Ruichong et al. (2009) used the "cost composition method" to set variables to control the water cost in the water use process of petrochemical enterprises [19].(5)Shilu (2015) constructed a "linear regression efficiency model" to optimize the steam power system to achieve the goal of "energy saving and efficiency improvement"[20].(6) Zhu Liangfeng et al. (2016) used “factor analysis” to determine the downward pressure index of economic of petrochemical enterprises[21].(7) Wang weixing et al. (2017) used "exponential function model and quadratic function model" to calculate the economic downturn pressure coefficient [22], thus predicting the economic development prospects of the petrochemical industry [23].

The above domestic and foreign studies show that foreign studies focus on improving the conversion efficiency of energy production and processing enterprises from the perspective of
reducing environmental pollution, and seldom use financial indicators to analyze the economic benefits of enterprises. Domestic research pays attention to the economic benefits of petrochemical enterprises and pays attention to the practical application value of research results, but most of the contents and models of the economic benefits of petrochemical enterprises focus on the inside of enterprises, seldom organically combine the internal and external factors of enterprises, and seldom specially study the economic benefits of different types of petrochemical enterprises. This paper intends to make an exploratory study on the economic benefits of petrochemical enterprises by using financial indicators in terms of external market environment, internal management and control.

2. Study on the External Market Environment Factors Restricting the Development of China's Petrochemical Enterprises

2.1. Index design of Restrictive Factors of External Market Environmental

The economic benefits of China's Petrochemical enterprises are mainly restricted by the external market environment in six aspects: (1) The impact of changes in international crude oil prices. There are two main reasons: first, if the international crude oil price rises, the domestic product oil price remains unchanged, or the fluctuation is lower than that of the international oil price, the profit of the enterprise will decrease, which directly affects the economic benefits of the enterprise; second, the Chinese government stipulates that the price of Chinese product oil will change with the fluctuation of the international oil price. If the international oil price falls too much, China's Petrochemical enterprises will also fall along with it. (2) The impact of changes in China's gross domestic product (GDP). An important indicator of China's economic development (level) is gross domestic product (GDP). In 2010, China's GDP fell to 10.6% compared with the previous year and 6.6% in 2018. That is to say, China's "high-speed" growth trend has changed to "medium-high-speed" growth trend. This change of economic environment will inevitably affect the development of petrochemical enterprises: when the economy rises, the economic benefits of petrochemical enterprises will rise; when the economy goes down, the economic benefits of petrochemical enterprises will decline. (3) The impact of changes in the proportion of China's oil consumption to total energy consumption. The Chinese government has formulated energy policies and regulations to reduce the proportion of fossil energy (coal, oil and natural gas) in total energy consumption and increase the proportion of non-fossil energy (wind, water, solar, nuclear, biomass, geothermal, marine and other renewable energy). The main reasons are that fossil energy emits too much carbon in the process of consumption and pollutes the environment, to limit. (4) The influence of government's carbon emission restriction on the economic benefits of petrochemical enterprises. On November 25, 2009, Premier Wen Jiabao of the Chinese Government announced to the world that carbon dioxide emissions per unit of gross domestic product of China will decrease by 40%-45% by 2020 compared with 2005. According to data released by the International Energy Agency (IEA) on May 24, 2012, coal accounts for 45% of global carbon dioxide emissions, 35% of oil emissions and 20% of natural gas emissions[24]. The Chinese government has taken strong measures to limit carbon emissions. Among them, limiting carbon emissions from fossil energy consumption, including petroleum consumption, will inevitably affect the demand for petroleum and finished goods from petroleum raw materials and the economic benefits of petrochemical enterprises. Every year, the National Bureau of Statistics of China publishes the emission of major pollutants in wastet gas by regions of China, including the emission of sulphur dioxide, nitrogen oxides, smoke and dust. On January 1, 2018, the Chinese Government formally implemented the Environmental Protection Tax Law, which stipulates that all units shall pay environmental protection tax to the state for the discharge of pollutants[25]. In order to pay less environmental protection tax, some units need to reduce the consumption of petrochemical products, thus affecting the economic benefits of petrochemical enterprises. (5) In order to save energy, the Chinese government has formulated a policy of saving energy and reducing consumption, which is to reduce the amount of energy consumption in products and services. The state has formulated an index of "energy consumption of 10,000 yuan GDP", which is used to assess the energy consumption of the regions and units under the management of government officials at all levels. China's government officials at all levels to focus on work of saving energy and reducing consumption will inevitably...
affect the consumption of oil, coal and other energy, and bring adverse economic benefits to petrochemical enterprises and other energy production units. (6) The influence of China Petroleum on the change of its dependence on foreign countries. China's domestic petroleum consumption is very large. When the petroleum products produced by domestic production enterprises cannot meet the demand, it is necessary to import petroleum from abroad. The proportion of imported petroleum to China's total petroleum consumption is called "the degree of dependence of China's petroleum on foreign countries". The larger the amount of oil imported from abroad, the smaller the proportion of oil consumption in the production and supply market of domestic enterprises (referred to in the paper as "self-sufficiency consumption rate of China's petroleum"), and the more the economic benefits will be affected. 

\[
\text{self-sufficiency consumption rate of China's petroleum} = 1 - \text{degree of dependence of China's petroleum}
\]

From 2010 to 2017, the specific data of China's Petrochemical enterprises impacted by external market environment are shown in Table 1:

| index | Unit/speed   | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  |
|-------|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Rate of Change of WTI Price  | USD/barrel | 46.34 | 81.51 | 90.3  | 101.81| 93.09 | 93.96 | 52.69 | 36.76 | 53.26 |
| Rate of Change of GDP  | Current/previous | 1.7590 | 1.1078 | 1.1275| 0.9144| 1.0093| 0.5608| 0.6907| 1.4489|
| Rate of change in the proportion of oil consumption  | preceding year=100 | 1.1060 | 1.0950 | 1.0790| 1.0780| 1.0730| 1.0690| 1.0670| 1.0690|
| Rate of change of Carbon Emission  | Current/previous | 1.0610 | 0.9655 | 1.0119| 1.0059| 1.0175| 1.0517| 1.0109| 1.0162|
| Rate of change of Oil Consumption/10000yuanGDP self-sufficiency consumption rate of China's petroleum  | Current/previous | 0.19167 | 0.1257 | 0.11427| 0.11427| 0.1028| 0.1028| 0.07998| 0.07998| 0.07481|
| %  | 45.20% | 43.30% | 43.60% | 41.60% | 40.50% | 40.20% | 35.60% | 32.60% |

Data source: International Crude Oil Network: https://www.plasway.com/price/price_base_d.jsp; China Statistical Yearbook; Website of National Bureau of Statistics of China: http://www.stats.gov.cn/

2.2. Model Construction and Application of External Restrictive Factors

From the above analysis, there are six external market environment factors impacting the economic benefits of China's Petrochemical enterprises. The concept of "market environment restriction index" is defined by combining the six factors. The model is as follows:

\[
\text{MarkRes}=a_1\text{WTIPrice}+a_2\text{IndicGDP}+a_3\text{CrudeOil}+a_4\text{CarbonEmi}+a_5\text{PetroGDP}+a_6\text{InerPetr}
\]

In model (1), MarkRes—Market Environment Restriction Index; WTIPrice—Rate of Change of International Crude Oil (WTI) Price; IndicGDP—Rate of Change of GDP; CrudeOil—Rate of change in the proportion of oil consumption; CarbonEmi—Rate of change of Carbon Emission; PetroGDP—Rate of change of Oil Consumption/10000 yuan GDP; InerPetr—self-sufficiency consumption rate of China's petroleum.

Model (1) The applied data are "Unit/speed" column data in of table 1 above from 2010 to 2017. The model (1) uses SPSS22.0 software and "factor analysis" to operate. The results are shown in Tables 2 and Tables 3:
Table 2. Total Variance explained

| Component | Initial Eigenvalues | Extraction Sums of Squared Loadings |
|-----------|---------------------|-------------------------------------|
| Total     | % of Variance       | Cumulative %                        |
| 1         | 3.047               | 50.777                              |
| 2         | 1.426               | 23.763                              |
| 3         | 0.853               | 14.224                              |
| 4         | 0.485               | 8.087                               |
| 5         | 0.172               | 2.872                               |
| 6         | 0.017               | 0.278                               |
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| 5         | 0.172               | 2.872                               |
| 6         | 0.017               | 0.278                               |

Retrieval method: Principal component analysis.

Tables 3. Component matrix

| symbol     | variable                      | Component         | 1   | 2   | 3   | 4   | 5   | 6   |
|------------|-------------------------------|-------------------|-----|-----|-----|-----|-----|-----|
| WTPrice    | Rate of Change of WTI Price   | 0.657             | -0.084 | 0.706 | 0.234 | 0.077 | -0.045 |
| IndicGDP   | Rate of Change of GDP         | 0.914             | 0.170  | 0.221 | -0.282 | 0.020 | 0.090 |
| CrudeOil   | Rate of change in the proportion of oil consumption | 0.336 | -0.850 | -0.264 | 0.262 | 0.160 | 0.038 |
| CartonEmi  | Rate of change of Carbon Emission | 0.687 | 0.474  | -0.264 | 0.453 | -0.169 | 0.016 |
| PetroGDP   | Rate of change of Oil Consumption/10000 yuan GDP | -0.742 | 0.567  | 0.105 | 0.229 | 0.249 | 0.043 |
| InerPetr   | self-sufficiency consumption rate of China's petroleum | 0.803 | 0.349  | -0.395 | -0.156 | 0.223 | -0.055 |

Retrieval method: Principal component analysis.a. Retrieve 6 components.

In Table 2, Total coefficient of Initial Eigenvalues 3.047, 1.426, 0.853, 0.485, 0.172, 0.017 were extracted a root as 1.7456, 1.1942, 0.9236, 0.6964, 0.4147, 0.1304, respectively. Divide each coefficient of component 1 (i.e. column 1) in Table 3 by 1.7456, and the other columns 2, 3, 4, 5 and 6 by 1.1942, 0.9236, 0.6964, 0.4147 and 0.1304, respectively, to obtain the following linear equations:

\[ z_1 = 0.3765 \text{WTIPrice} + 0.5233 \text{IndicGDP} + 0.1924 \text{CrudeOil} + 0.3933 \text{CartonEmi} + 0.4250 \text{PetroGDP} + 0.4603 \text{InerPetr} \]

\[ z_2 = -0.07 \text{WTIPrice} + 0.1428 \text{IndicGDP} - 0.7115 \text{CrudeOil} + 0.3967 \text{CartonEmi} + 0.4751 \text{PetroGDP} + 0.292 \text{InerPetr} \]

\[ z_3 = 0.7643 \text{WTIPrice} + 0.2388 \text{IndicGDP} - 0.286 \text{CrudeOil} - 0.286 \text{CartonEmi} + 0.1142 \text{PetroGDP} - 0.4274 \text{InerPetr} \]

\[ z_4 = 0.3359 \text{WTIPrice} - 0.4043 \text{IndicGDP} + 0.3764 \text{CrudeOil} + 0.6509 \text{CartonEmi} + 0.3292 \text{PetroGDP} - 0.2246 \text{InerPetr} \]

\[ z_5 = 0.1868 \text{WTIPrice} + 0.4074 \text{IndicGDP} + 0.3851 \text{CrudeOil} - 0.4085 \text{CartonEmi} + 0.6012 \text{PetroGDP} + 0.5386 \text{InerPetr} \]

\[ z_6 = 0.6883 \text{IndicGDP} - 0.3457 \text{WTIPrice} + 0.2893 \text{CrudeOil} + 0.1256 \text{CartonEmi} + 0.3306 \text{PetroGDP} - 0.4228 \text{InerPetr} \]

The total score of the six extracted factors is calculated by the weight of variance contribution in Table 2. The formula is as follows:

\[ Z = z_1 \times 0.50777 + z_2 \times 0.23763 + z_3 \times 0.14224 + z_4 \times 0.08087 + z_5 \times 0.02872 + z_6 \times 0.00277 \]

Through SPSS22.0 software "conversion"----"calculation variables", the total scores of the factors proposed in 2010-2017 were 1.2012, 0.9802, 0.9589, 0.8996, 0.9646, 0.7560, 0.7124 and 0.9900.

The determination of market environment restriction index: Firstly, the fixed base ratio is calculated. Based on the score of 1.2012 in 2010, base ratio in 2010 = 100% (1.0000); base ratio in 2011= 0.9802
\[ 1.2012 \div 0.8160; \text{base ratio in 2012}=0.9589 \div 1.2012=0.7983; \text{base ratio in 2013}=0.8996 \div 1.2012=0.7489; \text{base ratio in 2014}=0.9646 \div 1.2012=0.8030; \text{base ratio in 2015}=0.7560 \div 1.2012=0.62937; \text{base ratio in 2016}=0.7124 \div 1.2012=0.5931; \text{base ratio in 2017}=0.9900 \div 1.2012=0.8242. \]

Secondly, the market environment restriction index is calculated. The reciprocal of the fixed base ratio is used as the market environment restriction index.

| Year   | Market Environment Restriction Index | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|--------|-------------------------------------|------|------|------|------|------|------|------|------|
| 2010   | 1.2255                              | 1.000| 1.2527| 1.3353| 1.2453| 1.5889| 1.6861| 1.2133|
| 2011   | 1.2527                              | 1.2255| 1.3353| 1.2453| 1.5889| 1.6861| 1.2133|
| 2012   | 1.3353                              | 1.3353| 1.2453| 1.5889| 1.6861| 1.2133|
| 2013   | 1.2453                              | 1.2453| 1.5889| 1.6861| 1.2133|
| 2014   | 1.5889                              | 1.5889| 1.6861| 1.2133|
| 2015   | 1.6861                              | 1.6861| 1.2133|
| 2016   | 1.2133                              | 1.2133|

3. Study on the Factors of Controlling the Internal Consumption of Personnel, Property and Material in China's Petrochemical Enterprises

3.1. Improving the Internal Control Level of China's Petrochemical Enterprises and Its Evaluation

On May 22, 2008, the Chinese government issued "Basic Standards for Enterprise Internal Control". On April 15, 2010, the Chinese government issued "Guidelines for the Application of Enterprise Internal Control", "Guidelines for the Evaluation of Enterprise Internal Control" and "Guidelines for the Audit of Enterprise Internal Control", which regulated the content control activities of Chinese enterprises (Listed company and unlisted large and medium-sized enterprises). In order to evaluate the level of enterprise internal control, in 2011, Dibo Enterprise Risk Management Technology Co., Ltd., the first professional organization in China with internal control and risk management as its main business direction, was established in Shenzhen, Guangdong Province, China. The company has established a "DIB database". This database reflects the internal control and risk management of Chinese listed companies on the basis of foreign Audit Analytics Database. Among them, "Internal Control Base" is independently studied and created by Diboda Data Research Center. From the perspective of five elements of internal control (internal environment, risk assessment, control activities, information and communication, internal supervision), it designs and constructs nine sub-databases, such as internal control evaluation information base and internal control index database, which objectively and truly reflects the internal control of listed companies in China. The system level is the first professional and authoritative internal control information database in China, which has been recognized by high-end professionals in the field of internal control research in China and has been widely used [26]. The paper refers to the "internal control index" of Listed Companies in petrochemical industry in DIB database, and collates them according to industry (the internal control index of Listed Companies in various industries is added up to average, and then divided by 100, so as to match the data of the following model). See Table 5:

| type                                           | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   |
|------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1. Extraction of Petroleum and Natural Gas     | 0.6507 | 0.8919 | 0.8020 | 0.7121 | 0.6836 | 0.6592 | 0.6973 | 0.6861 |
| 2. Processing of Petroleum, Coking and Processing of Nuclear Fuel | 0.6664 | 0.7128 | 0.6331 | 0.6234 | 0.6234 | 0.6285 | 0.6597 | 0.6728 |
| 3. Manufacture of Raw Chemical Materials and Chemical Products | 0.6612 | 0.6818 | 0.6835 | 0.6508 | 0.6411 | 0.6299 | 0.6437 | 0.6480 |
| 4. Average of all petrochemical industries     | 0.6594 | 0.7622 | 0.7062 | 0.6621 | 0.6494 | 0.6392 | 0.6669 | 0.6690 |

Data source: http://www.dibcn.com/
3.2. Consumption Factors of Personnel, Property, physical assets in Petrochemical Enterprises

To achieve good economic benefits, petrochemical enterprises must invest a certain amount of personnel, property, physical assets in the process of production and operation, which are not only the investment of funds, but also the consumption of production process. When the production process of petrochemical products is completed and petrochemical products are provided to the society, the accounting statements of petrochemical enterprises provide relevant data of consumption on personnel, property, physical assets. The paper uses relevant data to calculate the indicators related to the economic benefits of enterprises: total profit, total assets, total cost, asset-liability ratio, asset turnover rate, etc.

4. Construction and Application of Model of Internal and External Constraints and Economic Benefit of China's Petrochemical Enterprises

4.1. Thinking of Model Construction

First of all, it should be based on the industrial chain of petrochemical enterprises. The industrial chain of petrochemical enterprises is shown in Figure 1:

![Figure 1. Industrial Chain Diagram of Petrochemical Enterprises](image)

As can be seen from Figure 1, petrochemical enterprises have three major industries to form the industrial chain: extraction of petroleum and natural gas; processing of petroleum, coking; manufacture of raw chemical materials and chemical products. Since the national energy industry takes crude oil, natural gas, product oil and coke as energy products for statistical summary, the paper designs the model by incorporating oil and gas exploitation, petroleum processing and coking industries, collectively known as "oil gas exploitation and oil products processing enterprises". Three models are set up: oil gas exploitation and oil products processing enterprise model, raw chemical materials and chemical products enterprise model, and all petrochemical enterprise model.

Secondly, the setting of variables. The variable being explained is change rate of total profit, because the economic benefits of enterprises are usually reflected by "total profit". There are three explanatory variables: one is market environment restriction index; the other is internal control index; and the third is external and internal control interaction value. There are four control variables: total assets logarithm; change rate of cost; leverage ratio; turnover of assets. There are two dumb variables: year and types of enterprises.

Thirdly, the definition of variables. Variable definitions are shown in Table 6:
Tables 6. Variable Settings and Definitions

| Variable Being Explained | Symbol | Variable definitions |
|--------------------------|--------|----------------------|
| Change rate of total profit | ProfG | Rate of current total profits to total profits of the previous period |
| Market environmental restriction index | MarkRes | Market environmental restriction index in 2010-2017 of table 4 |
| Internal control index | Contr | DIB "Internal Control Index" in Table 5 |
| External and internal control interaction value | ContrMarkRes | Calculating the average value of interaction coefficient in 2010-2017, the interaction coefficient in a given year is larger than the average value, take 1, and vice versa, take 0. |
| Total assets logarithm | LnAssets | Logarithm of current total assets |
| Cost | Cost | Total costs = Cost of principal business + selling expenses + administrative expenses + financial expenses; Change rate of cost = current total cost / total cost of the previous period |
| Leverage ratio | LEV | Ratio of end-of-period total liabilities to end-of-period total assets |
| Turnover of assets | AsTur | Ratio of current revenue from principal business to total assets at the end of the period |
| Year | Year | According to the sample of 2010-2017, eight annual dummy variables were set up |
| Types of enterprises | Type | Extraction of petroleum and natural gas 1; Processing of petroleum, coking and processing of nuclear fuel 2; Manufacture of raw chemical materials and chemical products 3; All petrochemical enterprises 4 (four types of enterprises are "industrial Enterprises above designated size") |

4.2. Construction of Classification Model

4.2.1. Construction of all petrochemical enterprise model (subscript "All")

\[
\text{ProfG}_{\text{all}} = \beta_0 + \beta_1 \text{MarkRes} + \beta_2 \text{Contr} + \beta_3 \ln\text{Assets} + \beta_4 \text{Cost} + \beta_5 \text{LEV} + \beta_6 \text{AsTur} + \beta_7 \text{Year} + \beta_8 \text{Type} + \epsilon (2)
\]

4.2.2. Construction of oil gas exploitation and oil products processing enterprise model (subscript "oil")

\[
\text{ProfG}_{\text{oil}} = \gamma_0 + \gamma_1 \text{MarkRes} + \gamma_2 \text{ContrMarkRes} + \gamma_3 \ln\text{Assets} + \gamma_4 \text{Cost} + \gamma_5 \text{LEV} + \gamma_6 \text{AsTur} + \gamma_7 \text{Year} + \epsilon (3)
\]

4.2.3. Construction of raw chemical materials and chemical products enterprise model (subscript "chem")

\[
\text{ProfG}_{\text{chem}} = \delta_0 + \delta_1 \text{MarkRes} + \delta_2 \text{Contr} + \delta_3 \ln\text{Assets} + \delta_4 \text{Cost} + \delta_5 \text{LEV} + \delta_6 \text{AsTur} + \delta_7 \text{Year} + \epsilon (4)
\]

The above model is residual. The above model (3) has two reasons for setting "external and internal control interaction value" (ContrMarkRes): (1) Oil and gas exploitation enterprises sell crude oil to petroleum processing enterprises and coal coke enterprises to produce finished oil (gasoline, diesel, kerosene) and coke. These oil-related energy products are particularly affected by international oil prices, that is, external factors restrict a very important role. Some petroleum processing enterprises also import crude oil for processing. The fluctuation of international petroleum prices has a more direct impact on their economic benefits. (2) Strengthening internal management, capital budget and cost control are important internal reasons for improving economic benefits of enterprises. According to the principle of materialist dialectics in philosophy, "external factors are the conditions of change, internal factors are the basis of change, external factors play a role through internal factors"[27]. The market environment restriction index and internal control index are reflected mutually, and the intensity of interaction between them can be better observed.
4.3. Sample Selection and Data Sources
Model (2) (3) (4) cites data of variable being explained and control variable from "China Statistical Yearbook" and website of National Bureau of Statistics of China(http://www.stats.gov.cn/). The specific sample situation is as follows:(1)Sample of oil gas exploitation and oil products processing enterprise: From 2010 to 2017, the average annual aggregate data of 157 enterprises in extraction of petroleum and natural gas above designated size are collected; From 2010 to 2017, the average annual aggregate data of 1970 enterprises in processing of petroleum, coking and processing of nuclear fuel above designated size are collected; (2) From 2010 to 2017, the average annual aggregate data of 23806 enterprises in manufacture of raw chemical materials and chemical products above designated size are collected; (3) From 2010 to 2017, the average annual aggregate data of 25933 enterprises in all petrochemical enterprise above designated size are collected. The annual aggregated data of all petrochemical enterprises are compiled from the annual aggregated data of extraction of petroleum and natural gas enterprises, processing of petroleum, coking and processing of nuclear fuel enterprises and manufacture of raw chemical materials and chemical products enterprises.

The explanatory variables in model (2) (3) (4) are derived from the market environment restriction index 2010-2017 in Table 4 and the internal control index of listed petrochemical companies 2010-2017 in table 5. External and internal control interaction values are determined according to the calculation in Table 6.

4.4. Application of the Model and Regression Results
4.4.1. Application of the Model
The model (2) (3) (4) is operated by SPSS22.0 software: descriptive statistics - collinearity test - correlation analysis - linear regression analysis. The results are shown in Table 7 and regression equation.

| variable | all petrochemical enterprise | oil gas exploitation and oil products processing enterprise | raw chemical materials and chemical products enterprise |
|----------|------------------------------|----------------------------------------------------------|------------------------------------------------------|
|          | minimum | Maximum | mean | minimum | Maximum | mean | minimum | Maximum | mean |
| Change Rate of total profit | -0.8190 | 9.3813 | 1.2401 | -0.8190 | 9.3813 | 1.3622 | 0.9299 | 1.6650 | 1.1474 |
| Market environmental restriction index | 1.0000 | 1.6861 | 1.3184 | 1.0000 | 1.6861 | 1.3184 | 1.0000 | 1.6861 | 1.3184 |
| Internal control index | 0.6234 | 0.8919 | 0.6768 | 0.6234 | 0.8919 | 0.6877 | 0.6299 | 0.6835 | 0.6550 |
| External and internal control interaction value | 0.0000 | 1.0000 | 0.5000 | | | | | | |
| Total assets logarithm | 9.6594 | 11.7265 | 10.5984 | 9.6594 | 10.2490 | 9.9354 | 10.5655 | 11.2445 | 10.9961 |
| Change rate of cost | 0.7756 | 1.4191 | 1.0841 | 0.7756 | 1.4191 | 1.0626 | 0.9298 | 1.2917 | 1.1121 |
| Leverage ratio | 0.4369 | 0.6639 | 0.5557 | 0.4369 | 0.6639 | 0.5539 | 0.4699 | 0.5794 | 0.5519 |
| Turnover of assets | 0.3236 | 1.9753 | 1.1474 | 0.3236 | 1.9753 | 1.0962 | 1.0710 | 1.3379 | 1.2120 |

From Table 7, it can be seen that the average change rate of total profits of all petrochemical enterprises is 1.2401, of which 1.3622 is for oil gas exploitation and oil products processing enterprises and 1.1474 is for raw chemical materials and chemical products enterprises. The average of market environment restriction index of all types of petrochemical enterprises is 1.3184. The average of internal control index of all petrochemical enterprises is 0.6768, of which 0.6877 is for oil gas...
exploitation and oil products processing enterprise, 0.6550 is for raw chemical materials and chemical products enterprise. Average of total assets logarithm of all petrochemical enterprises is 10.5984, of which 9.9354 is for oil gas exploitation and oil products processing enterprise, 10.9961 is for raw chemical materials and chemical products enterprise. Average of change rate of cost of all petrochemical enterprises is 1.0841, which 1.0626 is for oil gas exploitation and oil products processing enterprise, 1.1121 is for raw chemical materials and chemical products enterprise. Average of all petrochemical enterprises is 0.5557, of which 0.5539 is for oil gas exploitation and oil products processing enterprise, 0.5519 is for raw chemical materials and chemical products enterprise. Average of turnover of assets of all petrochemical enterprises is 1.1474 times, which 1.0962 is for oil gas exploitation and oil products processing enterprise, 1.2120 is for raw chemical materials and chemical products enterprise. Generally speaking, the economic benefit level of petrochemical enterprises is good, and the total profit increased by 14.72%-36.22% on average in 2010-2017.

4.4.2. Reveal of Regression Equation
Through regression analysis, the following regression equations (2)', (3)', (4)'

\[
\begin{align*}
\text{ProfGoil} &= 2.116 - 0.334\text{MarkRes} - 0.644\text{Contr} + 0.739\text{LnAssets} + 1.023\text{Cost} - 17.518\text{LEV} + 0.053\text{AsTur}\text{(2)'} \\
\text{ProfG}_{\text{c}} &= 227.319 - 15.802\text{MarkRes} + 4.813\text{Contr}\text{MarkRes} - 40.957\text{Cost} - 250.048\text{LEV} \text{(3)'} \\
\text{ProfG}_{\text{chem}} &= 4.641 + 0.040\text{MarkRes} + 2.223\text{Contr} - 0.410\text{LnAssets} + 2.059\text{Cost} + 2.459\text{LEV} - 3.416\text{AsTur} \text{(4)'} \\
\end{align*}
\]

4.5. Basic Analysis of Regression Equation
4.5.1. Regression Equation (2)’: Economic Benefit Analysis of All Petrochemical Enterprises
By analyzing the above regression equation (2)', the following conclusions are drawn:

1. Market environmental restriction index (MarkRes) is negatively correlated with the economic benefits of petrochemical enterprises. The coefficient of equation is -0.334. It is consistent with the direction of the T-test coefficient -9.849, both of which are negative. The regression equation coefficients are used instead of T-test coefficients to correlate more directly with the regression equation; Saliency sig. is 0.064 < 0.1, which indicates that the greater the restrictive effect of China's market environment on Petrochemical enterprises, the more factors that force them to do so [28], and the worse the economic benefits of petrochemical enterprises [29].

2. Internal control index (Contr) is negatively correlated with the economic benefits (ProfG) (equation coefficient is -0.644), but not significant (saliency Sig. is 0.186 > 0.1). This indicates that petrochemical enterprises have not produced good economic benefits by strengthening internal management and control under unfavorable external market environment. On the contrary, the worse the external market, the more internal intervention and control, the greater the enthusiasm suppression of internal units and their employees, and the worse the economic benefits of enterprises.

3. From the relationship between controlling variables and economic benefits of petrochemical enterprises, it can be seen that expanding the scale of assets, increasing the necessary cost and expediting the turnover of assets are beneficial to improving the economic benefits of enterprises. The positive correlation coefficients of regression equation are 0.739, 1.023 and 0.053, respectively. The significant levels of Sig are 0.078 < 0.1 and 0.826 > 0.1, i.e. total assets logarithm (LnAssets), rate of cost to profit (Cost) passed the significance test, turnover of assets (AsTur) failed to pass the significance test, but the economic benefit of petrochemical enterprises would be worse if they raised the debt level (LEV). The negative correlation coefficient of regression equation was -17.518, and the significant level of Sig was 0.049 < 0.05, that is, the LEV was significantly negatively correlated with the economic benefit at the level of 0.05.

4.5.2. Regression Equation (3)’: Economic Benefit Analysis of Oil Gas Exploitation and Oil Products Processing Enterprise
By analyzing the above regression equation (3)', the following conclusions are drawn:

1. Market environmental restriction index (MarkRes) is negatively correlated with the economic benefits of enterprises (ProfG). The coefficient of equation is -15.802; Saliency sig. is 0.027 < 0.05 indicates that the greater the restrictive effect of China's market environment on oil gas exploitation and oil products processing enterprise, the worse the economic benefits of enterprises.

2. External and internal control interaction value (ContrMarkRes) is positively correlated with economic benefits. The coefficient of regression equation is 4.813. The significance coefficient Sig. is
0.016 < 0.05. It shows that oil and gas exploitation and oil processing enterprises strengthen internal management and control under unfavorable external market environment, and change pressure into power, that is, external causes are good through internal causes. It has promoted the improvement of economic benefits of enterprises.

(3) From the relationship between control variables of oil gas exploitation and oil gas exploitation and oil products processing enterprise and economic benefits of enterprises, it can be seen that increasing cost (Cost) and expanding debt level (LEV) will reduce economic benefits of enterprises. The negative correlation coefficients of regression equation are -0.957 and -250.048, respectively. The significant coefficients Sig. are 0.004 < 0.01 and 0.009 < 0.01, respectively.

4.5.3. Regression Equation (4)': Economic Benefit Analysis of Raw Chemical Materials and Chemical Products Enterprise

By analyzing the above regression equation (4)', the following conclusions are drawn:

(1) Market environmental restriction index(MarkRes) is positively correlated with the economic benefits of enterprises. The regression equation coefficient is 0.040, but it fails to pass the significance test. The significance coefficient Sig. is 0.375 > 0.1. It shows that the greater the restrictive effect of China's market environment on raw chemical materials and chemical products enterprise, the stronger the endogenous power of enterprises, the better the economic benefits, but not significant.

(2) Internal control index (Contr) is positively correlated with the economic benefits of enterprises. The regression equation coefficient is 2.223, but it has not passed the significance test. The significance coefficient Sig. is 0.141 > 0.1. It shows that strengthening the internal management and control of raw chemical materials and chemical products enterprise can produce good economic benefits, but not very significant.

(3) From the relationship between control variables and economic benefits of raw chemical materials and chemical products enterprise, it can be seen that increasing necessary cost (Cost) and moderately increasing liabilities (LEV) are beneficial to improving economic benefits of enterprises. The positive correlation coefficients are 2.059 and 2.459, respectively. Significance coefficients Sig. are 0.048 < 0.05 and 0.047 < 0.05, respectively, but chemical raw materials and products enterprises expand. Large-scale assets (LnAssets) will make the economic benefits of enterprises worse. Negative correlation coefficient is -0.410, and it has not passed the significance test. Significance coefficient Sig. is 0.111 < 0.1. Even if we speed up asset turnover (AsTur), it will not improve the economic benefits of enterprises. The correlation coefficient of regression equation is -3.416, and the significance test coefficient is 0.019 < 0.05.

4.5.4. Comprehensive Analysis of Regression Equation——Comprehensive Analysis of Economic Benefits of Various Types of Enterprises

The "mean" in Table 7 descriptive statistics is substituted into the models (2)', (3)', (4)', and the following results are obtained:

\[ \text{ProfGall}=2.116-0.334 \times 1.3184-0.644 \times 0.6768+0.739 \times 10.5984+1.023 \times 1.0841-7.518 \times 0.5557+0.053 \times 1.1474=0.5071 \]

\[ \text{ProfGoil}=227.319-15.802 \times 1.3184+4.813 \times 0.5000-40.957 \times 1.0626-250.048 \times 0.5539=26.8696 \]

\[ \text{ProfGchem}=4.641+0.040 \times 1.3184+2.223 \times 0.6550-0.410 \times 10.9961+2.059 \times 1.1121+2.459 \times 0.5519-3.416 \times 1.2120=1.1481 \]

The results show that the mean (average) "change rate of total profit" of all petrochemical enterprises in 2010-2017 is 0.5071 (minimum), the mean (average) "change rate of total profit" of oil gas exploitation and oil products processing enterprise is 26.8696 (maximum), and the mean (average) "change rate of total profit" of raw chemical materials and chemical products enterprise is 1.1481 (general). The actual average of "change rate of total profit " of raw chemical materials and chemical products enterprise in this data 1.1481 and Table 7 is basically similar to 1.1474 (that is, the average residual=1.1474-1.1481=-0.0007=0, which is exactly the same as the total residual average calculated by SPSS 22.0 software is 0.0000). The main reason why the economic benefit of oil gas exploitation and oil products processing enterprise (average of change rate of total profit is 26.8696) is better than that of raw chemical materials and chemical products enterprise (average of change rate of total profit is 1.1481) is that China's oil price has a better development space, and the pollution problem of chemical enterprises is constantly limited (many enterprises are closed down) which affects the
economic benefit of chemical enterprises. The number of raw chemical materials and chemical products enterprise decreased from 29504 in 2010 to 23366 in 2017.

5. Research Conclusion
From 2010 to 2017, the complex and changeable market environment at domestis and abroad has led a lot of disadvantage to the development of China's petrochemical enterprises. China's petrochemical enterprises combine the unfavorable factors of market environment with the internal management and control of enterprises. That is to say, focusing on seizing market opportunities and making up for market deficiencies can produce good economic benefits. If China’s petrochemical enterprises are helpless under the external environment restriction and can not turn pressure into power, the economic benefits will decline. At the same time, China's petrochemical enterprises will control costs and level of LEV, the effective allocation of assets and the acceleration of funds turnover can make the economic benefits of enterprises continue to rise [30]. The government should improve the market environment and formulate policies conducive to increasing the profit development space of downstream petrochemical enterprises (raw chemical materials and chemical products enterprise) [31].

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References
[1] Emerald Group Publishing Limited.VAT may support energy efficiency push in Europe[EB/OL]. http://dx.doi.org/10.1108/meq.2008.08319aab.005.
[2] Raymond J.G.M. Florax, Henri L.F. de Groot and Peter MulderEdward Elgar. Improving Energy Efficiency Through Technology – Trends, Investment Behaviour and Policy Design[J]. Management of Environmental Quality: An International Journal, 2011, 23(4):352.
[3] Mauricio Garrón Bozo.Energy policies in Latin America and the Caribbean and the evolution of sustainability[J]. International Journal of Energy Sector Management, 2008(1): 8 - 35.
[4] Liga Ozoliņa, Marika Rošģa.A review of energy efficiency policy and measures for industries in Latvia[J]. Management of Environmental Quality: An International Journal, 2012(5): 517 - 526.
[5] Piotr Zientara.Polish Government policy for coal(1989 - 2006)[J]. International Journal of Energy Sector Management, 2007(3): 273 - 294.
[6] Matevž Pušnik , Boris Sučič. Integrated and realistic approach to energy planning – a case study of Slovenia [J]. Management of Environmental Quality: An International Journal, 2014(1): 30 - 51.
[7] Nadine Gatertz, Thomas Kosub.Determinants of policy risks of renewable energy investments[J]. International Journal of Energy Sector Management, 2017,11(10):28-45.
[8] Margarita A.Kurgankina,Galina S.Nyashina,Pavel A.Strizhak.Advantages of switching coal-burning power plants to coal-water slurries containing petrochemicals[J]. Applied Thermal Engineering, 2019,147, (1):998-1008.
[9] China Petroleum Chemical Industry Federation.Economic Benefits of Petroleum and Chemical Industries in 2015 [J].China Petroleum and Chemical Industry, 2016, (3): 49.
[10] Zhao ZhiPing.A Review on Economic Operation of China's Petroleum and Chemical Industry in 2016 and a Prospect for 2017[J].Petroleum & Petrochemical Today,2017,(2):1-6+12.
[11] Zhang DeYi.Speeding up the Promotion of New Technologies and Improving the Economic Benefits of Petrochemical Enterprises [J].Petrochemical Industry Trends,1993,(4):1-7+35.
[12] Zhang DeYi..Speeding up Deep Processing of Crude Oil and Improving Economic Benefit of Petrochemical Enterprises [J].Petrochemical Industry Trends,1994,(7):1-6.
[13] Wang YeXiang.Measures for Petrochemical Enterprises to Improve Economic Benefits [J].Sinopec Monthly,1997,(10):29-30.
[14] Deng KaiShan. Ways and Methods of Improving Economic Benefit of Power System in Petrochemical Enterprises [J]. Guang Zhou Chemical Industry and Technology, 2005, 33(8): 82-84.

[15] Wang GuoHua. Discussion on Measures to Improve Economic Benefit of Petrochemical Construction Enterprises [J]. Sinopec Monthly, 2006, (7): 41-43.

[16] Li Jin-dong, FENG Xiao. Load assignment optimization of heat and steam supply system in petrochemical industry [J]. Journal of North China Electric Power University, 2004, 31(6): 75-77.

[17] Li Chufu, He Xiaorong, Zhang Qiuyi, Gong Zhenzhi. Development of a graphic modeling system for optimal production planning in petrochemical industry and its application [J]. Petroleum Processing and Petrochemicals, 2005, 36(10): 45-49.

[18] Long Kaifang, Chen Bin. Analysis of Production Cost Change in Petrochemical Enterprises [J]. International Petroleum Economics, 2006, (5): 42-44.

[19] Yang Ruihong, Cao Yuping. Study on Water Cost Control in Petrochemical Enterprises [J]. Modern Business Trade Industry, 2009, (2): 177-178.

[20] SHI Lu. Optimal strategy of steam & power system in large petro-chemical enterprise [J]. Energy Engineering, 2015, (1): 64-68.

[21] Zhu Liangfeng, Zhu Xueyi, Zhang Wei. Determination of downward pressure index of petrochemical enterprises [J]. Statistics & Decision, 2016 (14): 185-188.

[22] Wang Weixing, Xu Yuxian, Zhu Xueyi, Wang Yishu. On the Economy New Normal and Development Strategy Repositioning of Petrochemical Industry [J]. Journal of Changzhou University (Social Science Edition), 2017, 18(1): 42-51.

[23] Wang Weixing, Zhu Xueyi, et al. Research on Driving Development Ability of China's petrochemical Industry [M]. Beijing: Chemical Industry Press co. ltd., 2017-10: 28.

[24] Zhu Liangfeng. Study on Support Theory and Operation Efficiency about Capitalization of Coal Resource [M]. Beijing: China Economic Publishing House, 2017-01: 58.

[25] Zhang Hong-xiang, Xi Li-juan. A Nonlinear Relationship about government Tax Competition and Environmental Pollution: Based on the Empirical Analysis of Panel Threshold Model [J]. Journal of Xi’an University of Finance and Economic, 2018, (6): 13-21.

[26] Chi GuoHua. Functional Orientation and System Construction of Internal Control Index of Chinese Listed Companies [J]. Management World, 2011(06): 172-173.

[27] Mao Zedong. Selected Works of Mao Zedong (Volume II) [M]. Beijing: People’s Publishing House, 1968-12: 277.

[28] Zhu Liangfeng, Hu Huang Guoliang, Zhang Yajie. A Research on the Trend of Chinese Energy Structure Coal Market Forced Mechanism [J]. Price Theory and Practice, 2014 (3): 57-59.

[29] Zhu Liangfeng. Analysis of the relationship between the economic benefits of coal enterprises and external force and internal funds operation [J]. Resources Science, 2015(12): 2414-2420.

[30] Li Qian. On the Definition of Government Intervention and Market Regulation [J]. Chinese & Foreign Entrepreneurs, 2013(4): 257-258.

[31] Zhu Liangfeng, Zhu Xueyi. Energy policy, market environment and the economic benefits of enterprises: evidence from China’s petrochemical enterprises [J]. Natural Hazards, 2019, 95(1-2): 113-127.