Natural Gas Price Policy Based on python Data Mining and Measurement

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Abstract-China is a traditional sense of "rich in coal, short of oil and gas" country. These three energies occupy a high position in China's energy consumption structure. With the increasing proportion of natural gas in the world energy consumption structure, more and more attention has been paid to the use of natural gas. The mutual substitution and influence of the three factors are of great significance to the safety situation, price regulation and policy making of natural gas in China, and therefore need to be further studied. On the basis of fully exploring the current situation of natural gas resources in China and the prices of the three, this paper uses Python data mining and econometrics to explore the causal relationship among the three. After the empirical study, this paper puts forward some suggestions for China's gas price reform mode, including improving the pricing mechanism, building a unified natural gas pricing market and establishing a "coal+gas" gas price mechanism in accordance with China's national conditions.

Keywords-gas market; price policy; energy

1 Introduction

1.1 Research Background

Following the initial impact of the pandemic, fossil fuel prices rose in 2021, widening the gap between international market prices and low, fixed prices for consumers in some countries. At present, China's energy use, less pollution and efficient natural gas demand and the proportion of total energy consumption increased year by year, foreign dependence and import scale gradually increased, the gap between supply and demand is widening.In order to solve the natural gas problem, the state is comprehensively deepening the reform of the upper, middle and lower reaches of the system and mechanism. The development of China's natural gas pricing mechanism has experienced about 20 years, and the market-oriented reform of the pricing mechanism has accelerated significantly in recent years. In 2020, a new Central Pricing Catalogue will come into effect.

1.2 Research Significance

With the increasing proportion of natural gas in the world energy consumption structure, natural gas has become an important clean nova energy in China. At present, there is a large gap between supply and demand, and the external dependence increases year by year. The external dependence of natural gas in China is increasing, and the existing price mechanism to be improved has accelerated the growth of natural gas demand. China has not yet established a

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unified natural gas trading market, and the international pricing power is not as good as Henry Hub and other trading hubs, so they often passively accept prices.

For China, the degree of marketization of domestic natural gas pricing is not enough, so it is very important to promote the price reform to conform to the international level. China's inherent natural gas pricing mechanism -- government control, to a certain extent, limits the market development, affecting the security of natural gas supply, and therefore needs to be gradually updated. This paper analyzes the data of natural gas production and supply and demand gap in China from 1990 to 2019, and puts forward corresponding countermeasures and draws conclusions through empirical research and analysis of the data, which can provide some reference for the gas price reform strategy.

1.3 Domestic literature review

1.3.1 In terms of proposing marketization and price regulation reform:

He, R.M. (2013) [1]and Tan, X.Y. (2012) [2] put forward the reform model of natural gas price regulation that ADAPTS to the national conditions and does not copy the western regulations, so as to coordinate the development of economy and society. Nie, G.H. (2014)[3] and Wang, F.P. et al. (2018) [4]use quantitative analysis and quantitative model creatively, take game theory as the basic tool, and put forward specific measures. Geng, J.B. (2014) [5]provides suggestions for China's natural gas price reform by studying the price fluctuation characteristics and influencing factors of the three global natural gas trading markets. Gong, C.Z. (2016) [6]analyzed the supply and demand situation of natural gas in China. Hu, O.L., Dong, Q. (2015) [7]provided reference for natural gas price reform by analyzing the obstacles faced by China's natural gas price regulation reform and learning from the PRICING mechanism of the United States. Qi, A.H., Yang, L. (2020) [8]emphasized the adaptation of policies to national conditions by analyzing the comparison between China and the United States in relevant industrial chains.

1.3.2 In terms of proposing a new natural gas pricing mechanism:

Tan, X.Y. (2012) [2]and Nie, G.H. (2014) [3]pointed out that we should actively explore a new mechanism to link the pricing of natural gas with coal and oil (mainly coal) to avoid risks and make full use of domestic advantages. Li, T.D. et al. (2021) [9]pointed out through analysis that the pricing mechanism should be promoted to be linked to oil prices while making progress in the pricing mechanism. He, R.M. et al. (2019) [1]pointed out that the United States is promoting the decoupling of natural gas prices from oil prices. Guo S.J. (2016) [11]confirmed the significant mutual influence of the three energy sources in China through empirical research. Ding, H, Cai, L. (2016) [12]made an empirical analysis of the correlation between crude oil price, natural gas price and PPI, and believed that the risk of price fluctuation should be avoided by improving the domestic price system. Yang, H.X, Gu, H. 012) [13]tested the long-term equilibrium relationship among natural gas production, investment and price variables through co-integration test, and thus extended the problem of natural gas pricing mechanism.

1.3.3 Foreign literature review

Dong, K.Y.et al. (2019) [1] , through empirical analysis and measurement methods, compared the global sub-regions and explained the trend of the change of price demand elasticity caused by the change of natural gas and price reform in the past several decades.

Caporin, M., Fontini, F. (2017) [15] studied the fluctuation relationship between Henry Hub oil and shale gas prices in the United States through empirical analysis, and explored its impact on the fluctuation of natural gas prices.

2Methods and Materials

2.1 Data crawling

hon code input process is shown below, and the generated corresponding analysis diagrams are shown below.

The data analysis process is shown in Figure 1 below:

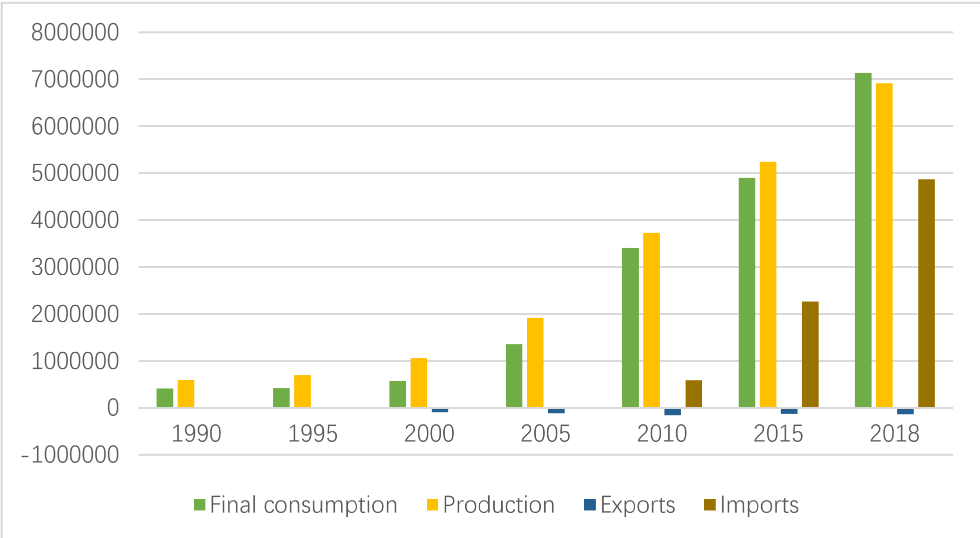
```
import xlrd
import math
import datetime
from xlrd import xldate_as_tuple
import time
import matplotlib.pyplot as plt
import tkinter as tk

file ="1. xlsx'

book = xlrd.open_workbook (filename=file)

sheet1 = book.sheet_by_name('sheet1')

cola = []
for i in range (sheet1.nrows) :
value = sheet1.cell(i,0).value
if sheet1.cell(i,0).ctype == 3:
date = xldate_as_tuple(sheet1.cell(i,0).value,0)
value = str(datetime.datetime(*date))
t = time.strptime(value,"%Y-%m-%d %H:%M:%S")
value = time.strftime("%Y-%m-%d ,t)
cola. append (value )
colb = zheet 1. col_ _values (1)
colc = zheet1. col_ values (2)
cold = sheet1. col_ values (3)
cole = sheet1. çol_ values (4)
colf = sheet1. col_ values (5)
colg = sheet 1. col_ values (6)
colh = sheet1. col_ values (7)
coli = zheet1. col_ values (8)
colj = sheet1. col_ values (9)
colk = sheet1. col_ values(10)
coll = sheet 1.col_ values(11)
colm = sheet1. col_ values (12)
coln = sheet 1. col_ values (13)
colo = zheet1. col_ values (14)
colp = sheet1. col_ values(15)
colq = sheet1. col_ values(16)
çolr = sheet1.col_ values(17)
```

Figure1 Data crawling:

2.2 Data visualization

(Unit: 100 million cubic meters; Data interval: 1990-2019, the same below.)

Table.1 Comparison of China's natural gas import and export volume and production and consumption



2.3 Data Sources

"2020 China Overseas Investment Country Risk Rating Report", BP World Energy Statistical Yearbook, National Bureau of Statistics, China Statistical Yearbook, International Energy Agency," China Energy Statistical Yearbook" and the World Bank Database.

In this paper, the total production of natural gas and its composition (unit: 100 million cubic meters) were obtained by conversion calculation.

3 Results and Discussions

3.1 Data selection

Data interval is 2000-2020, from BP World Energy Statistical Yearbook 2021 and National Bureau of Statistics.

(1) Coal price: The spot coal price in Qinhuangdao of China is selected, denoted as C. Coal prices are shown in Figure 2 below:

Coal: Prices

US dollars per tonne	Northwest Europe marker price†	US Central Appalachian coal spot price index‡	Japan steam spot CIF price†	China Qinhuangdao spot price†
2000	35.99	29.90	–	27.52
2001	39.03	50.15	37.69	31.78
2002	31.65	33.20	31.47	33.19
2003	43.60	38.52	39.61	31.74
2004	72.13	64.90	74.22	42.76
2005	60.54	70.12	64.62	51.34
2006	64.11	57.82	65.22	53.53
2007	88.79	49.73	95.59	61.23
2008	147.67	117.42	157.88	104.97
2009	70.39	60.73	83.59	87.86
2010	92.35	67.87	108.47	110.08
2011	121.48	84.75	126.13	127.27
2012	92.50	67.28	100.30	111.89
2013	81.69	69.72	90.07	95.42
2014	75.38	67.08	76.13	84.12
2015	56.79	51.57	60.10	67.53
2016	59.87	51.45	71.66	71.35
2017	84.51	63.83	95.57	94.72
2018	91.83	72.84	112.73	99.45
2019	60.86	57.16	77.63	85.89
2020	50.28	42.77	69.77	83.10

Figure2 Coal price

(2) Natural gas price: Since China's natural gas trading pricing hub is still under construction, the transaction price of Henry Hub Trading Center in the United States is selected as the ex-factory price of natural gas, which is denoted as G.

(3) Crude oil price: select the CIF price of crude oil of OECD, denoted as O. Crude oil prices are shown in Figure 3 below:

Prices

	LNG		Natural gas					Crude oil
US dollars per million Btu	Japan CIF[1]	Japan Korea Marker (JKM)[2]	Average German Import Price[3]	UK (Heren NBP Index)[4]	Netherlands TTF (DA Heren Index)[4]	US Henry Hub[5]	Canada (Alberta)[6]	OECD countries CIF[6]
1990	3.64	–	2.78	–	–	1.64	1.05	3.82
1991	3.99	–	3.23	–	–	1.49	0.89	3.33
1992	3.62	–	2.70	–	–	1.77	0.98	3.19
1993	3.52	–	2.51	–	–	2.12	1.69	2.82
1994	3.18	–	2.35	–	–	1.92	1.45	2.70
1995	3.46	–	2.43	–	–	1.69	0.89	2.96
1996	3.66	–	2.50	1.87	–	2.76	1.12	3.54
1997	3.91	–	2.66	1.96	–	2.53	1.36	3.29
1998	3.05	–	2.33	1.86	–	2.08	1.42	2.16
1999	3.14	–	1.86	1.58	–	2.27	2.00	2.98
2000	4.72	–	2.91	2.71	–	4.23	3.75	4.83
2001	4.64	–	3.67	3.17	–	4.07	3.61	4.08
2002	4.27	–	3.21	2.37	–	3.33	2.57	4.17
2003	4.77	–	4.06	3.33	–	5.63	4.83	4.89
2004	5.18	–	4.30	4.46	–	5.85	5.03	6.27
2005	6.05	–	5.83	7.38	6.07	8.79	7.25	8.74
2006	7.14	–	7.87	7.87	7.46	6.76	5.83	10.66
2007	7.73	–	7.99	6.01	5.93	6.95	6.17	11.95
2008	12.55	–	11.60	10.79	10.66	8.85	7.99	16.76
2009	9.06	5.28	8.53	4.85	4.96	3.89	3.38	10.41
2010	10.91	7.72	8.03	6.56	6.77	4.39	3.69	13.47
2011	14.73	14.02	10.49	9.04	9.26	4.01	3.47	18.55
2012	16.75	15.12	10.93	9.46	9.45	2.76	2.27	18.82
2013	16.17	16.56	10.73	10.64	9.75	3.71	2.93	18.25
2014	16.33	13.86	9.11	8.25	8.14	4.35	3.87	16.80
2015	10.31	7.45	6.72	6.53	6.44	2.60	2.01	8.77
2016	6.94	5.72	4.93	4.69	4.54	2.46	1.55	7.04
2017	8.10	7.13	5.62	5.80	5.72	2.96	1.58	8.97
2018	10.05	9.76	6.66	8.06	7.90	3.12	1.18	11.68
2019	9.94	5.49	5.03	4.47	4.45	2.51	1.27	10.82
2020	7.81	4.39	4.06	3.42	3.07	1.99	1.58	7.19

Figure3 Crude oil price and Natural gas price

3.2 Data analysis and processing

Use Eviews10.0 for operation.

(1) Take the logarithm of the three variables:

(2) Unit root test was performed on the original sequence (C was taken as an example for limited space here). The outcome of unit root test is shown in Figure 4 below:

Null Hypothesis: ____C has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.723045	0.4052
Test critical values:	1% level	-3.808546	
	5% level	-3.020686	
	10% level	-2.650413	

Figure4 Unit root test was performed on the original sequence

According to the results, The P value is 0.4052, and P >0.05 indicates that sequence C is unstable.

(3) Stationary test (to eliminate the influence of fluctuation)

Using the Ln ____ C sequence, select 1st Difference in the Unit Root Test window. The outcome of unit root test is shown in Figure 5 below:

Null Hypothesis: D(LN____C) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=4)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.924330	0.0082
Test critical values:	1% level	-3.831511	
	5% level	-3.029970	
	10% level	-2.655194	

Figure5 Stationary test

According to the results, The P value is 0.0082 ($P<0.05$), indicating that the first-order difference sequence is stable and does not have unit root. Similarly, it can be concluded that the other two new sequences DLN amplo and DLN ampli g are all stable.

(4) Johansen test:

The outcome of Johansen test is shown in Figure 6 below:

Johansen Cointegration Test

Date: 07/20/21 Time: 17:10
Sample (adjusted): 2002 2020
Included observations: 19 after adjustments
Trend assumption: Linear deterministic trend
Series: LN____C LN____G LN____O
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.591577	28.11033	29.79707	0.0773
At most 1	0.322123	11.09676	15.49471	0.2056
At most 2	0.177371	3.709761	3.841466	0.0541

Figure6 Johansen test

It shows that there is a long-term and stable co-integration relationship among the three.

3.3 Granger causality test

The outcome of Johansen test is shown in Figure 6 below:

Pairwise Granger Causality Tests
Date: 07/20/21 Time: 17:31
Sample: 2000 2020
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
LN____G does not Granger Cause LN____C	18	2.16380	0.1500
LN____C does not Granger Cause LN____G		3.63883	0.0482

Figure7 Granger causality test

In the table, at the 95% confidence level, P =0.0482 rejected the null hypothesis, P =0.1320, P =0.1500 Accept the null hypothesis. Therefore, China's coal price is the Granger reason of natural gas price.

4 Conclusions

4.1 Reform China's natural gas market and improve the pricing mechanism

Following the gas price reform, the pricing mechanism of "controlling the middle and releasing the two ends" should be gradually realized, the practice of government management of all pricing processes should be abandoned, and market mechanism regulation should be gradually implemented on the basis of consistent with China's national conditions, with the government playing the role of formulating and supervising market management.

4.2 Gradually establish a natural gas pricing center to form a trading hub price

Throughout the international natural gas pricing mechanism, its main characteristics are that the natural gas price is mainly formed by market competition, and the degree of government supervision is gradually reduced.

Establish and improve the natural gas market center, and use the benchmark price of the market hub to replace the government pricing. The national "one network" mechanism will be gradually formed to improve the level of competition in China's natural gas price market. Natural gas benchmark prices are gradually forming in China and even in East Asia.

4.3 Establish a Chinese-style "gas price" mechanism

China is a country rich in coal and short of oil and gas. The linkage between oil price and gas price will lead to the risk of international oil price fluctuation and we have to bear all the risks.

In the field of coal, however, China is the world's largest producer and consumer of coal, and has a certain influence and discourse right in the international coal market. Moreover, coal has a better mobility than natural gas, so a combination of various factors makes it less susceptible to fluctuations in the international situation. There should be a linkage between natural gas prices and coal prices to ensure dynamic fuel substitution or switching.

In terms of price, China's price mechanism should be in line with that of the world: the wellhead price of natural gas should be regulated by the market and linked to the price of alternative fuels.

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