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Impact of Removal of City Gas Subsidies on Chinese Urban Residents

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Abstract: The current cost-plus natural gas pricing mechanism makes the gas price too low, resulting in a lot of consumer-side subsidies, which makes natural gas over-consumed. This paper applies the price-gap approach and input-output analysis technology to quantitatively analyze both of the direct and indirect effects on urban residents on the condition that natural gas subsidies are cancelled in China in 2007. It is shown that the gas price will increase by 33.3%-41.6%, and the residential consumption expenditure by 0.26%~0.33%. The low-income groups are mostly affected, so different subsidies should be implemented, to make subsidies more efficient.

Keywords: price subsidies; price-gap approach; input-output analysis technology

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Since the 1990s, natural gas market in China has entered a period of rapid development. Consumption of natural gas grew from 15.25 billion m^3 in 1990 to 109.04 billion m^3 in 2010. During the same period, natural gas production increased from 15.30 billion m^3 to 96.76 billion m^3 [1]. And the natural gas subsidy increased significantly.

According to the Organization for Economic Cooperation and Development (OECD)[2] and the International Energy Agency (IEA)[3] , in a broad sense, subsidy means that the government takes action to raise the purchase price of energy producers, and reduce energy production costs or price charged on energy consumers. In a narrow sense, subsidy means that the government transfers payments or tax credits to producers and consumers. Different forms of energy subsidies will have different effects on producers or consumers[4]. In terms of subsidy ways, energy subsidies can be classified into direct and indirect types; in terms of the subsidy objects, they can be categorized into production- and consumer-side types. In China, energy subsidies are often carried out by the government, aimed at regulating energy prices, thus the prices are lower than the full economic cost[5]. Therefore, China's energy subsidies are mainly consumer-side subsidies.

In practice, due to the lack of strict standards and existence of institutional barriers, energy subsidies usually cannot achieve their declared objectives. With the development of energy industry, the drawbacks of energy subsidies have gradually emerged. First of all, many of them have increased the government's financial burden. IEA[2] estimated that the average energy subsidy rate in China was 10.9%, and welfare loss was equivalent to 0.36% of GDP. In 2005, only electricity and natural gas subsidies were over $12 billion, accounting for 0.54% of GDP of that year[6]. Ref.[5] used the price-gap approach and Computable General Equilibrium(CGE) model to estimate China's energy subsidies, finding that China’s energy subsidies reached 356.73 billion YUAN only considering the terminal energy subsidies, which meant 1.43% of GDP in China. Secondly, energy subsidies are harmful to improve the energy efficiency and energy consumption structure. Moreover, energy subsidies distort the price signal, which is not conducive for transition countries (e.g. China) to cultivate the market economy. Last but not the least, the rich will benefit more than the poor, due to the limitations of the subsidy mechanism design, thus exacerbating the social unfairness[7].

However, the removal of energy subsidies will also have some negative impacts. Ref.[8] proved the existence of energy subsidies in Nigeria, and recommended a gradual removal to

weaken the negative impact on economy. Ref.[5] concluded that the removal would lead to a substantial decline of energy consumption and carbon emissions, but at the same time also has a negative impact on the macroeconomic variables. Specific to a certain type of energy subsidies, Ref.[9] pointed out that the subsidies on kerosene and electricity in Ethiopia, did not improve the total expenditure of the residents significantly in the energy sector. Ref.[10] suggested that with the elimination of subsidies in Kuwait, the welfare losses suffered by the residents should be returned to offset the resistance to the tariff reform and achieve a win-win situation.

Compared with international studies, Chinese scholars paid less attention to energy subsidies, especially for natural gas subsidies. Ref.[11] estimated that the electricity subsidies were 209.76 billion Yuan, or about 0.84% of GDP in 2007, and pointed up the inefficiency of the electricity subsidy mechanism. Ref.[12] calculated the scale of natural gas and electricity subsidies in 2007, and pointed out that, the low-income residents, especially those in rural areas would suffer a greater loss due to the removal.

Considering the rapid development of city gas, this paper takes the city gas as the research object, whose users come from residential user, transport, commerce fields**.** Residential users were the biggest consumers, which accounted for 58% in 2007[13]. Therefore, this paper selects residential user as a representative case. Because the urban consumed more than 90% of the residential gas in 2007, we choose it as the study object here. Since different income groups have different elasticity of demand for natural gas, the removal of the natural gas price subsidies will have different effects on them. Reasonable measurements of the scale of natural gas subsidies and calculations of the different effects on different income groups are necessary for the design of natural gas pricing mechanism and for the development of reasonable subsidy policies.

1 Estimation on city gas subsidies for residential users

There are many methods of estimating the scale of energy subsidies, including: (1) price-gap approach; (2) producer subsidy equivalent method; (3) consumer subsidy equivalent method; (4) specific projects; (5) effective rate of assistance; among which price-gap approach is the most effective way to estimate the consumption-side subsidies. Because most of China's natural gas subsidies are consumer-side, this article uses the price-gap approach to estimate the scale of city gas subsidies of residential user. It is noteworthy that this study

is limited to static impact of gas subsidy elimination, and the dynamic impact may be greater[3]. Therefore, the result of estimation in this paper is the lower bound.

1.1 Price-gap approach

We can measure the size of energy subsidies through calculating the cap between reference price formed in the competitive market and the end-use price before the removal of energy subsidies.

According to IEA [3], the price-gap approach is specified as follows:

$$S_i = (M_i - P_i) \times C_i \tag{1}$$

where S_i is the size of subsidies; M_i is the reference price; P_i is the price before the removal of price gap; C_i is the scale of consumption; and i represents the type of energy, i.e. natural gas in this paper.

1.1.1 Reference price of natural gas

It can be seen from Eq. (1) that the key to determining the scale lies in the reference price of natural gas. With the composition of natural gas price, the reference price can be decomposed as follows:

Reference price = ex-factory price + transmission and distribution fee + taxes (2)

Eq. (2) can be explained as follows.

(1) Ex-factory price. China's current natural gas prices are under government control, which does not reflect the upstream mining costs and the incentive for further exploration costs. On the other hand, UK, USA, Canada and other Western countries have relaxed control on gas industry since 1970s. In order to avoid artificial and arbitrary, and to ensure the sensitivity of reference price, this paper selects the EU CIF (EUcif), Japan LNG CIF (Japancif), U.S. Henry Hub (Henry Hub)[1],the three major international gas prices, imports of Central Asian natural gas border settlement price in China (CA)[14], the heat value Price (HVP)[15] as the ex-factory reference price.

(2) Transmission and distribution fee. We determine the average transmission and distribution costs through the gap between the average end-use price and the average ex-factory price.

In 2007, the average market price of residential natural gas of China's 36 large and medium-sized cities was 2.2 Yuan/m³, and the average ex-factory price of the major gas

production area, such as Sichuan Basin, Xinjiang and Qinghai provinces, was 0.8 Yuan/m³ in 2007, therefore the average fee of transmission and distribution in China was about 1.4 Yuan/m³.

(3) Taxes and fees. China's value-added tax (VAT) on natural gas product in 2007 was 13%, which was levied on gas exploration sectors, thus the VAT was 0.104 Yuan / m³.Based on the Eq. (2), it can be calculated that the reference price of natural gas in China in 2007.

1.1.2 End-use price and consumption of city gas for resident

In 2007, the average end-use price of natural gas for residents in China's 36 large and medium-sized cities was 2.15 Yuan/m³. The consumption of natural gas for urban residents is 17.707 billion m³ [14].

1.2 Estimation of city gas subsidies

Calculated by the Eq. (1), in 2007, city gas subsidies ranged from 22.03 to 34.60 billion Yuan, and the subsidy rate was 36.65%-47.61%, accounting for 0.08%~0.13% of GDP in 2007. The results are listed in Tab.1.

Tab.1 Size of subsidies and subsidy rate of residential gas

Symbol	Natural gas reference price (Yuan)	Actual price (Yuan/m³)	Gas consumption (billion m³)	Size of subsidies (billion Yuan)	Subsidy rate
EUcif	3.72	2.15	17.71	27.74	42.15%
Japancif	3.72	2.15	17.71	27.76	42.17%
Henry Hub	3.39	2.15	17.71	22.03	36.65%
CA	4.1	2.15	17.71	34.6	47.61%
HVP	4.05	2.15	17.71	33.64	46.91%

2 Direct impact of removing natural gas subsidies on different income groups

Removal of natural gas subsidies will inevitably lead to rising gas prices. On the one hand, rising natural gas prices, by themselves, will make consumer pay more. This paper defines it as the direct impact on the residents. On the other hand, the increase of natural gas price will lead to changes in the prices of related industries' products, therefore leading to changes in consumer expenditure. Here we define it as the indirect effects on residents.

2.1 Classification and characteristics of each resident group based on natural gas

consumption

According to the data released by China Statistical Yearbook 2008 and Chinese City (Town) Life and Price Yearbook 2008, urban residents are classified into three groups based on disposable income per capita, as listed in Tab.2. It can be seen from that with the increase of disposable income per capita, energy consumption per capita gradually increases, but the proportion of energy consumption in total consumption gradually declines. Therefore, the removal of subsidies will exert different effects on different income groups.

Tab.2 Classification and expenditure/income condition of urban residents[16]

Classification	Disposable income (*I*/Yuan)	Consumption expenditure (*C*/Yuan)	Energy expenditure (*E*/Yuan)	*E/I*
Low-income group	5 357.33	4 835.24	198.78	3.71%
Middle-income group	12 442.88	9 263.81	252.54	2.03%
High-income group	29 509.04	19 317.53	405.21	1.37%

2.2 Direct impact with the removal of natural gas subsidies

The removal of subsidies will affect the price of natural gas, as follows[3],

$$Q = P^{\varepsilon} \tag{3}$$

$$\Delta Q = Q_0 - Q_1 \tag{4}$$

where Q is the natural gas consumption; P is the natural gas price; ε is the long-term price elasticity of demand for natural gas; Q_0 and Q_1 are the consumption before and after the removal of subsidies; and ΔQ is the difference

Residents will adjust the consumption of natural gas when the price fluctuates. The actual rise of gas prices after the removal of subsidies should consider the price elasticity of demand for natural gas, i.e. ,

$$\tau = \theta \cdot \frac{Q_1}{Q_0} \tag{5}$$

$$\ln Q_1 = \varepsilon \cdot (\ln P_1 - \ln P_0) + \ln Q_0 \tag{6}$$

where τ is the rate of increase after the removal of subsidies; θ is the subsidy rate; P_0 and P_1 are the end-use prices before and after the removal of subsidies respectively.

The price elasticity of demand for natural gas differs in literature due to differences in data and methods. According to Ref. [4], this paper applies -0.31 as residential natural gas price elasticity of demand.

Natural gas demand elasticity of different income groups are not the same. In general, the higher the income, the greater the absolute value of elasticity of demand will be. However, when the income is extremely high, it will be insensitive to price changes. Therefore, the middle-income's absolute value of the elasticity of demand is the biggest, -0.31, i.e., and we assume that the elasticity of demand for the low-income is -0.21, and the high-income -0.26.

According to the elasticity values of the different groups identified above, combined with Eq. (5) and Eq. (6), we can calculate the direct impact on different groups after the removal of subsidies, as is shown in Fig. 1. It can be seen from the results that the low-income groups suffer most, as the gas price increase within 33.30%~41.57%; the impact on middle-income group is the smallest, as the gas price increase from 31.82% to 38.96%; and a gap of 1.49% - 2.60% between the two groups can also be observed. Therefore, in the reform of the existing subsidy mechanism, more attention should be paid to the low-income group. In addition, the price gap will change if different reference prices are applied. The reference price of CA plus the average transmission and distribution costs imposes the largest impact on the residents, while USA Henry Hub plus the average transmission and distribution costs" is smallest. The gap of the results between the two reference prices is about 8 percentage point.

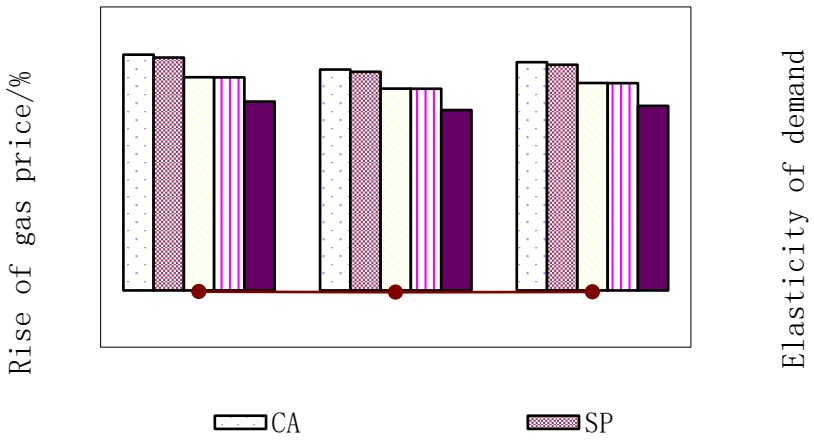

Fig. 1 Direct impact on different income groups after the removal of natural gas subsidies

3 Indirect effects on different income groups after the removal of subsidies

3.1 Input-output analysis technology

3.1.1 Input-output table

Input-output Analysis is first proposed by the American W. Leontief in 1936. It is a scientific method for analysis, which can reveal the quantitative ratio between technical and economic links between the industries, realized through the compilation of input-output table.

For sector *i*, there are four equations as follows,

$$\sum_{j=1}^{n} x_{ij} + y_i = q_i \tag{7}$$

$$\sum_{i=1}^{n} x_{ij} + n_j = q_j \tag{8}$$

$$q_i = q_j \tag{9}$$

$$\sum_{i=1}^{n} y_i = \sum_{j=1}^{n} n_j \tag{10}$$

where, x_{ij} is the product produced by sector *i* and consumed by sector *j*; q_i is the total product value created by sector *i*; y_i is the final product value created by sector *i*; n_j is the national income created by sector *j* within a year; and q_j is the total input.

3.1.2 Direct consumption coefficient

Also known as the intermediate input coefficient, direct consumption coefficient refers to the amount of intermediate inputs consumed by a sector for the output of product per unit. It is used to reflect the direct input-output relationship between the two sectors *i* and *j*.

$$a_{ij} = \frac{x_{ij}}{q_j} \tag{11}$$

By substituting Eq. (11) into Eq. (7), we can get Eq. (12),

$$\sum_{j=1}^{n} a_{ij} q_j + y_i = q_i \tag{12}$$

Eq. (12) can be expressed in a matrix form:

$$\boldsymbol{AQ} + \boldsymbol{Y} = \boldsymbol{Q} \tag{13}$$

where $\boldsymbol{A}=(a_{ij})_{n\times n}$ is the direct consumption coefficient matrix; $\boldsymbol{Y}=(y_1,y_2,\ldots,y_n)^{\mathrm{T}}$ is the final product column vector; *and* $\boldsymbol{Q}=(q_1,q_2,\ldots,q_n)^{\mathrm{T}}$ is the column vector of the total product.

If $\boldsymbol{Q}$ is known, we can calculate $\boldsymbol{Y}$:

$$\boldsymbol{Y}=(\boldsymbol{I}-\boldsymbol{A})\boldsymbol{Q} \tag{14}$$

If $\boldsymbol{Y}$ is known, $\boldsymbol{Q}$ is calculated as follows:

$$\boldsymbol{Q}=(\boldsymbol{I}-\boldsymbol{A})^{-1}\boldsymbol{Y} \tag{15}$$

where, $(\boldsymbol{I}-\boldsymbol{A})^{-1}$ is known as the Leontief inverse matrix.

3.2 Indirect effects on residents after the removal of gas subsides

As an important raw material or fuel, natural gas with rising price will cause the closely related product or (and) service prices to change, thus making the change in consumer spending, which is called the indirect effects on residents after the removal of price subsidies. The input-output tables measuring the linkages among sectors can be used to calculate the changes of other sector price caused by the removal of subsidies, and ultimately measure the changes of final consumer price in different groups of residents. The formula is as follows:

$$(\Delta P_1,\Delta P_2,\ldots,\Delta P_{k-1},\Delta P_{k+1},\ldots,\Delta P_n)^{'}=(C_{1,k},C_{2,k},\ldots,C_{k-1,k},C_{k+1,k},\ldots,C_{n,k})^{'}\cdot\frac{\Delta P_k}{C_{k,k}} \tag{16}$$

$$\eta=\frac{\sum\Delta P_i\cdot Q_i}{\sum P_i\cdot Q_i},\quad i\neq k \tag{17}$$

where, C_{ij} is the element of $(\boldsymbol{I}-\boldsymbol{A})^{-1}$; ΔP_i (i=1,2,…,n) is the relative change of each industrial product price; Q_i is the consumption of sector i for residents; η represents the proportion people have to spend more, in order to maintain the original consumption.

The results are shown in Fig. 2. It can be seen from that if subsidies are eliminated, expenditure burden for different income groups will increase at significantly different rates. Specifically, the increase in expenditure of the low-income group ranks the highest, from 0.26% to 0.33%, while the welfare loss of the middle-income group is the smallest, from 0.25% to 0.31%. The price gap slightly differs when applying different reference prices. The reference price of CA plus the average transmission and distribution costs imposes the largest impact on the urban residents, while USA Henry Hub plus average transmission and distribution costs

smallest. However, the gap between the two reference prices is less than 0.06%.

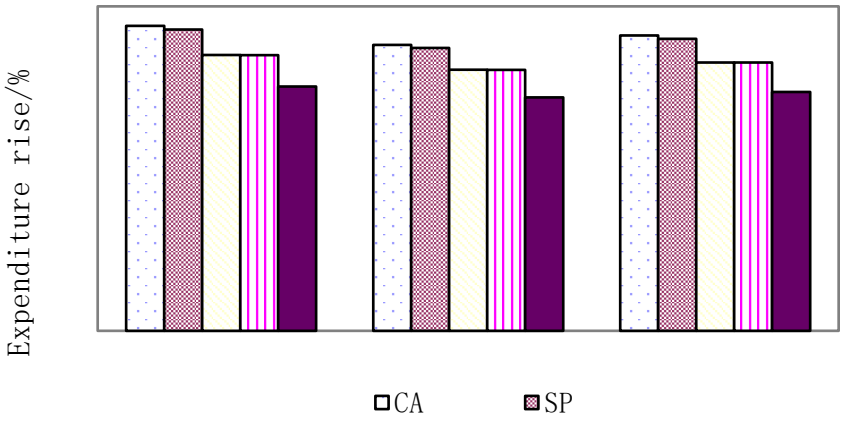

Fig. 2 Indirect impact on the residents after the rise of natural gas prices

Notes: changes in expenditure of residents caused by price changes of gas of prices themselves are not included. The input-output table in this paper is from Ref.[16].

It is worth noting that whether the impact is direct or not, the welfare loss of the low-income group is greater than the high income residents after the removal of subsidies. Therefore, in the reform of natural gas pricing mechanism, it is the low-income group that should be paid more attention to.

4 Conclusions and Recommendations

With the growing concern on the issue of climate change both domestically and abroad natural gas, as a relatively clean fossil energy, is widely used. However, the resource endowment in China is "rich coal, less oil and gas shortage". Till the end of 2010, the proven gas reserves in China are 2.8 trillion m^3, accounting for only 1.5 percent of those in the world. However, the total consumption of natural gas in China in 2010 accounts for 3.4% of the whole world consumption. With domestic natural gas production growth lagging behind the demand growth for a long time, the contradiction of supply and demand for natural gas in China has become drastically prominent. Furthermore, China's current natural gas pricing mechanism makes the domestic natural gas price too low, which leads to a serious deviation from its market value, resulting in the excessive consumption of natural gas, further exacerbating the imbalance of the natural gas supply and demand. In addition, with the existing natural gas subsidy mechanism, on one hand, most of the subsidies are beneficial to the high-income groups who don’t need the subsidies actually, leading to excessive consumption of natural gas; on the other hand, the low-income group, to whom subsidies are

fairly important, only get small portion, simply for the reason of lacking access to natural gas. Above a range of issues, the existing natural gas pricing mechanism and subsidy mechanism have been widely criticized. The appeal for reform is increasing. Under such circumstances, we do this research and find the following conclusions:

(1) There are a large number of end-use subsidies in natural gas consumption, among which, residential natural gas subsidies accounted 0.08% to 0.13% of GDP in 2007. With the further development of natural gas industry, the heavy burden of natural gas subsidies will make the natural gas subsidy unsustainable, if the existing policy maintained.

(2) Natural gas subsidy mechanism without differentiation is inefficient, exacerbating the imbalance of gas use among different income groups, as high-income group consume more incited by low-cost subsidies.

(3) With the relatively small elasticity of demand, and the relatively high proportion of consumer spending in natural gas, if the gas subsidies are completely abolished, low-income residents will suffer more than high-income residents.

We can conclude from the above analysis that after the elimination of natural gas subsidies, prices change separately among different income groups. The low-income groups get most affected, with the gas price increases from 33.30% to 41.57%, 1.49%-2.60% higher than the middle-income group, 0.75%-1.32% higher than the high-income group. In addition, as gas prices rise, prices of the closely related products and services also increase in general, household consumption expenditure of different income groups have different levels of increase. Among them, the impact on the low-income residents is greater than that on the high-income residents.

Therefore, the "one size fits all" subsidy mechanism reform will do harm to low-income residents. Under such circumstances, differential subsidies should be implemented, such as the implementation of the gradient of the gas price pricing mechanism. In this way, it may make the subsidies more efficient. In addition, the reform on the low-income residents should be implemented step by step to minimize the negative impact.

(4) When it comes to the redistribution of the money saved by the reform, the principle of "Who lose, who compensated" should be applied, which means giving appropriate subsidies to the low-income. At the same time, part of the funds should be saved for the construction of new energy industry, so as to improve China's energy consumption structure and to achieve

the goal of energy saving.

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