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Economic Impacts Analysis of ShaleGas Investment in China

ShangfengHan[1],Baosheng Zhang[2,*] and Xuecheng Wang[3]

[1]China University of Petroleum-Beijing, China, upchsf@163.com
[2]China University of Petroleum-Beijing, China, bshshysh@cup.edu.cn
[3]China University of Petroleum-Beijing, China, wangxuecheng027@163.com
[*]Corresponding author

Abstract. Chinese government has announced an ambitious shale gas extraction plan, which requires significant investment. This has the potential to draw investment from other areas and may affect the whole China's economy. There is few study to date has quantified these shale gas investment's effects on Chinese economy. The aim of this paper is to quantify the economic effect and figures out whether shale gas investment in China is a good choice or not. Input-output analysis has been utilized in this study to estimate the economic impacts in four different Chinese regions. Our findings show that shale gas investment will result in approximately 868, 427, 115 and 42 Billion RMB economic impacts in Sichuan, Chongqing, Inner Mongolia and Guizhou, respectively. The total economic impact is only around 1453 Billion RMB, which is not significant compared to the economic impact of coalbed methane investment. Considering the potential risks of environmental issues, we suggest that it may be a better strategy for the government, at least in the current situation, to slow down shale gas development investment.
Keywords: Shale gas investment,Economic impacts;Input-output analysis.

1. Introduction

It is widely recognized that such greenhouse gas emissions will affect every country in the world and cause unprecedented damage to the environment, economy and society [1]. China is the largest carbon dioxide emitting country in the world [1]. However, in 2014, China's energy consumption consisted of up to 66% produced from coal, which is the greatest CO2 emitter of all fossil fuels, as well as impacting heavily on local air quality. To combat this, the Chinese government has been intensifying its efforts to seek clean energy to replace this massive coal consumption, which will have long-term advantages in reducing the local and global environmental impact of energy [2]. Due to its large reserves and clean burning advantages, shale gas has attracted more and more attention across the globe, including China [3]. According to the IEA and China Land & Resource Bureau, China has the world's largest shale gas reserves, with technically recoverable resources estimated at 25.5 Trillion Cubic Meters (TCM) [4]. Therefore, shale gas has been regarded as a promising option for reducing coal dependence at the present stage and hailed as a bridge to energy independence and a clean future, because of its domestic sourcing and, compared with coal and petroleum derivatives, its smaller carbon footprint and reduced emissions of other pollutants (such as, particulates, sulfur dioxide, carbon monoxide, and nitrous oxides). In addition, successful shale gas development in the United States has significantly accelerated America's economic recovery and creats millions of new jobs, which has further strengthened China's confidence to develop shale gas domestically [3].

According to the successful experience of United States, the increased capitalization in the shale gas industry promoted rapid development of the corresponding infrastructure and technology, resulting in, apart from the soaring natural gas supply and other environmental benefits, significant economic

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benefits expansion of the economy in the local area, increase of residents' income in the development region and government revenues increase, etc [5, 6]. Thus, investing in shale gas has potential to overcome both the economic and supply crisis that China faces at present time. The Chinese government has announced a series of ambitious targets for shale gas extraction, so it is of great interest and importance to investigate in a quantitative manner the economic effects associated with this ambitious promotion of shale gas production. To date, there are no specific studies focusing on the quantitative economic effects and created jobs in China. Therefore, in this context, we focus on evaluating the effects of large-scale shale gas investment on economies and employment at the regional level by using an input-output (IO) model.

The structure of this paper is as follows: Section 2 presents a discussion of the methodologies used in the paper. Section 3 includes the results of the main effects of shale gas investments on regional economies. In Section 4, we analyze the economic effects caused by shale gas investment.

2. Model Section

2.1. The input-output model

The basic IO model consists of rows showing "who gives to whom" and columns that show "who receives from whom" in economic sectors [7]. The output of sector I can be computed as follows:

$$x_{i1} + x_{i2} + \cdots + x_{ij} + Y_i = X_i \quad (1)$$

Where: x_{ij} purchases by the sector j of the goods produced by sector i, Y_i sales from sector i to final demand, X_i total output of sector i.

In this paper, the work includes two parts: firstly, we estimate the economic effects created by shale gas investment at sectoral level. Then secondly, the specific number of employees is estimated.

We use $M=(I-A)^{-1}$. The inverse matrix M can reflect the cumulative output augmented by both direct demand increase and indirect increase. The output multiplier S_j is the total output increase in whole economy brought about by unit investment in sector j [8]. It is calculated by using the column sum of M:

$$S_j = \sum_i m_{ij} \quad (2)$$

Where, m_{ij} is the element of M.

The income technical coefficient ah_{ij} is given by:

$$ah_{ij} = \left(in_j / X_j\right) \times a_{ij} \quad (3)$$

Where, in_j is the labor income in sector j contained in China's IO tables, and X_j is the total output of sector j. Here, ah_{ij} is the income share by sectors, so it can be expressed by allocating the labor income share [9] in_j / X_j into sector i according to the input-output share of sector i in a_{ij}.

The income technical coefficient matrix AH is expressed as:

$$AH = \begin{pmatrix} ah_{11} & \cdots & ah_{1n} \\ \vdots & \ddots & \vdots \\ ah_{n1} & \cdots & ah_{nn} \end{pmatrix} \quad (4)$$

The cumulative income effect can be calculated by using the modified Leontief inverse matrix MH, which is expressed by:

$$MH = (I - AH)^{-1} \quad (5)$$

The income multiplier I_j of sector j is the column sum of MH, where mh_{ij} is the element of MH.

$$I_j = \sum_i mh_{ij} \quad (6)$$

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2.2. Data

2.2.1. IO Data
China's regional IO tables have been published every five years since 1987. The IO tables used in this paper were published in 2016 by the National Bureau of Statistics. All the data in the regional IO tables are in 2012 RMB (Renminbi) values.

2.2.2. Shale gas Investment Data in China
Accurate data oninvestments in shale gas is difficult to find, as there is no specific data announced by the government or any company that has so far invested in shale gas development. Therefore, in this study it was required to estimate investment in shale gas projects. Firstly, the average cost of one shale gas well and the average production of one well were calculated [10, 11]. Secondly, according to the relevant shale gas development plans, we identified the shale gas production goals of target provinces. Thus, we were able to gain a rough estimate of the investment of each province. Obviously, the cost of shale gas wells in different regions of China will be different based on the geological conditions, available facilities, other inputs and labor cost difference among regions. In this paper, we focus on the analysis of economic effect differences caused by distinctions in regional economic structure. As a result, we use the average production investment in different regions.

According to research of Xia [10] andWu [11], the average shale gas production costs in China are shown in Table 1.

Table1. The costs of shale gas development per well

Process	Core technology (estimation method)	Average cost (Million RMB)
Exploitation cost		2.56-4.76
Logging while Drilling	logging while drilling (LWD)	3.43-6.64
Drilling Fluid	depends on different geological conditions	3.22-4.12
Drilling Construction	estimate the cost of drilling team	16.54-21.27
Well completion process	perforating and fracturing	6.75-9.54
Logging process		0.43-1.43
digital logging	imaging logging	0.37-1.32
Surface facilities cost		1.67-4.32
Total		34.97-53.41

3. Results

3.1. Economic Impacts of Shale Gas Investment in Four Different Regions in China
By multiplying these sectorial investments by the corresponding output multipliers and income multipliers, the effects of shale gas development in the four regions can be calculated. We examine the economic impacts of shale gas investment across the four target regions overall, as shown in Figure 1.

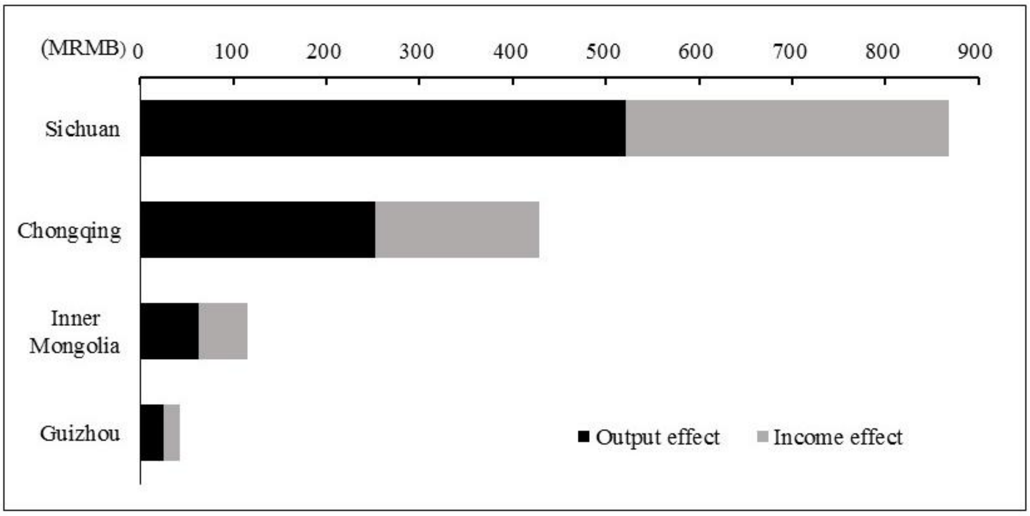

Figure 1. The economic impacts of shale gas investment

Figure 1 presents the total sectorial economic impacts caused by shale gas investment in the target regions. The output and income effect in Sichuan are 521 and 347 Million RMB, respectively, and the total economic impacts are approximately 2.68 times the initial investment. Similarly, the output effect is 252, 62, 24, respectively, in Chongqing, Inner Mongolia and Guizhou.

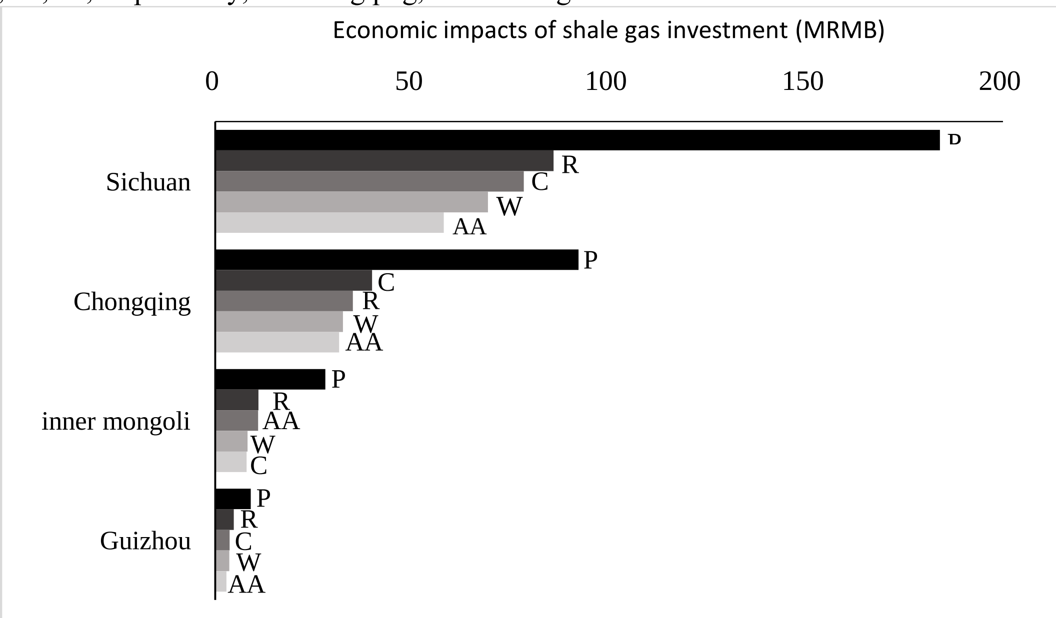

Figure 2. sectorial economic impacts of shale gas investment in four regions

The sector codes from the input-output table are: (C: Exploitation of petroleum and natural gas and conventional natural gas industry; R: Electric Equipment and Machinery manufacturing industry; P:General and special equipment manufacturing; W: Electricity and heating production and supply industry; AA: Transport and warehousing industry, respectively).

When it comes to the sectorial level, Figure 2 presents the sectorial economic impacts of shale gas investment. We find that the "Special equipment manufacturing" sector has the largest economic impact in all four regions, mainly because the shale gas development in these regions is at the primary stage and needs significant investment in equipment to construct shale gas wells. The similarity between the four regions is caused by the similar requirements for sectorial investments across the regions.

In general, the shale gas investments are shown to be up to tens of Billion RMB and the stimulation effect on the economy is more than 2.64 times the initial investments. The economic effects (the sum of outcome and income impacts) differ across all four regions. On one hand, the sectorial economic effects multipliers differ considerably in the four regions. As a result, a region with larger multipliers in certain sectors will have greater economic effects. On the other hand, the sectorial investments in different regions also alter the overall economic effects. We summarize sectorial investments, which shows that more than half the investment goes into the "Special equipment manufacturing", "Exploitation of petroleum and natural gas and conventional natural gas industry" and "Electricity and heating production and supply industry" sectors in all four regions. Thus, we can predict that those sectors will also have the greatest economic effects. Although the regional economic effect, to a large extent, connects and is adjusted by regional economic structure, there are a few similarities between four regions caused by similar sectorial investment.

4. Discussions

4.1. The Optimistic Opinion VS Gloomy Opinion about ShaleGas Development

Due to increasing serious environmental pressures, the Chinese government has announced a series of national energy development strategies, which stressed that China will use more clean energy to substitute for excessive coal consumption. However, the domestic conventional natural gas production will not see a rapid increase in the short time. At the same time, according to the IEA and China Land & Resource Bureau researches, China has the world's largest shale gas reserves, with technically recoverable resources around 25.5 TCM. So, some policy makers believe that the considerable gap between demand and supply in the future should be filled by developing domestic shale gas, rather than importing from other countries. Furthermore,according to Markaki's research [12], investments in domestic manufacturing activities are a prerequisite for maximizing positive macro-economic effects, so some researchers believe that the investment in shale gas will not only boost macro-economic growth, but that shale gas related technologies will also benefit from the investment, lowering costs and improving the economic effects further. For example, Considine [13] estimated that a $4.2 billion increase and 48,000 new jobs would be caused by shale gas development in Marcellus, United States. In 2010, Marcellus saw an $8.04 billion increase in revenues and 8,800 created new jobs. Husain [14] also predicted that the economic impact of shale gas production would be $18.85 billion in value added, $1.87 billion in state and local taxes, and nearly 212,000 jobs in 2020. CBER [15] calculated that shale gas extraction would increase gross revenues in the state of Arkansas by $2.6 billion in 2007 and generate 9,000 jobs. Scott [16] estimated that shale gas extraction would grow to $2.4billion in revenues and 11,000 new jobs in Hayensville. As a result, some policy makers hold over-optimistic attitudes towards shale gas development.

On the other hand, it is worth mentioning that the core idea of Keynesian economics, according to Snowdon and Vane [17], is that the economic resources such as labor, capital infrastructure, and natural resources are not fully used, so proper investment will increase the whole economy. These are economic effects that this paper attempts to estimate. However, these economic effects, according to Thomas [18] are very likely overestimated, because the models that are used for estimating economic effects, contain too many idealized assumptions and overlook other stimulation activities. Furthermore, the shale gas development may contribute to a series of environmental problems, such as water contamination. Luisa [19] showed hydraulic fracturing causing water pollution, while Grubert [20] calculated the whole water consumption of shale gas development. Air pollution may also be a problem, with Blasing [21] and Howarth [22] calculating methane emissions during the shale gas development life cycle, while Stamford[18], identified that shale gas development will cause depletion of the stratospheric ozone layer and photochemical pollution. Public health risk has also been examined, Kargbo [5] estimated the overall likelihood of health problems. The impact on land resources and values have also been investigated, Adams [23] estimated the indirect effect of shale gas development on forests and land due to pollution, and Lucija [24] estimated the housing markets' negative impacts attributable to shale gas development [25]. As a result, a bunch of people hold a gloomy opinion in shale gas investment.

5. Conclusion and PolicyImplications

Shale gas development requires a huge amount of expenditure, while at the same time it can significantly stimulate regional economic growth and create new jobs. In this paper, we first examined the shale gas expenditures based on single wells from other authors' research, and combined this with the China shale gas development plans, and estimated the possible investment in shale gas development. Then, we measured the regional economic structure, which varies between the four target regions and calculated the sectorial investments in question based on estimates presented in the national energy plan and other relevant supporting documents. After that, we used the Input-Output Model to estimate the impacts of shale gas investments in the four different regions and compared the differences in the economic between them.

As a result, we acquired the total economic effects (1453 Billion RMB) of shale gas investment in four regions. We also compared the regional economic effects and find it varied noticeably across regions. Regional economic effects are approximately 868, 427, 115 and 42 Billion RMB, and create 666,000, in Sichuan, Chongqing, Inner Mongolia and Guizhou, respectively.

Based on our discussion and conclusions, we have several policy recommendations:

First, we highly suggest that a detailed, correspondingly precise and comprehensive resource assessment should be published by Chinese authorities, since resources are the fundamental data to predict future production and investment potential. Shale gas resources assessment should include an analysis of economically recoverable resources, which needs to take more variables, like the accessed water and pipeline line, applied exploit technologies, into consideration. Currently, only a preliminary assessment of shale gas resource is available. China's national resource reports mainly focus on technically recoverable resources (TRR), which, of course, are very important to estimate future production in national levels. However, for investors, they are more likely to pay attention to the economic value of shale gas development, so, it is worth considering economically recoverable resources.

Second, as we discussed, the investment in CBM seems to be more attractive. We recommend that China should put priority to the development of CBM resources instead of massively investing in shale gas development at the present stage. Even though, it is possible to exploit shale gas in the long term, and shale gas will become one of the most supply of natural gas in the future, the main investment in shale gas should focus on the shale gas related technology and the method that can decrease the cost of shale gas development.

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