Employment Creation of Shale Gas Investment in China

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Abstract. An ambitious shale gas extraction plan has been proposed. The huge investment of shale gas may put an effect on the whole China’s economy, especially for employment. However, there is few study to date has quantified these effects. The aim of this paper is to quantify these effects especially employment creation 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 employment creation in four different Chinese regions. Our findings show that shale gas investment will result in creating 660000, 370000, 140000 and 58000 equivalent jobs in Sichuan, Chongqing, Inner Mongolia and Guizhou, respectively. 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; Employment creation; Input-output analysis.

1. Introduction

With the expanded interest in shale gas development, an increasing number of research papers focus, on the one hand, on negative effects of shale gas development. Some of them [1] have shown that the development of shale gas in China has been slowed due to the relative inexperience, lack of technology, geographical complexity, hostile economic environment, disincentives of the pipeline regime, and a complex land ownership system. Some scholars even argue that the investment in shale gas development should be postponed [1], because those resources, could be better-off directly spent on improving citizen’s welfare under the current investment environment. Furthermore, some studies also show that the massive investment in shale gas is an inefficient allocation of resources and may cause expenditure reduction on the coal industry, for example, which can result in economic and job losses in the broader economy [2].

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 created jobs in China. Therefore, in this context, we focus on evaluating the effects of large-scale shale gas investment on employment at the regional level by using an input-output (IO) model.

The structure of this paper is as follows: Section 2 presents a literature review regards as existing studies presenting the different views on shale gas development. Section 3 presents a discussion of the methodologies used in the paper. Section 4 includes the results of the main effects of shale gas investments on regional created jobs. In Section 5, the main findings of this study are summarized and conclusions are drawn.
2. Literature Review

There are an increasing number of studies worldwide examining the shale gas development questions from diverse perspectives. This review of literature on shale gas related issues focuses on economic effects and environmental effects in different countries.

On one hand, there are six main perspectives in studies that have been used for analyzing the macroeconomic implications of investing in shale gas. These are: (i) resource accessibility [3], listings the total potential resources and introduces the basic development situation; (ii) industry feasibility [1,4], which is the most widely method for analyzing a new emerging industry, and gives a basic overview of the shale gas in China; (iii) major barriers analysis [1, 5], which are focused on the main challenges faced by Chinese governments; (iv) shale gas development efficiency management studies [6], which offer some effective and efficient management methods for policy makers to gain a comprehensive understanding of the shale gas industry; (v) methodological approaches to analyze the macro-economic implications [5], which use economic analysis methods to calculate the discounted cash flow and average economic viability of shale gas; (vi) policy impact studies, as China has a powerful government, governmental policies seem to play a significant role in developing shale gas, many studies give particular attention to policy and policy considerations [7].

A large number of studies, on the other hand, focus on environmental effects caused by shale gas development. For example, Zhang [8], optimizes different wastewater treatment options accounting for the uncertainty of water management during hydraulic fracturing operations and finds out that the optimization has the tradeoffs between the economic objective and system reliability. Claudia [9], modelled a range of scenarios of shale gas development in Poland to calculate the related land use. In 2014, Stamford [10] et al., quantified a range of overall lifecycle environmental impacts of shale gas production and found that shale gas development will cause depletion of the stratospheric ozone layer, photochemical pollution, and terrestrial eco-toxicity. Thus shale gas is ‘worse’ even than coal as an energy source for generating electricity. Rob [11], however, raised objection on Stamford’s study and argued that its study underestimated the gas production per well and thus overestimated the negative effects of shale gas development.

In conclusion, these studies’ principal viewpoint on shale gas investment and development, from which we can obtain a general understanding of the macro-economic implications and environmental effects of shale gas development. Most studies (except Xia [1], L. Stamford [10], Claudia [9]) hold an opinion that the development of shale gas will inevitably stimulate economic and employment growth. However, there is no specific quantitative estimation of economic effects and created jobs. Thus, in this paper, we use an input-output (IO) model to measure these economic effects and created jobs.

3. Model Section

3.1. 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 [2]. The output of sector I can be computed as follows:

\[ x_{i1} + x_{i2} + \cdots + x_{ij} + Y_i = X_i \]  

(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 \( i \).

The income technical coefficient matrix \( AH \) is expressed as:

\[
AH = \begin{pmatrix}
ah_{11} & \cdots & ah_{1n} \\
\vdots & \ddots & \vdots \\
ah_{n1} & \cdots & ah_{nn} 
\end{pmatrix}
\]

(2)

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

\[
MH = (I - AH)^{-1}
\]

(3)
The income multiplier $l_j$ of sector j is the column sum of MH, where $m_{hij}$ is the element of MH.

$$l_j = \sum_i m_{hij} \tag{4}$$

We calculate the direct employment effects using the coefficient $\lambda$ that expresses the employment per unit of sectoral output, defined by

$$\lambda = \frac{in_j}{X_j} \times a_{ij} \tag{5}$$

Where, $in_j$ is the labor income in sector j contained in China’s IO table, and $X_j$ is the total output of sector j.

Then, we can estimate the total employment effects through the following equation:

$$L_{SG} = \lambda (1 - A)^{-1} \times T_{SG} \tag{6}$$

Where, $L_{SG}$ is the vector of the employment created by shale gas investment; $T_{SG}$ the vector of shale gas development investments.

Due to the regulation of the regional IO tables, the four regional IO tables used in this paper have the same pattern, which means the whole calculation process in four different regions is quite similar.

### 3.2. Data

#### 3.2.1. 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.

#### 3.2.2. Shale Gas Investment Data form the Government’S Plans and Documents. The economic impacts of shale gas development are estimated, in this paper, by using the IO model. However, shale gas development is relatively new to the Chinese economy; we have to adjust the original IO model to incorporate it. The process, which was developed by Miller and Blair [12], requires detailed investment data on the sectorial level. These specific data are gathered through a survey of relevant research, enterprise plans and governmental documents.

The Chinese government announced the “Energy Development Strategy Action Plan (2014-2020)” based on the China’s 13th 5-year Plan, aimed to build a clean, efficient, safe and sustainable modern energy system. This plan sets out a series of strategies for reducing greenhouse gas emissions, optimizing the energy structure in China and developing clean energy. Those strategies are expressed as follows:

1. Saving strategy: total primary energy consumption is expected to rise to 4.8 Billion tonnes of coal equivalent by 2020. Comparing the figure (4.26 Billion tonnes of coal equivalent) in 2014, we find the annual growth rate of primary energy should be controlled to lower than 2.2%.

2. Domestic strategy: the Chinese government plans to maintain energy security by keeping energy self-sufficiency at 85%. Considering the present energy production and increasing energy demand, China needs to continue to strengthen, expand and improve its energy industry.

3. Green and low-carbon strategy: non-fossil energy will make up 15 percent of the total primary energy consumption by 2020. In the meantime, natural gas consumption will increase to more than 10 percent, while the proportion of coal consumption will decrease to less than 62 percent. In order to meet the clean energy demand, especially for natural gas, the Chinese government announced that the production of conventional natural gas will reach 185 Billion Cubic Meters (BCM) and shale gas production will grow to 30 BCM by 2020.

Apart from these recently issued strategies, the Chinese government also announced a series of regulations to support shale gas industry development. These include the “China Mineral Resource report (2015),” which provides the official data about the proven reserves of shale gas in China; The “Notification about shale gas exploitation regulations,” which describes the relevant regulations about shale gas exploitation, and it is the first official document concerning shale gas development; The
“Technical calculation and evaluation of shale gas reserves,” which set the criterion about shale gas reserve evaluation; The “Policy for the shale gas industry,” which designs the related regulation for the grants for shale gas development, during 2016-2018, the Chinese government provide 0.3 yuan/per CBM subsidy, 0.2 yuan/per CBM for 2019-2020.

According to the targets for shale gas production announced by the Chinese government, approximately 20 thousand wells would be required to be drilled, with planned production of 30 BCM shale gas by 2020, which means China needs to invest about 40-60 billion RMB in developing the shale gas industry. It is then possible for us to calculate the specific investment across the whole economy.

4. Results

4.1. Employment Creation of China’s Shale Gas Investment

The effect of shale gas development on employment is also a crucial parameter in any economic system, because it shows the extra jobs that can be created in the economy by investment activities. The specific employment number can be estimated by dividing the total employment incomes by average local salaries. The average annual salary in 2012 in Sichuan, Chongqing, Inner Mongolia and Guizhou is 61,404, 59,940, 56,532 and 55,128 RMB per worker, respectively. And in this paper, when we estimate the jobs created by shale gas investments, we use sector-specific average salary in four regions to improve credibility.

The employment effect resembles the trend in economic impact as it is largely influenced by employment multipliers and sectorial investments. However, the quantity of employment is also influenced by the regional average salary. Figure 1 shows the regional employment creation of shale gas investment. According our calculation, the equivalent jobs created by shale gas investment in Sichuan, Chongqing, Inner Mongolia and Guizhou are 0.66, 0.37, 0.14 and 0.05 million, respectively. Furthermore, Guizhou creates a relatively high number of jobs per unit investment, which benefits the relatively low average salary and high employment multiplier.

![Figure 1](chart.png)

**Figure 1.** Figure headings

In summary, the shale gas investment in question results in overall economic output increases of 1453 Billion RMB, which corresponds to 0.22% of the China’s GDP (in 2015). These investments also create approximately 1,238,000 equivalent jobs in total. It is estimated that these effects will be lower, where there is potential for automation to counteract this beneficial impact, although technology may lead to shale gas production increased. When it comes to the regional level, the shale gas investments in question result in regional economic effects of approximately 868, 427, 115 and 42 Billion RMB in Sichuan, Chongqing, Inner Mongolia and Guizhou, respectively. It also creates
666,000, 371,000, 143,000 and 58,000 equivalent jobs. Although, the boosting effect would likely be more noticeable if we evaluated it at a smaller scale (e.g. city level).

5. Discussions

5.1. What if Those Investment Was Allocated to Coalbed Methane Investment in China

In China, other alternative energy sources’ development require less investment, but can create more production, which means they may have a better investment effect. Luo and Dai [13] evaluated China’s CBM resources, indicating that there is a large resource that is economic to develop. Qin[14] estimated that the capital invested in Coal Bed Methane to produce about 30 billion cubic meters gas (the same production as the shale gas production goal) in 2020, would be approximately 200 Billion RMB, which is just two fifths of the amount being invested in shale gas. Therefore, shale gas development may not be as attractive as it seems.

In order to compare, a virtual scenario was designed that allocated the massive Shale gas investment to the coalbed methane industry in China instead, and investigated the economic impacts and employment creation in this scenario. We use the same method as in the shale gas investment’s economic impacts and employment creation. The “coalbed methane investment” results in overall economic output increase about 1985 Billion RMB, and creates approximately 839,000 equivalent jobs in total. The comparison of the total economic impacts and employment creation of shale gas and coalbed methane investment is shown at figure 2.

![Figure 2](image.png)

**Figure 2.** Comparison of the economic impacts and employment creation of shale gas and coalbed methane investment

Figure 2 shows that the economic impacts of shale gas investment are not as high as for coalbed methane. The main reason is that the development of shale gas is at the primary stage, at which shale gas has not developed the scale effect, and the cost of shale gas development is significantly higher. The number of employment creation of shale gas investment is higher than the “coalbed methane investment”. The main reason is that shale gas industry, like coalbed methane industry in China, is labor-intensive. Since shale gas has never been developed before, as a result, the number of employment creation by shale gas investment is expected to be very high. However, the large number of the employed population also implies the higher labor costs, to some extent reduced the economic impacts of shale gas investment.

5.2. Is Massive Shale Gas Investment Really a Good Choice for China Right Now?

In this paper, we did not consider a number of additional economic factors, such as natural gas prices and tax. These economic factors, may shift the impact of investment- for example, Considine[15]...
found that a 10% decrease in the price of natural gas is estimated to reduce the number of new wells drilled by 17.4%, and when tax increased 10% the number of future wells drilled was expected to decrease by 30% [16]. As a result, such future uncertainty may cause a vastly different economic effect. On November 25th, 2015, a few regions in China announced the decrease of natural gas prices. The gas price reduced by 0.45-0.7 RMB per cubic meter, which was an approximate decrease of 10%-25% compared to the initial price, which means the economic effect of shale gas development will also decrease.

Available capital can be considered as a resource which is limited if one industry spends too much, the remaining investment available for other industries is less. Shale gas development requires significant investment in related industries, which in turn, will cause a significant decrease in investment available to other industries. Specifically, in China, the investment in the coal industry will see a noticeable decline. As a result, it may cause a serious employment issue. In this paper we only calculate the positive economic effect of shale gas investment, but ignore the negative impacts of the investment. It is quite important for future studies to investigate the economic and employment effect between the decrease of coal consumption and the increase of unconventional energy in the short and medium term so as to provide useful insights to decision makers for balancing different energy development investments.

Considering all of these factors, it can be argued that we should reconsider the investment in shale gas development, at least, in the current situation. It may be a “better choice” to slow the shale gas development and maintain it as a future option when prices and technologies improve.

6. Conclusion and Policy Implications
The development of Shale gas industry needs large investment, which in turns, will create new jobs. In this paper, we calculated the number of new jobs though input-output model.

The results show that the employment effects (1.23 million equivalent jobs) of shale gas investment in four regions. We also compared the regional economic effects and find it varied noticeably across regions. Employment creation 666,000, 371,000, 143,000 and 58,000 equivalent jobs in Sichuan, Chongqing, Inner Mongolia and Guizhou, respectively.

Based on our discussion and conclusions, we have several policy recommendations: we recommend that China’s government should establish and perfect the mechanism of market of shale gas, allowing more social capital to take part in the development of shale gas, and encouraging the international cooperation between national oil companies and international oil companies. As we noted in section 1, the Chinese government expects that its unconventional gas resources would compensate for China’s natural gas shortage. According to this paper, shale gas development will face various challenges, including high cost, immature technical condition and serious environmental impacts. As a result, investment in shale gas development seems to be less attractive in short term. China’s government should continue to encourage companies to invest in R&D, reduce the cost and promote shale gas to be economically viable.

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