Panel Regression Model Analysis on Effect of Regional Economic Development on Industrial Safety in China

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Abstract. This paper made a panel regression model analysis on relationship between regional economic development and regional industrial safety among 4 economic regions in China based on statistical similarity. Results showed that regional economic development has certain influence on regional industrial risk. A region with high gross domestic product could be found low industrial fatality rate. Regional proportion of industry, human resource and technology are obvious elements effecting regional industrial safety. It is benefit for decreasing regional industrial accidents by way of improving regional economic structure, human resource and technical level.

Introduction

Industrial accidents such as coalmine gas explosion occur rather frequently with rapid economic development in China. Various industrial accidents have brought huge economic losses as well as many peoples’ lives. Economic loss caused by work accidents were about 200 billion Yuan (RMB) each year, accounting for about 2% of GDP (national gross domestic products) [1]. Statistic studies have found that industrial safety situation is closely related to the social and economic development in different countries or in different historical stages[2]. Generally speaking, industrial safety situation in developed countries are better than that of developing countries. According to the statistical data collected by International Labor Organization, fatality rate per 10⁵ workers in developed countries was rather low, which was 4 on average, while fatality rate per 10⁵ workers in developing countries were above 10. Several previous studies have estimated the relationship between economic development and accidents risks. Vilanilam JV (1980) [3] made a historical and socioeconomic study on occupational safety in India, and proved that occupational accidents fatality rate declined along with economic development in India. Andreoni (1986) [4] proved that occupational accidents, occupational injury and occupational diseases could shorten business cycle, even terminate it. Wiener Klinische (2007) [5] studied the relationship between decrease of occupational injury and economic growth in Austria and found that economic growth could decrease occupational injury. A Barth, R Winker, E Ponocny-Seliger, L Sögner (2007) [6] studied the relativity between gross domestic product (GDP) and occupational hurts by method of statistics analysis and found that there is close relationship between economic growth and the decrease of occupational hurts. WANG Xian-zhen et al. (2007) [7] made a statistical research on
occupational safety and socioeconomic indexes in typical developed countries and China, and proved that occupational safety is related to socioeconomic development level on national level. SONG Li (2011) [8] studied the relativity between economic development and occupational accidents using statistical methods, and proved that variation of economic speed had important influence on occupational accidents in short term. But no research studied how regional economic development elements affect regional industrial accidents up till now. This study aimed to explore how regional economic development and its key elements influence regional industrial safety on the basis of comparative statistical description.

Method

Data
Two kinds of data including regional economic development and regional industrial accidents were collected and analyzed in the paper. As regional economic development is a compound variant, we used six variants including regional gross domestic product per capita, regional industrial proportion, proportion of regional import and export commodity value in national total, production value of regional non-state economy, regional technology contracts value and regional financial input on education to describe regional economic development. All of data on regional economic development come from China Statistics Yearbook each year, and data on regional industrial accidents could be found in China Work Safety Yearbook compiled by State Administration of Work Safety, which takes charge of work safety administration and statistic data collection of all kinds of work accidents. We adopted death toll \( L_{\text{ofd}} \), fatality rate per 10^5 workers \( L_{\text{ofwr}} \) and fatality rate per unit production \( L_{\text{ofre}} \) to describe industrial accidents risks. We adopted compound variants including regional gross domestic product \( L_{\text{agi}} \), regional industrial proportion \( L_{\text{iri}} \), regional foreign trade value \( L_{\text{opi}} \), regional technology value \( L_{\text{tepi}} \), regional financial input on education \( L_{\text{hri}} \) and production value of regional non-state enterprises \( L_{\text{mri}} \).

Method
Statistical figures are usual methods which could describe variation of both economy and industrial safety. We used line figures and scatter diagrams to compare spatial distribution difference both in regional economic development and industrial accidents among 4 economic regions in China. Panel models were built based on the above statistical analysis. Eviews6.0 was used to operate model. Characteristics of panel data were tested by Hausman test to find which kind of regression model is suitable to the data and improve validity of parameter estimate. Shown as in table 1, all of probabilities of Hausman statistics value were zero. This means that test results refused hypothesis “panel data could be made random effect models”. Fix effect models could be built.
Table 1. Hausman test results of the panel data.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Statistics value</th>
<th>d.f.</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_i$</td>
<td>4.09</td>
<td>(3,26)</td>
<td>0.0165</td>
</tr>
<tr>
<td>$R_{ui}$</td>
<td>12.15</td>
<td>(3,26)</td>
<td>0.0000</td>
</tr>
<tr>
<td>$R_{ei}$</td>
<td>8.09</td>
<td>(3,22)</td>
<td>0.0008</td>
</tr>
</tbody>
</table>

Note: If probability is zero, then reject random effect models.

We built fix effect regression model as following:

$$y_{it} = \delta_i + \lambda + \sum_{k=1}^{i} \beta_{ki} x_{kit} + u_{it}$$

Where $y_{it}$ was $L_{i\text{of}}$, $L_{i\text{fwr}}$, and $L_{i\text{fve}}$, respectively. $x_{kit}$ was regional economic development variances including $L_{i\text{gpl}}$, $L_{i\text{rbi}}$, $L_{i\text{hri}}$, $L_{i\text{opi}}$ and $L_{i\text{mri}}$.

$i = 1,2,3,4$. $i$ refers 4 economic regions. $t = 1,2,...,8$. $t$ refers time point. $\delta_i$ is intercept, $\lambda$ is parameter of the model, $\beta_{ki}$ is estimated parameter; $u_{it}$ is random error.

Results

China is traditionally divided into 4 economic regions including the East, the Midland, the West and the Northeast. Owing to many factors such as resource gift, geographical and social condition, 4 economic regions take on obvious differences in economic development elements such as technology, human resource foreign trade and marketing-oriented economy. As shown in figure 1 and figure 2, the East was the richest area with technical and talent advantage, and the West was backward. Meanwhile the West showed higher industrial accident risk, both fatality rate per unit production and fatality rate per $10^5$ workers in the West was on the high side, while that of the East was at the bottom.

![Figure 1. FR per $10^5$ workers and gross domestic product per capita; 2014.](image-url)
Fix effect models could be built using regional industrial accidents variants $L_{onfi}$, $L_{ofrwi}$ and $L_{ofrei}$ as dependent variants, and regional economic development elements $L_{agi}$, $L_{iri}$, $L_{tepi}$, $L_{hri}$, $L_{opi}$, $L_{mri}$ as independent variants. Results were shown in table 2. Both $R^2$ and adjusted $R^2$ were above 0.96, which means all of models had goodness of fit.

$$L_{onfi} = \alpha_i - 0.93 - 0.03 \times L_{agi} + 0.68 \times L_{iri} + 0.37 \times L_{tepi} - 0.46 \times L_{hri} + 0.59 \times L_{opi} + 0.05 \times L_{mri}$$

where $i = 1, 2, 3, 4, \alpha_1 = -1.89, \alpha_2 = 0.76, \alpha_3 = 1.18, \alpha_4 = -0.08$

Although death toll in 4 regions had same trend during 2002-2014, difference among 4 regions was obvious. We compared absolute value of coefficients in above equation from big to small as following: $L_{iri}(0.68), L_{opi}(0.59), L_{hri}(0.46), L_{tepi}(0.37), L_{mri}(0.05), L_{agi}(0.03)$. All
of economic development variants had different effect on regional industrial accident death toll. Proportion of industry in regional economy, regional foreign trade, human resource and technology has obvious influence on regional death toll.

Equation 2 is fixed effect panel regression equation of regional fatality rate per $10^5$ workers and regional economic development.

$$L_{ofrwi} = a_i - 12.32 + 0.26 \times L_{agi} + 2.38 \times L_{iri} + 0.22 \times L_{tepi} - 1.49 \times L_{hri} - 0.06 \times L_{opi} + 0.07 \times L_{mri}$$

Where $i = 1, 2, 3, 4$, $a_1 = -0.78, a_2 = 0.004, a_3 = 0.64, a_4 = 0.25$

Compared value of $a_i$, we can see obvious difference in fatality rate per $10^5$ workers among 4 economic regions during 2002-2014, although they had same trend of variation. According to absolute value of coefficient in above equation, we ranged variants as following:

$$L_{iri} (2.38), L_{hri} (1.49), L_{agi} (0.26), L_{tepi} (0.22), L_{mri} (0.07), L_{opi} (0.06)$$

Regional industry proportion, human resource and technology were three obvious influencing elements.

Equation 3 was fixed effect panel regression equation of regional fatality rate per unit production and regional economic development.

$$L_{ofrwi} = a_i - 9.61 + 0.09 \times L_{agi} + 1.22 \times L_{iri} + 0.05 \times L_{tepi} - 1.16 \times L_{hri} - 0.003 \times L_{opi} + 0.076 \times L_{mri}$$

Where $i = 1, 2, 3, 4, a_1 = -1.39, a_2 = 0.32, a_3 = 0.94, a_4 = 0.14$

Compared value of $a_i$, we can see obvious difference in fatality rate per unit production among 4 economic regions during 2002-2014. The West was the highest, the East was the lowest. According to absolute value of coefficient in above equation, we ranged variants as following: $L_{iri} (1.22), L_{hri} (1.16), L_{tepi} (0.25), L_{agi} (0.09), L_{mri} (0.076), L_{opi} (0.003)$. Regional industry proportion and human resource were two obvious elements influencing industrial safety.

**Discussion of Results**

Scatter diagram showed that regional economy development has certain relationship with regional industrial safety, and spatial distribution of regional wealth would influence that of industrial safety risk. A region with high gross domestic product could be found low fatality rate. Results of panel regression analysis on 4 regions during 2002-2014 showed that regional economic elements have different role on regional industrial safety. Thereinto, gross domestic product per capita which is used to represent national wealth can interpret spatial distribution difference among 4 economic regions, but not the only one, nor obvious one. Proportion of industry which is usually describes economic structure is the most important element effecting regional safety, following are human resource and technology. Owing to high risk of industry, high proportion of industry in each region was the most important element which increased regional industrial accidents risk during 2002-2014. Improvement of human resource and technical level would have benefit on decrease of regional industrial accidents.

**Conclusions**

In summary, the purpose of this study is to explore relationship between regional economic development and regional industrial safety and how regional economic elements influence on
industrial safety risk. Findings were limited, possibly due to limited data, but still indicated that regional economic development has effect on regional industrial safety, regional wealth distribution can interpret spatial distribution of industrial safety risk to some extent.

Fatality rate per $10^5$ workers and fatality rate per unit production could reflect efficiency of economic development. Due to advantage of technology, human resource, the East had lowest fatality rates with highest economic growth efficiency from 2002 to 2014. While economy in the West had much lower efficiency due to disadvantage of technology and human resource at the same time. As a developing country, China is still on the way of industrialization, industry accounts for highest proportion in national economy, which means all of 4 economic regions are still in high industrial safety risk. It is essential to decrease national industrial safety risk by methods of improving skill of human resource and promoting technical development in industrial field.

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References


