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Statistical Analysis of China's Coal Mine Particularly Serious Accidents

Zhao Dai-ying[a,b], Nie Bai-sheng[c,d], a*

[a] Explosion Science and Technology, State Key Laboratory of Beijing Institute of Technology, Zhong Guan Cun South Street Haidian District，Beijing,100081,
[b] School of Environment and Safety Department of Tianjin University of Technology, TianJin 300384,China,
[c] School of Resource and Safety Engineering; China University of Mining and Technology (Beijing), Beijing 100083; China;
[d]State Key Lab of Coal Resources and Safe Mining, China University of Mining and Technology, Beijing 100083, China)

Abstract

Based on China's coal mine particularly serious accident data from 1981 to 2010, the times and death toll of PSCA are described by statistical methods; the relative indexes according to time, output, employee are analyzed by statistical methods, and the results show the developing trend of PSCA is grim. According to month, area and accident type, some useful and important analysis conclusions are drawn. At last, the main factors of PSCA are analyzed by granger causality test, impulse response function and variance decomposition. The result can provide reference for decision-making.

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Keywords: particularly serious accident in coal mine,absolute index,relative index, granger causality test,variance decomposition;

1. Introduction

Particularly serious accident is defined as one time accident which death toll is more than or equal to 30. It is the highest level of accident in China, and it express the accident is very critical. China is one of the largest coal production countries in the world. Coal mining provides a strong driving force for China's economic development, but now China's coal industry is the most serious casualty of industrial accidents

* Zhao Dai-ying. Tel.: +0+86+13821062116; fax:.
E-mail address: zhaodaiyingjady@126.com.

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in the production industry [1].Especially in 2005, there are 11 particularly serious accidents in China's coal industry, and the death toll is 953, which reaches a new record. The coal developing trend is very grim. It is necessary to analysis the history and status to grasp the development characteristics and trends, so as to attain the aim of reducing accident.

Some scholars have done valuable work in accident statistics. HE Xue-qiu, SONG Li, NIE Bai-sheng [2] analyzed basic characteristics of occupational safety from the view of socioeconomic development angle. Liu Xiaoli, Guo Liwen[3], Liu Liang[4] and An Mingyan[5] have done statistical analysis according to the time, zone and other factors of China's coal mine. The results show China coal mine gas accident is the most important factor in all types of accidents, which should be controlled by accident prevention measures

2. Statistical description of indexes in particularly serious coal mine accidents(PSCA)

2.1. Statistical description of absolute indexes in PSCA

According to the data of 1981-2009 year, fig. 1is plotted as follows.

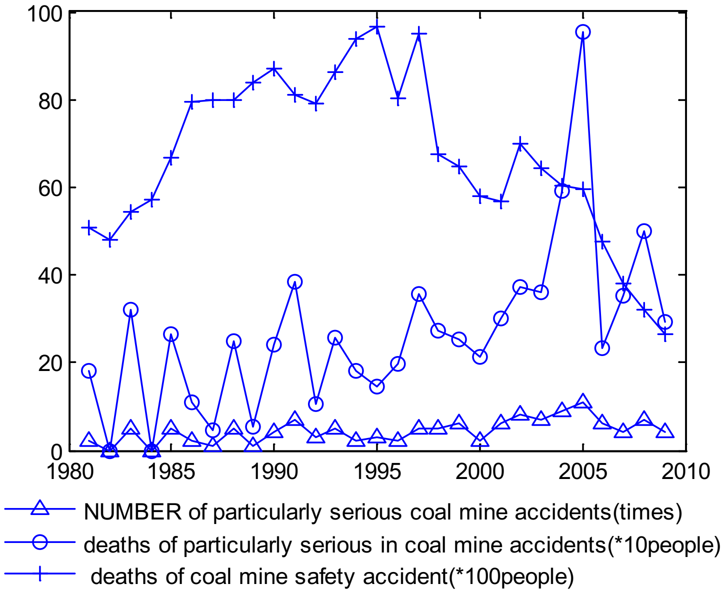

Fig. 1. Absolute indexes of PSCA

In the fig.1 above, we can see before the year 1997, the number of death of coal mine accidents and PSCA maintain a stable level. The period is defined as fluctuations, expressed as a period of alternating high and low every 1 or 2 years.

The death toll of coal mine accident is declining after 2000 year. However, the number of death in PSCA is rising sharply. The death toll of PSCA in 2005 is as high as 953.

2010-2015 is assumed as a critical stage of changes. If the declining trend is contained, coal safety will get a great improvement. By the contrary， If we are overly optimistic, the situation maybe turns worse.

The coal mine accident-prone situation in 2005 caused national attention, so several important documents were introduced and safety monitoring efforts were strengthened. These measures played a role gradually after 2006.

2.2. Statistical description of relative indexes in PSCA

There are three indicators deserving research. They are rate of deaths of particularly serious accidents and of all coal accidents, deaths of particularly serious coal accidents per million tons coal and Deaths of particularly serious coal mine accidents per million tons coal.

In figure 3 we can see 2005 and 2008 year are the highest points clearly, which mean that the rate of deaths in particularly serious accidents and in all coal accidents is very grim, about 15%. So to curb particularly serious accidents is one of the most important tasks currently. Similarly in figure 4 deaths of particularly serious coal accidents per million tons coal has no obvious signs of improvement.

Fingure 5 expresses the change situation of deaths of hundred thousand employees in coal mine which is generally an indicator of measure of employee risk. We are pleased to see that the curve declining rapidly from 2002 year. The reason is State Administration of Work Safety was established in 2002 year. Strengthening the administrative played an important role to reduce employee risk.

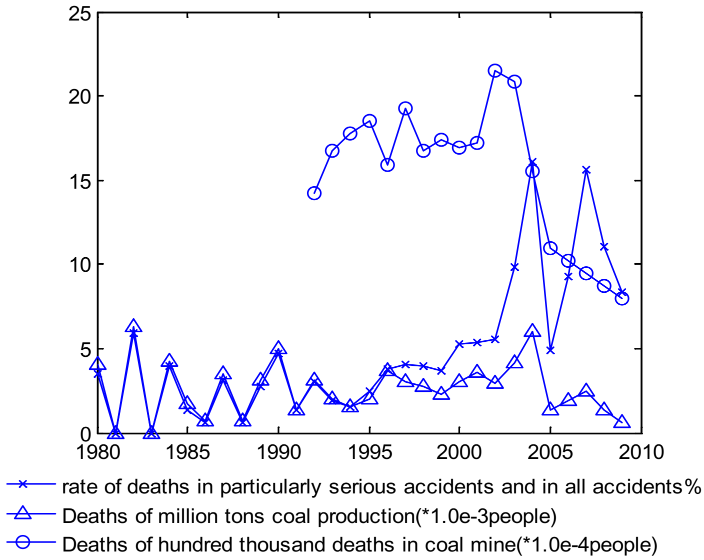

Fig. 2. Relative indexes of PSCA

2.3. Time series statistical analysis of PSCA according to month

Based on the data of number of particularly serious coal accidents and deaths of 1950-2010, fig.3 is plotted as follows. The accident occurrence shows some characteristic of the time. The annual March-May and November-December are month of the high incidence of PSCA.

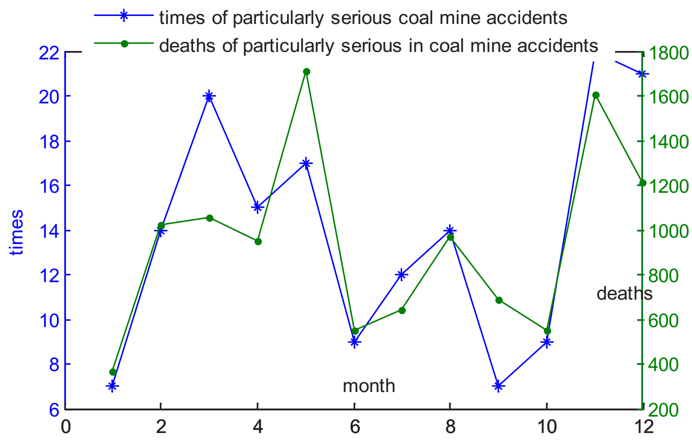

Fig. 3. Time series of PSCAt according to month

2.4. Regional distribution statistical analysis of PSCA

Based on the data of number of deaths of PSCA of 1950-2010, fig.4 is plotted as follows:

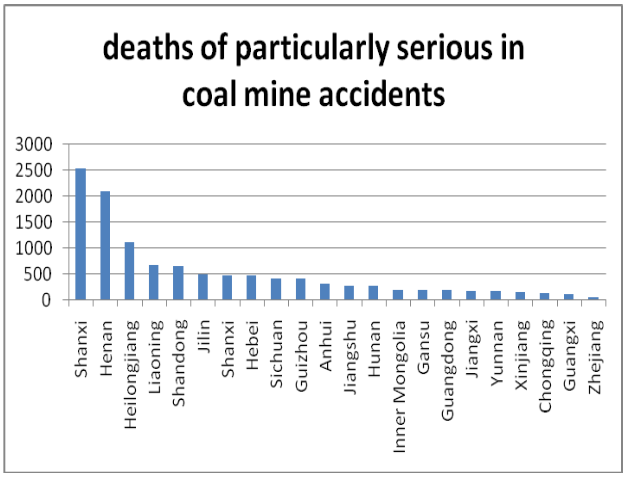

Fig. 4. Regional distribution of PSCA

Shanxi, Henan, Heilongjiang provinces are accident-prone provinces, in the statistics span of 61 years, 32 cases occurred in Shanxi, and 29 cases occurred in Henan, which means there is once accident on average every 2 years. 17 cases occurred in Heilongjiang, which means there is once accident on average every 3.5 years. Certainly the frequent is too high to bear.

The fig.4 shows Shanxi, Henan and Heilongjiang are the most serious provinces. They have more death toll than others. In the span of 61 statistical years, the death number due to particularly serious accident in Shanxi is as high as 2512, average 41 people die each year, Henan killed 2087 people, on average 34 people die each year, Heilongjiang killed 1099 people, average annual killed 18 people.

Undoubtedly, Shanxi, Henan and Heilongjiang provinces are the focus of monitoring.

2.5. Statistical analysis of PSCA according to types

Based on the data of number of deaths in particularly serious coal accidents of 1950-2010, fig.5 is plotted as follows.

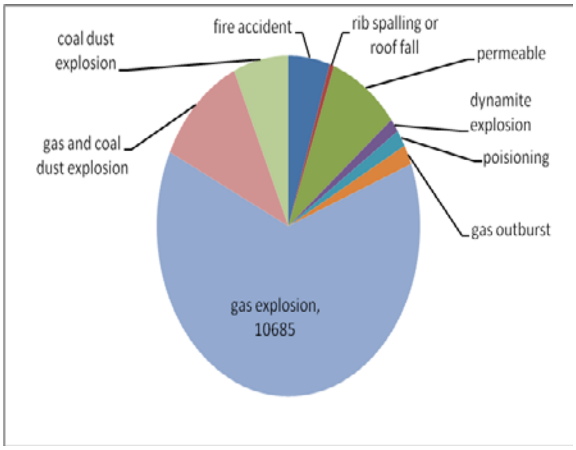

Fig. 5. Type distribution of PSCA

There are 9 types in terms of accident types: gas explosion, flooding, gas and coal dust explosion, fire, dust explosion, gas outburst, cave-chip, poisoning and suffocation. According to the various types of particularly serious accidents, mine death toll ratio plotted in Fig.5. It can be seen from the figure, most gas explosion, and gas-related accidents accounted for most ratio , which is 71%. Flooding accident take second place, the total number of accidents accounted for 12%. Therefore, the work of gas control will remain as the most main work of China's coal mine.

3. The statistical analysis of influence factors of PSCA

3.1. VAR model and stability analysis of data

In order to analysis death toll of PSCA (DOP) and number of PSCA (NOP), several indexes are chosen as main influence factors: death toll of coal mine accidents (DEATHS), output of raw coal (PRODUCTION) and GDP growth rate (GDPV). Fig.6 shows the variables time series curves.

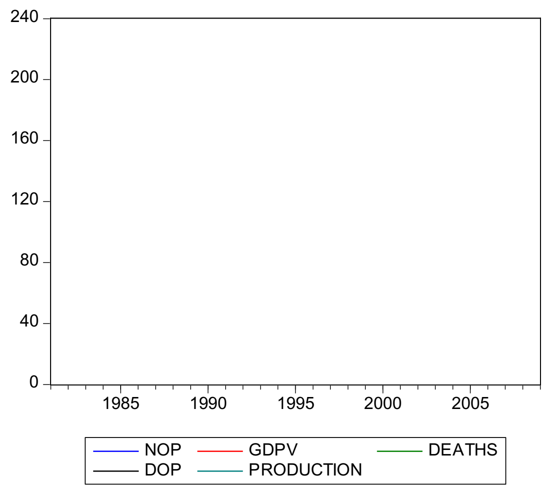

Fig. 6. Variables time series curves

According to AIC and SC Minimization principle [8], choosing the best lag period of VAR model is two periods. The models are showed as follows:

$$DOP = C(1,1)*DOP(-1) + C(1,2)*DOP(-2) + C(1,3)*GDPV(-1) + C(1,4)*GDPV(-2) + C(1,5) \quad (1)$$

$$DOP = C(1,1)*DOP(-1) + C(1,2)*DOP(-2) + C(1,3)*PRODUCTION(-1) + C(1,4)*PRODUCTION(-2) + C(1,5) \quad (II)$$

$$NOP = C(1,1)*NOP(-1) + C(1,2)*NOP(-2) + C(1,3)*GDPV(-1) + C(1,4)*GDPV(-2) + C(1,5)*DEATHS(-1) + C(1,6)*DEATHS(-2) + C(1,7) \quad (III)$$

The three VAR models above have passed AR ROOTS test shown in fig.7

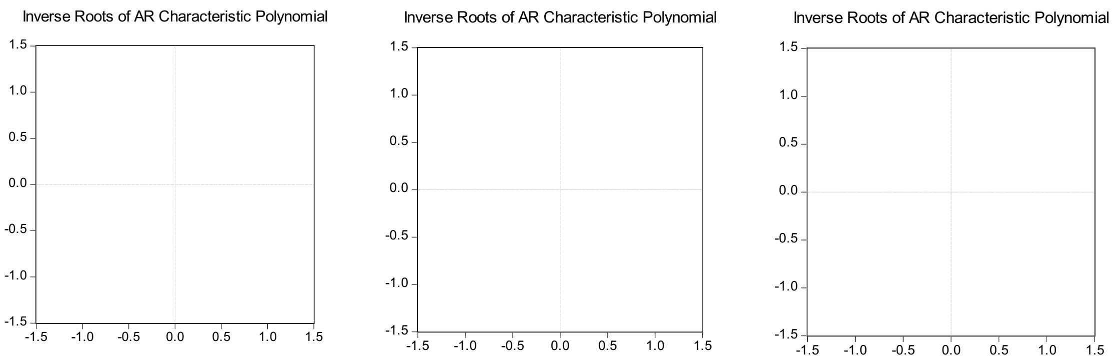

Fig. 7. (a) DOP and GDPV model;(b) DOP and PRODUCTION model;(c) NOP, DEATHS and GDPV model

In order to study stable of variables, ADF test are applied.

Table 1. ADF unit root test results

Variables	Value of ADF	5% Threshold	Probability P value	Is it stable?
DOP	-5.588175	-3.580623	0.0005	YES
NOP	-5.293533	-3.580623	0.0010	YES
GDPV	-4.274864	-2.986225	0.0028	YES
PRODUCTION	-0.917889	-3.587527	0.9391	NO
DEATHS	-1.259063	-3.580623	0.8774	NO

From table above, we can see the dependents variables are stable, so cointegration analysis won't be done.

3.2. Granger Causality test

Granger causality test result show that only PRODUTION is granger cause of DOP Bulleted lists may be included and should look like this:

Table 2. Granger Causality test

	Chi-sq	df	Prob.
GDPV is not DOP's granger cause	0.999769	2	0.6066
PRODUCTION is DOP's granger cause	7.415615	2	0.0245
GDPV is not NOP's granger cause	2.994516	2	0.2237
DEATHS is not NOP's granger cause	0.424038	2	0.8089

3.3. Impulse Response Analysis

In order to study the dynamic relationship of variables, impulse response analysis is conducted. The result showed as follows:

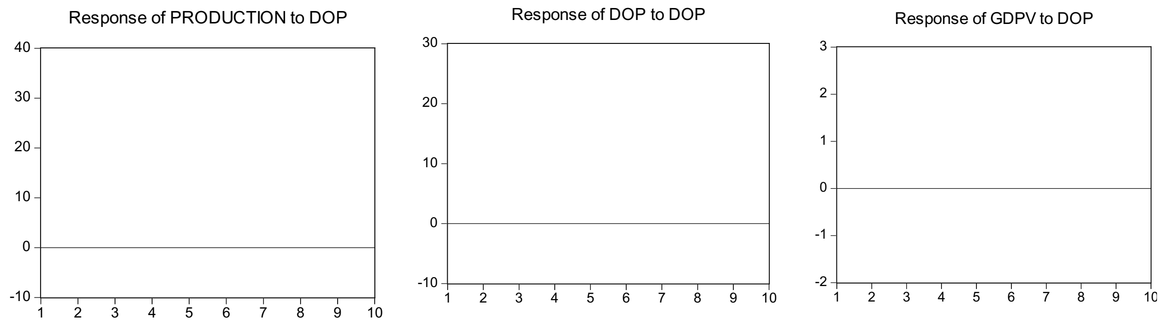

Fig. 8. DOP response curves to influence factors

The first graph of Fig.8 show PRODUCTION has positive impulse effect to DOP, and the effect will maintain a long time. The underlying reason should be safety management level lags to coal output ability[9].

The second graph of Fig.8 show DOP has negative impulse effect to DOP, and the effect will only maintain one period.

The third graph of Fig.8 show GDPV has both positive and negative impulse effect to DOP. Because bigger GDPV means more production work, and more work means more risk. We believe the positive impulse effect in terms of the analysis. The positive effect will maintain three periods.

3.4. Variance Decomposition Analysis

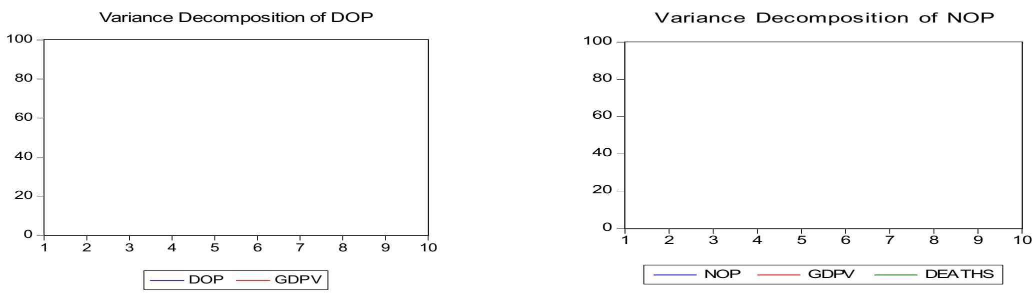

Fig. 9. The result of variance decomposition

The first graph of Fig.9 shows variance decomposition of DOP, the changes results in itself is much large than results in GDPV.

The second graph of Fig.9 shows variance decomposition of NOP, the changes results in itself gradually decreases, at last maintain at 80 percent level, while the changes results in NOP gradually increases.

4. Conclusions

According to China's PSCA data, absolute indexes and relative indexes are analyzed by statistical methods. Several useful conclusions are drawn. Variance dynamic relationship is researched by VAR models. It can be concluded as follows:

- Relative indexes analysis shows that the deaths of hundred thousand employees in coal mine is declining, but PSCA developing situation is very grim;The analysis according to month shows annual March-May and November-December are month of the high incidence of PSCA;The analysis according to region shows Shanxi, Henan and Heilongjiang should be strengthen management;The analysis according to type shows gas and flooding accidents still are the most serious types.
- VAR models of DOP and NOP are build and the result of granger causality analysis shows only output of raw coal is DOP’s cause.
- Impulse response and variance decomposition analysis show the relationship of variances in detail.

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