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Utility optimization strategy of safety management capability of coal mine – A case study of JCIA ☆

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ABSTRACT

This article describes optimization strategy of SMCCM from perspective of utility of coal miner with the method of empirical research. Four elements of SMCCM are put forward which consist of "employee safety knowledge", "equipment safety knowledge", "environment safety knowledge" and "rule safety knowledge". Eight elements of utility are put forward which consist of "benefit satisfaction", "promotion satisfaction", "job satisfaction", "enterprise satisfaction", "management satisfaction", "colleague satisfaction", "relationship satisfaction" and "communication satisfaction". Then hypotheses of influence path between SMCCM and utility are proposed. JCIA is chosen as the sample to carry out survey, which questionnaire is designed based on the likert six-point scale to avoid the middle tendency of the test samples. Data analysis is done from following angles: analysis of the structure and utility of test samples, variables analysis of SMCCM and utility, model analysis of interaction between SMCCM and utility. And then results are obtained from the analysis of elements of SMCCM and elements of utility. Conclusions: first, "rule safety knowledge" should be strengthened above all; second, "job satisfaction" should be paid more attention to; third, coal miner's benefit should be concerned specially.

1. Introduction

According to official data of State Administration of Work Safety, the death toll of coal mine accident accounts for 30.67% of that in mining and commercial enterprises from 2004 to 2010, which leads to heavy losses of human life and property, destroys image of country. According to statistical data of major accidents case of 49 coal mine in recent 5 years, "operation against rules" and "command against rules" account for 61.9% of the accident reasons, and "low safety management capability" accounts for 38.1% of it. It is shown that psychological factors of coal miner will contribute to safety situation of coal mine positively (Burt et al., 2009; Chen et al., 2009). On the contrary, the worse attitude toward errors and risking behaviors is, the lower "job satisfaction" and risk preference behaviors are, which may lead to more coal mine accidents (Margolis, 2010; Hohnen and Hasle, 2011). Since subjective factors of coal miner contribute to the accident of coal mine seriously, it should be paid more attention to.

Safety management capability of coal mine (SMCCM) has close relationship with employee's attitude as a kind of cumulative safety knowledge (Liu and Li, 2008). The bounded rationality of coal miner makes it difficulty to pursue optimal solution of SMCCM, so utility of coal miners should be discussed to discover optimization strategy of it.

2. Methodology

2.1. Variable design

Because elements of SMCCM involve cumulative knowledge of four dimensions (Li et al., 2010), SMCCM system can be set out according to these dimensions, which are "employee safety knowledge", "equipment safety knowledge", "environment safety knowledge" and "rule safety knowledge". "Employee safety knowledge" belongs to tacit knowledge (Burke et al., 2011) mastered by individuals; "equipment safety knowledge" belongs to explicit

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knowledge materialized in protective equipment and facilities of coal mine Kuhlmann, 1991); "environment safety knowledge" exists in the way of explicit knowledge (Bi and Zu, 2009; Kinilakodi and Larry Grayson, 2011), which is used as underground hydrogeology, risk analysis and safety atmosphere to resist the impact of internal and external environment; "rule safety knowledge" belongs a kind of explicit knowledge, which is the summary of experiences of safety production (Page, 2009; Kecojevic, 2011) as a kind of relevant knowledge of procedures, planning and standards of coal mine.

The corresponding research of utility mainly focus on satisfaction, which could be divided into two kinds: the one focus on the work itself, which consists of satisfaction of work environment and work achievements (Zhang et al., 2009; Fisher, 2003); the other focus on management flow, which consists of satisfaction of matching degree between people and work, salary and welfare, etc. (Huang, 2005; Paul and Maiti, 2007; Wang et al., 2009). Then variables system of utility with eight dimensions is put forward in this paper, which are "benefit satisfaction", "promotion satisfaction", "job satisfaction", "enterprise satisfaction", "management satisfaction", "colleague satisfaction", "relationship satisfaction" and "communication satisfaction".

2.2. Hypotheses

Hypotheses of influence path between SMCCM and utility are proposed as shown in Table 1. Symbols in Table 1 represent the relationship between indexes of SMCCM and utility, which are assumed as positive.

2.3. Questionnaire design

Questionnaire is designed with likert six-point scale in order to avoid the middle tendency of the test samples.

First part of questionnaire is about SMCCM, which involved 20 items in four dimensions. In which, safety experience, safety realization and safety behavior are included in "employee safety knowledge"; equipment platform, operating rules and work flow are included in "equipment safety knowledge"; safety atmosphere, working environment and working condition are included in "environment safety knowledge"; rule implementation, rule rationality and responsibility range are included in "rule safety knowledge".

Second part of questionnaire is about utility, which involved 29 items in eight dimensions. In which, fair return and award opportunities are included in "benefit satisfaction"; opportunity to get promotion are included in "promotion satisfaction"; work flow, work significance and sense of accomplishment are included in "job satisfaction"; business tradition and development opportunities are included in "enterprise satisfaction"; capability of managers and his democratic management are included in "manager satisfaction"; colleagues' work ability are included in "colleague satisfaction"; harmonious interpersonal relationships are included in "relationship satisfaction"; information channels and feedback are included in "communication satisfaction".

2.4. Scope and object

Jilin Coal Industry Association (JCIA) is chosen as the object, which are formed by merging several state-owned coal mine with local coal mine in 2009. The survey is started on December, 2010, which mainly focuses on headquarters of JCIA and its four subordinate mines. Total 254 persons take part in the investigation. At last the number of valid questionnaire is 245, with a effective rate of 96.46%.

Table 1
Hypotheses of influence path between SMCCM and utility.

Variables	E_1	E_2	E_3	S
B	H1	–	H2	–
P	–	H3	H4	H5
J	H6	–	H7	H8
E_4	–	H9	–	H10
M	H11	H12	H13	H14
C_1	H15	–	H16	–
R	–	H17	H18	H19
C_2	H20	H21	–	H22
E_1	–	H23	H24	H25
E_2	–	–	H26	H27
E_3	–	–	–	H28

Symbol interpretation: E_1 – employee safety knowledge; E_2 – equipment safety knowledge; E_3 – environment safety knowledge; S – rule safety knowledge; B – benefit satisfaction; P – promotion satisfaction; J – job satisfaction; E_4 – enterprise satisfaction; M – manager satisfaction; C_1 – colleague satisfaction; R – relationship satisfaction; C_2 – communication satisfaction.

2.5. Data analysis method

Several methods are used as the tool to analyze data. In which, descriptive statistical is used to analyze the sample structure from distribution and percentage of characteristics; reliability analysis is used to test the consistency and stability between the items of questionnaire by Cronbach' a; correlation analysis is used to find the relationship between variables, which is done by structural equation model (SEM). Then the interaction path between SMCCM and utility is constructed.

3. Empirical analysis

3.1. Analysis of the structure and utility of test samples

The output data are displayed separately to show different features of sample, as is shown in Table 2.

3.2. Variables analysis of SMCCM and utility

In order to show the improvement of variables, these variables' value is displayed in Table 3. It can be seen that the absolute value of variables are located in the middle level and upper level of Table 3; and the Crobach's α of two categories of variables are over 0.9, which represents the high reliability of result (Page, 2009).

It can be seen through the analysis of SMCCM variables that "employee safety knowledge" gains the highest score, which shows that the training of employee safety realization, the accumulation of employee safety experience and the improvement of employee safety behavior have been emphasized; "equipment safety knowledge" and "environment safety knowledge" get the middle score, which shows that the investment in equipments and facilities has been paid more attention to; "rule safety knowledge" is located in the last place, which shows that the law, regulations, standards have a relatively lower position.

3.3. Model analysis

In order to test the interaction between SMCCM and utility, method of SEM with endogenous variables and exogenous variables is used, which is shown as Fig. 1.

3.3.1. Model checking and entire fitting degree analysis

Six steps are taken to modify the model above based on the corresponding standard (Hou et al., 2005): first, to modify the latent variable factor loading λ_y; second, to modify the latent variables