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Coal miners' livelihood vulnerability to economic shock: Multi-criteria assessment and policy implications

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ABSTRACT

Because of the profound adjustment of the global economy and significant fluctuations in energy prices, many coal workers in coal-mining cities are experiencing great risks to their livelihood. Thus, coal workers' livelihood have become an important social issue worthy of investigation. This study use the rough set-technique for order preference by similarity to ideal solution-rank-sum ratio (RS-TOPSIS-RSR) methodology and construct a composite coal miners' livelihood vulnerability index (CMLVI) to assess coal workers' livelihood vulnerability in 33 coal-mining cities. The results show that, from the time dimension perspective, the livelihood vulnerability of cities varies with time and even the same cities have different degrees in each of the three years. From the horizontal perspective, the coal miners' livelihood vulnerability level in comparatively developed mid-eastern region is significantly lower than that in the underdeveloped western and northeast regions of China. In addition, cities with the same level of livelihood vulnerability may have different vulnerability patterns and even low vulnerability cities may have high vulnerability in some dimensions. Based on the findings, we propose policy measures that aim to reduce the sensitivity of habitat conditions, improve the resilience of society, and enhance the stability of individuals in order to address livelihood problems.

1. Introduction

There are many arguments about coal's utilization (Sun et al., 2016a, 2016b); however, coal is the world's most abundant source of fossil energy and is still one of the most important foundations for future energy needs. Moreover, it is likely to remain so for a long time (Li and Hu, 2017; Xia et al., 2017). Between 2002 and 2015, world coal production rose from 49.2 billion tons to 78.6 billion tons, an average annual increase of approximately 3.4%. Further, coal accounts for approximately 30% of global primary energy consumption. China is the world's largest producer and consumer of coal. In 2015, China's coal production and consumption accounted for approximately 47% and 50% respectively of the global totals; in addition, coal accounted for 72% of China's energy production and 64% of its energy consumption (Tang and Peng, 2017; Yuan, 2016). Because of factors such as resource endowment, path dependence, and energy security, the energy structure relies mainly on coal and cannot be changed for a long time (Li and Hu, 2017; Wang et al., 2013). The increasing exploitation of coal and the rapid development of the coal industry have also created many jobs. According to the third issue of the national economic census data released by the National Bureau of Statistics in 2015, there are approximately 20,000 enterprises related to coal mining and washing in China and nearly 7 million people in the industry. Indeed, the coal industry has become the industry with the largest number of employees among the 41 industrial sectors in China.

However, because of many reasons associated with coal workers, such as their single social relationships, strong professional technology, low levels of education, emotional moods, and so on, the coal workers' livelihood vulnerability problem is serious (Hilson, 2010; Laney and Attfield, 2014; Morris, 2016). For example, a small change in economic factors can trigger significant changes in coal miners' livelihood. This is because compared with light industries, the coal industry is more sensitive to macroeconomic fluctuations (Wang et al., 2017), and the impact of the coal industry's prosperity on miners is more significant. Since the 2008 financial crisis, China's economic growth has gradually slowed and the market demand for coal has declined. In this context, the increasing scale of coal overcapacity has led to a sustained decline in the industry's profitability and a significant decline in miners' income. For example, in 2016, the losses of China's coal industry were more than 70%; in addition, 90% of miners earned less than 4000 yuan

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a month.[1] However, the Chinese government has issued a series of policies to resolve the excess capacity for coal, including the problem of 1 billion tons of excess capacity by 2020 (*The Opinion on Solving Excess Capacity to Realize the Development of Coal Industry* released by the State Council in February 2016). Solving the excess capacity issue will cause the unemployment of 1.5 million coal workers. A large number of such workers are faced with special difficulties for re-employment, a situation that can lead to serious problems of poverty and can even have a significant impact on social stability in coal-mining cities (Zeng et al., 2016). Thus, it is both critical and urgent to understand how to mitigate coal-workers' livelihood risks and improve their ability to create sustainable livelihood.

In recent years, many challenge-seeking researchers among both academia and industry have spent considerable efforts on livelihood vulnerability assessments and coal industry policies. Since the 1990s, following the aggravation of global environmental problems and the development of human activities, the research on livelihood vulnerability has attracted increasing attention and has achieved some significant breakthroughs in certain areas, such as famine (Block and Webb, 2001), poverty reduction (Mahdi et al., 2008), livelihoods strategy (Fang et al., 2014; Tittonell, 2014), conceptual frameworks, developmental policy (Cherni et al., 2007; Jie et al., 2011), and so on. In terms of livelihood vulnerability assessment, most researches consider developing countries in Africa, Asia, and other regions as their study areas, take farmers and herdsmen with relatively poor habitat conditions as study objects, use a fuzzy cognitive mapping approach and a comprehensive index method to assess livelihood vulnerability in terms of climate change and epidemic diseases, and then propose corresponding strategies and suggestions (Huang et al., 2017; Petare et al., 2016; Recanati et al., 2017; Singh and Nair, 2014). In recent years, the market demand for coal has been declining. Such a decline is attributed to the combined influences of an economic downturn, market failure, system distortion, energy transformation and climate change challenge (Sun et al., 2017b, 2017a). This situation has seriously affected economic development, worker employment, and social stability. Against such a background, many experts and specialists have made significant efforts to ensure a sustainable development policy for the coal industry from the perspectives of excess capacity management (Liu et al., 2017; Yang et al., 2016; Zhang et al., 2017), structural adjustment (Bergerson and Lave, 2007; Kavouridis and Koukouzas, 2008), industrial transformation (Kuai et al., 2015; Long et al., 2013), technological innovation (Sun and Anwar, 2015; Sun et al., 2017c), market-oriented reform (Kamiński, 2009; Song et al., 2017), et cetera. There is no doubt that the results have acted as positive guides to the formulation of government policies. However, the studies suffer from limitations, as follows.

- The literature on livelihood vulnerability assessment mainly focuses on the impact of external risks such as climate change and human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS) on the livelihood vulnerability of farmers and herdsmen in developing countries. However, the problem of the livelihood vulnerability of coal miners under conditions of economic fluctuation has not been paid sufficient attention. Further, studies tend to describe livelihood vulnerability from different viewpoints and cannot present an overall perspective of livelihood security by capturing a range of vulnerability information in one index score. This inadequate approach is unfavorable for policymakers when they are evaluating relative livelihood vulnerability and developing targeted programs. Thus, it is desirable and necessary to create an overall coal miners' livelihood vulnerability index. Obviously, combining coal miners' livelihood vulnerability indicators into an index is a methodologically intensive process. It includes assigning weights to indicators and aggregating the indicators. In this respect, new methods are worth exploring and testing for the assessment of coal miners' livelihood vulnerability.
- The existing theories and practices of policies in the coal industry mainly focus on the coal industry itself and have not brought the issue of coal miners' livelihood into the analytical framework. Take the policy on coal capacity, currently the most observed issue, as an example. China has adopted a series of measures about resolving the coal industry's overcapacity from economic, environmental, ecological, technological, safety, and other perspectives. Further, the country has proposed the total amount of excess coal production capacity that needs to be resolved and has applied specific goals in various provinces. However, with regard to the allocation of capacity quotas in various provinces and cities, the current practice is to apportion the quotas in accordance with the scale of coal production in each region. This approach ignores the imbalance of economic development between different provinces and cities and the differences in the coal industry's competitiveness, especially with regard to the heterogeneity of the miners' livelihood. Consequently, local governments find it hard to strike a balance between resolving excess coal production capacity and ensuring employment (Wu and Li, 2015). This problem is the fundamental reason why local governments are not motivated to resolve productive capacity and why the central government's policy has not been implemented effectively. Thus, assessing the level of coal workers' livelihood vulnerability in coal-mining cities and revealing the differences among cities, and their causes, play a significant role in the development of policies in the coal industry.

Evaluating vulnerability is an interesting and challenging problem and is always an important concern for policymakers in the coal industry. Thus, we attempt some exploratory research for a coal miners' livelihood vulnerability assessment under conditions of economic fluctuation. This study contributes to the literature in three ways. First, we propose a new rough set-technique for order preference by similarity to ideal solution-rank-sum ratio (RS-TOPSIS-RSR) methodology to assess coal miners' livelihood vulnerability. In this regard, the integration of three isolated models can make the best of each model's advantages and overcome their disadvantages. Second, we introduce a hierarchically structured coal miners' livelihood vulnerability index (CMLVI). The CMLVI captures a multitude of risk information in a comprehensive manner instead of considering isolated indicators and offers advantages in terms of benchmarking and decision-making. Third, we rank and classify the 33 coal-mining cities of China into three groups; the causes of high livelihood vulnerability patterns are thereby revealed. This approach will help the coal industry's policymakers in drawing up targeted programs.

The remainder of this paper is structured as follows. After the introduction, Section 2 introduces the hierarchical structure of the composite CMLVI as well as the study areas and data sources. Section 3 presents the integrated RS-TOPSIS-RSR methodology for miners' livelihood vulnerability evaluation. Section 4 reports the application of the methodology and the computational results. Section 5 discusses the corresponding results and Section 6 summarizes the key conclusions and implications.

2. Indicators and data

2.1. Livelihood vulnerability response mechanism of miners to economic fluctuations

The livelihood concept was originally identified as a way in which a living is made, based on capabilities, tangible and intangible assets, and activities (Chambers and Conway, 1992). Approaches to livelihood analysis were then proposed to deal with growing global environmental and poverty problems. One of these approaches, the sustainable livelihood (SL) framework, includes five core parts that represent five

[1] http://www.mkaq.org/html/2016/07/16/376257.shtml.