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Prevention and Control Strategies and Mechanism Analysis for Risk Derivative of Coal Energy Supply Chain

Zhongfu Tan,Yinhui Zhao,Chen Zhang

(School of Economics and Management, North China Electric Power University, Beijing 102206, China)

Abstract

This paper analyzes the risk derived source of the coordinated development between the coal production, coal transportation, power generation, coal-powered energy to the electricity supply chain; coal production, coal transportation, power generation, electricity supply to the investment risk between incremental development, incremental development cost risk, price risk mechanism of delivery of development; the risk prevention and control of coal production, coal transportation, power generation, power supply to the electricity supply chain.

Keywords: coal energy supply chain, risk derivative，risk transmission and expansion, risk prevention and control

1. Introduction

It is known to all that, a risk transmission between all parts of coal energy supply chain occurred before the Spring Festival of 2008: a power interruption happened as a result of snowstorm; the power interruption leaded to the disruption of coal production and railway transportation which leaded to the shortage of power plant coal storage; diesel alternative power, pressure load of coal-fired units and the start and stop of generator consumed a large amount of fuel, which leads to a great consumption of oil (the annual fuel consumption of China is 1.6 billion tons, including which, the boiler start and stop of power plant accounts 60% and low-load combustion fuel accounts 40%); the disruption of railway transportation brought about transportation tension of air and road transportation and then made an oil shortage. In fact, behind the happening of energy supply chain disruption, one of the main reasons is there's a lack of unified plan about coal production, coal transportation, generating electricity and electricity transmission in our country, for example, the local government takes charge of coal production, mainly focusing on coal resources; the railway sector takes charge of coal transportation, mainly focusing on mine location and user needs; the electricity transmission plan is in the charge of power grid company, mainly focusing on power and load node. In fact, there need to be a unified plan between each power generation group and a balance between thermal power and coal development; otherwise, the power wouldn't be sent out, which will bring about lots of damage to both power generation group and users. Thus, to guarantee a smooth operation of the coal energy supply chain, we need to analyze the production capacity, investment time node investment scale, price allocation and the supply and need balance between upper and lower links and then find out the derivation source of risk, establish the risk delivery mechanism, constitute risk control models and strategies.

The electricity cannot be deposited and its production and consumption must be kept in a real-time balance; it's an industry which needs a great amount of investment and a long payback period. The development of electricity has an intimate relationship with the coal development, "the shortage of electricity---expansion of power--- expansion of power grid---increasing of the coal production", "the surplus of electricity---decreasing investment of power---decreasing investment of power grid--- compression of the scale of coal production", Ups and downs of the chain of coal industry investment will be a waste of the society resources, this damage would transfer to the users at last.

2. The link relationship analyzing of risk source for coal energy supply chain

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With the global economic integration, refinement of specialization, the lengthening of supply chain, people are paying more and more attention to risk management. The risk of supply chain is some uncertain factors or events which may have some bad effect on one or more member companies and make them fail to reach their anticipated goal or even lead to a failure of supply chain.

The link relationship of risk source coal energy supply chain can be analyzed by DEMATEL, which is combination use of graph theory and principle of matrix theory, constituting a direct impact matrix, calculating each risk factor's influential degree to the others and the other's influential degree to itself so as to calculate each factor's centrality and reason degree; to get the type(reason factor or result factor) of this factor according to the corresponding centrality and reason degree； to adjust the system's risk structure graph according to the amount of centrality and reason degree; to analyze the clustered risk structure relationship of coal energy supply chain and to establish the hierarchy of all risk factors by ISM; to constitute a multi-level hierarchical structure model of coal energy supply chain risk factors and to uncertain all risk factor's relationship.

3. Analyzing of coal power supply chain's risk delivery relationship

The modes for coal power supply chain's delivery can be ensured in the following:

(1) Forward transferring in chain: the risk transfers in the fixed downstream direction, which means arising from the upstream node, coal producers, with the collect of risk, transferring to the next node level by level after exceeding the threshold risk and transferring to the risk receptor at the bottom, which means electricity consuming companies.

(2) Backward transferring in chain: he risk transfers in the fixed upstream direction, which means arising from the downstream node, electricity consuming companies, with the collect of risk, transferring to the last node level by level after exceeding the threshold risk and transferring to the risk receptor on top, which means coal producers.

(3) Interactive delivery: the risk events transfer from one node to another node (risk receptor) by risk carrier, while the risk receptor will lead to some new risks which will be transferred to the original node in the same way.

(4) Center divergent delivery: the risk transfer from some center enterprise to enterprises in upstream and downstream, its transferring direction may be in different paths. If there exists two or more risk center enterprises, the transferred enterprise risk can be increased by the coupling of multiple risk in the transferring process.

(5) Focused delivery in multiple items: different risk node enterprise transfer to some other enterprises, as a result of the difference in resilience of enterprises being affected in upstream and downstream, it may come out different risk receptors and one or several final risk receptors. In the delivery process of risk, the coupling of multiple risk can make the receptor's risk increase rapidly.

4. Analyzing of coal power supply chain risk transmission and expansion mechanism.

The coal power supply chain is affected by some internal and external uncertain factors inevitably, making some tiny risk of a initial node be transferred to the next node, and with the time processing and part transferring process, this risk is magnified level by level until it evolves into a crisis. For example, the surplus investment risk brings about coal surplus investment risk; the shortage of coal transportation leads to limits to power generating; the blockade of electricity transmission brings about risk of generating nest power (risk of large amount of idle wind power is appearing now); coal production, uncoordinated risk of coal transportation, power generating and power supply price chain makes electricity shortage, risk of society loss and so on.

Risk of natural disasters (earthquake, storm, blood and so on) brings about power disruption risk, power disruption brings about coal transportation risk, coal transportation risk brings about power generating risk; surplus thermal power investment risk brings about surplus coal investment; surplus coal investment brings about price transferring risk of fixed cost; investment chain risk brings about price chain risk, price chain risk brings about supply chain risk and so on.

In the process of information delivery from downstream to upstream in the energy supply chain (electricity consumption---electricity transmission---electricity generating--- coal transportation-coal production), the fluctuation risk of coal need is generally greater than the fluctuation risk of electricity sale amount, which expands the risk of coal power chain. Its mechanism can be classified in the following types:

(1) Mechanism of game theory: coal and power enterprises are assumed rational "broker" and its policy decision is thought to be optimal, but the optimal policy decision combination between coal and power enterprises in the supply chain would eventually be " prisoner's dilemma" and " fallacy of composition", which means coal and power enterprises will be in a game to realize their own utility maximization, all of this constitutes the risk expansion.

(2) Principal-agent mechanism: the enterprises in the upstream cannot get enough information and form a deviation with the downstream power generating enterprises when anticipate their future need, while the devotion is magnified level by level in the supply chain and eventually constitutes the expansion of supply chain.

(3) Inventory control optimization mechanism: each coal and power enterprises have different reactive corresponding when faced with customer's need, and with the limitation to production capacity and production lead

time difference, it constitutes a deviation risk between the upstream enterprises' storage and the down stream's, the up stream's storage can be magnified or reduced level by level and eventually constitutes risk expansion.

(4) Anticipated deviation transferring mechanism: Due to a lack of coordination mechanism, enterprises in the downstream anticipated their final consuming information in the condition that they don't know all the need information, making deviation risks between factual need and anticipated need. Thus, the anticipated deviation is magnified in the supply chain and eventually constitutes a risk expansion.

Environment risk derived source, structure risk derived source, plan risk derived source, operation risk derived source, supply risk derived source, policy risk derived source, the six internal and external environment risk derived source interact with each other and respond to each other and form a complex system at last, which is called a cluster risk system of supply chain. The system is a combination of risk factor structure and risk factor loss, it means the sub-structure and their relationships, the feedback loop structure and the new-born risk factors in their interacting. We describe the risk information feedback system and risk expansion system by System dynamics (SD). We establish risk loss model according to the SD model, which including game theory model, principal-agent model, inventory control optimization model, anticipated model of econometrics and so on.

5. Risk prevention and control in coal power supply chain

(1) Scale match of each part in the coal power supply chain

To prevent the interruption of energy supply chain, we need to not only analyze the cycle law in different parts, but also need to study a development scale in which they match with each other. To do so, we need to analyze the relationship of power generating amount and consumption amount of coal, generating scale and transmission scale, coal consumption and coal transportation capacity. These relationships need to be analyzed in quantity and with them to establish corresponding statistical analysis of the relationship model.

(2) Price match of each part in the coal power supply chain

The price of coal fluctuates with the market's need in our country and the price of power generating and transmission is decided by the government, which is relatively fixed. When the coal price increases, price signals cannot be sent to users and so can have an effect on the users' need for power. Due to a disruption between coal and power generating prices, it would lead to deficit if the generating plant coal in very high prices and they won't be positive to generate electricity; If we can find a combination between coal and power generating prices, the sales price of power must be unified with them, or some enterprises will not be positive enough to buy electricity and it will lead to power crisis. Thus, to study the unified model of coal, generating and electricity transmission, we must demonstrate the marginal changes together with encouraging energy consumption control and guaranteeing this chain's smooth and steady development.

(3) Structure balance of each part in the coal power supply chain

According to SCP (market structure---market behavior---market performance) model, the market structure influences the competition behavior in the market, competition behavior in the market influences market performance. There is a high market concentration in power generating market, it can be viewed as an oligopolistic market; electricity market is almost a completely monopoly market; Coal industry has a low market concentration, the production amount is sensitive to changes of price and its supply price ranges in a larger scale. The thermal power accounts about 80% of the entire electricity, to add the asset-specific property of power generating equipments, when the coal prices increases, we must generate electricity while when it decreases, we cannot store them because of the great cost. Thus, the coal price has a low demand price range. The larger supply range for coal and its low demand price range make the coal enterprises a stronger control in the coal used for power generating. We need to enlarge the market concentration for coal market to lower its supply price, meanwhile, we have to develop re-generating energy (water power, wind power, atomic power), decrease the dependence to thermal power, to increase the need price range of coal. With all the strategies above, the control in coal of coal buyers and sellers will be the same.

The coal power supply chain including coal production, coal transportation, electricity generating, electricity transmission, electricity consumption which constitutes a supply chain with five nodes. Between the upstream and downstream node market of this chain, and between the enterprises in the same nodes, there need to be a two-way coordination for production capacity plan. When the nodes in upstream and downstream are different, the entire supply chain will have a low efficiency and a waste of resources; when the enterprises in the same node cannot be coordinated, it would lead to these enterprises' low efficiency and resource waste. If more nodes and enterprises can be planned, we must consider the collaboration and amount effect relationships between these nodes, between these enterprises and during different period. Based on all the consideration above, we can finally constitute a multi-staged complex big system optimization model with a multi-level investment risk control.

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