ISSN : 0974 - 7435 Volume 10 Issue 12

2014

BioTechnology
An Indian Journal

FULL PAPER
BTAIJ, 10(12), 2014 [6194-6201]

The risk element transfer model of electric power industry chain in China

Cunbin Li, Tongtao Ma*, Qi Zhang, Pumeng Sun
School of Economics and Management, North China Electric Power University, Beijing, (CHINA)
E-mail : mtt@ncepu.edu.cn

ABSTRACT

Electric power industry chain refers to the chain composed by upstream and downstream subjects, which consist of the four segments--electric generation, transmission, attribution, and marketing. At present the main components of electric power industry chain in China incorporate power generation enterprises, power supply enterprises, users, etc. Electric power industry chain mainly composed by these three kinds of enterprises can maintain smooth operation within a certain period. However, if the external economic environment changes, such as change of national economic policy, may influence the major components. In addition, if risks of mutation appear in a certain kind of enterprise, it will certainly affect other enterprises in the industry chain. By analyzing the risk element system of electric power industry chain, this paper studies risk element transfer path and establishes the risk element transfer model of electric power industry.

KEYWORDS

Risk element transfer; Electric power industry; Risk chain.

INTRODUCTION

The large-scale construction of the smart grid is bound to cause the pattern of interests in the electricity market, the existing interests of the chain impact the interests of the electricity market in the smart grid environment chain risk Element Transmission-depth study has important practical significance. From smart grid electricity market risk management, the interests of the chain of the electricity market research, risk transfer the theory three transfer theory described for the interests of the electricity market chain risk element in the smart grid environment at home and abroad research status and development trends. Currently, the electricity market risk management research more fully, little research interests of the chain in the electricity market in the smart grid. The risk element transmission theory introduced, there will be a relatively large space and better prospects in the smart grid electricity market risk management, especially to reflect the interests and the interests of the chain flow characteristics of the electricity market in the interests of chain risk element transmission theory will become the focus of future research scholars.

Since 70% of the thermal power generating units are in China. Therefore, the risk of coal price and electricity tariff to bring the relationship between the direction of the country has become one of the research scholars. In the current power market, power supply companies face different risks. It is a new research method to quantify and classify these risks and build risk knowledge database to provide reference for risk controlling and evading. Based on the characteristics of risk elements of power supply enterprises, a new linear model of risk transmission is built in this paper, in which the power supply risk data is classified, impact factors of risk transmission is found, and an example is analyzed to prove that this model is applicable in risk management of power supply enterprises.

Arguably, the most theoretically rigorous and powerful method to model uncertainty is by using stochastic programming, at least if the uncertainty can be represented by a stochastic process. Meaningful robust decisions could be obtained for the short-term, as shown in[1]. However, it is a methodology with high computational cost, because of the exponential growth in size of the scenario tree, unless a simplified modeling of the driving stochastic process is included. However, this can be unacceptable in risk analysis applications, where it is often required to address low- probability scenarios of potentially huge impact. Hence, this paper presents an alternative method to include uncertainty by using linear equations simulation of electric power industry chain, in which several risk factors scenarios are simulated using a market equilibrium model.

THE RISK ELEMENT SYSTEM OF ELECTRIC POWER INDUSTRY

From the perspective of supply chain, the main parts of electric power industry chain consist of the upstream coal suppliers, several power generation enterprises, a few power grid enterprises, electric power industry, commercial, agricultural and inhabitant users, etc. Theoretically, electric power industry chain has a chain structure, but the electric power industry chain should be a net structure formed by these main subjects because of many subjects in the operation. Assuming that coal suppliers are tagged for C, generator G, power suppliers S and users U, the electric power industry chain structure can be shown in Figure 1. The first layer is primary energy suppliers, such as coal suppliers; and the second is generators, among which some of the hydroelectric, wind power and other renewable energy power generators have no connection with their primary energy suppliers, such as Gm, but generators need to sell their product through power grid, in this way, they all link to node S --power suppliers. All users get power from power grid, therefore, they also connect with node S.

Risk element transfer of electric power industry chain mainly studies behavior changes of some nodes and the transfer effect of failure occurred on the other subjects in the industry chain. Risk elements of all kinds have different transfer ways -- some transfer from the upstream to the middle and lower stream while some transfer from the middle and lower stream to the upstream.

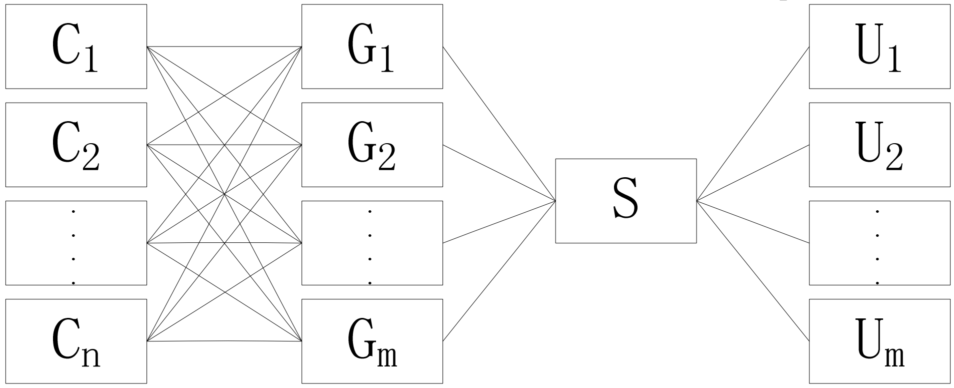

Figure 1 : Electric power industry Chain Structure

One operation subject from the middle and lower stream in the electric power industry chain forms a new energy to provide it to downstream by purchasing resource or energy from the upstream, processing it with their equipment and tools. The industry chain starts with coal corporations and ends in power users. Therefore, a typical risk element transfer model can be seen as the influence on generators, power suppliers, and users after the occurrence of coal price fluctuation risk. Intermediate link of some main risk elements can also have some influences on other parts. Therefore, in electric power industry, risk element forms a series of transfer influence. Based on such premise, the paper establishes a risk element transfer. In this paper, it first determines composition system of risk element, describes the probability of the risk occurring element by methods, and then creates transfer model to other influenced operating subjects after risk element happens, finally it tests the model by establishing a risk element transfer case of typical regional electric power industry chain.

The electric power industry chain, based on the energy resource flowing, is made up of fuel suppliers, generators, electricity suppliers and users. There are several risk elements in each subject. From the perspective of electric power industry chain system, there are upstream risk element and the middle and lower stream risk element. The upstream risk element, as the source of electric power industry chain, includes fuel prices risk element, carbon trading risk element, generation trade risk element and carbon tax policy risk element while the middle and lower stream risk element mainly includes electricity price risk element, electric equipment damage risk element, power demand risk element and electricity investment project risk element, and risk element results from some irresistible natural disasters, such as equipment failure loss risk element caused by typhoon, rainstorm, debris flow and other irresistible natural factors. The risk element system of electric power industry is showed in Figure 2

Each of the risk element listed above can be measured by certain method and only after effective measurement of the risk element can the transfer model be precisely described. Typically, the risk element can be described through a certain kind of probabilistic method, for instance, fuel price risk element, electricity price risk element, power load risk element and other time-series data can be mode and analyzed through time sequence model, then the probability distribution method can be further analyzed. Electric power equipment failure risk element mainly focuses on the maintenance and replacement of the loss of equipment, and this loss can be analyzed on the electric power equipment maintenance data. Electricity investment project risk element mainly focus on analyzing the power plant capacity expansion in the electric power industry chain, expansion of power grid scale and other investment scale; the carbon trade, carbon tax and generation rights trade are certain measures the nation adopted to reduce carbon emission, and this policy is bound to have huge impact on the electric power industry especially the thermal power industry. Electric equipment damage caused by irresistible natural factors is one of the main risk elements in electric power industry chain, and it is of certain practical significance to mode and analyze it.

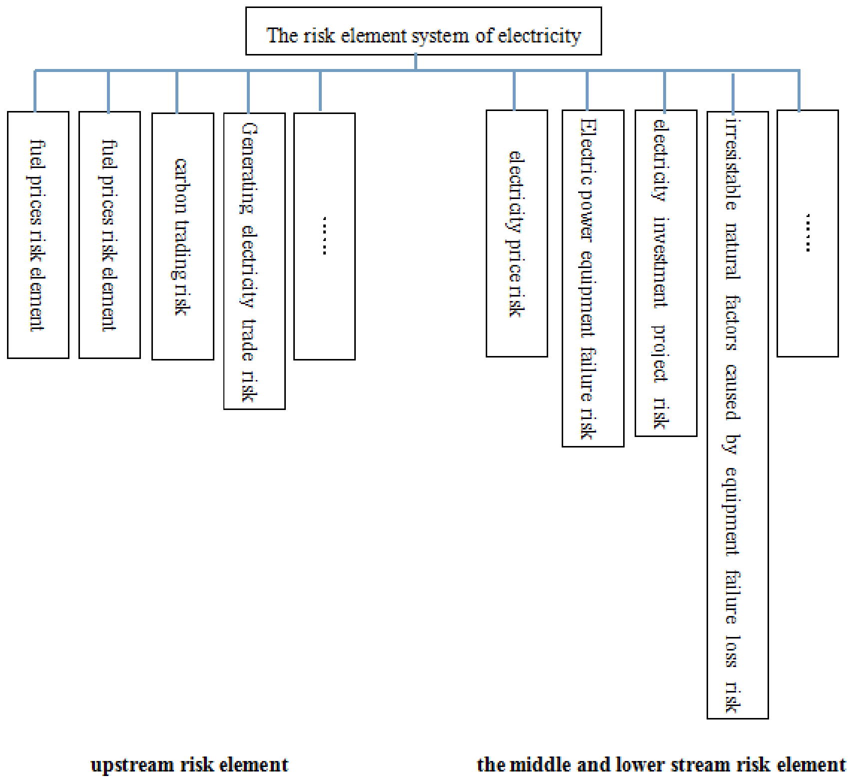

Figure 2 : The risk element system of electric power industry chain

THE UPSTREAM RISK ELEMENT TRANSFER MODEL OF ELECTRIC POWER INDUSTRY CHAIN

The upstream risk element in electric power industry chain mainly contains fuel price risk element, carbon trading risk element, carbon tax risk element and generation rights trade risk element, etc. The influence of upstream risk element takes place mainly according to energy and power supply in electric power industry chain. We can find the risk element transfer process gradually.

Analysis of the impact of upstream risk element change on thermal power supplier offer

The upstream risk element mainly changes the generating cost of power generators. The cost of generators can be divided into variable cost and average cost. The average fixed cost is the fixed cost needed during the electricity generators' operating period, and here it is a fixed numerical value, and we set it as C_f. Here we mainly focus on the variable cost of the generator. The variable cost of the generator mostly depends on the fuel cost needed by the generator or the carbon emissions fee paid by the generator. And we set the function of variable cost of the generator as C_v. Feed-in tariff of the generator is as P_g, the profit is as π_g. Referring to the chapter 3, the revenue function of the generator can be written as,

$$\pi_g = (1-\sigma_3)(1-\sigma_2)[(1-\sigma_1)P_g Q - C_f - C_v] \quad \textbf{(1)}$$

The C_v here can be written as the function of upstream risk element and Q. Supposing the upstream element in transferring is as PE_i, which represents the changes in cost brought by the unit generating capacity. And then we set coal consumption rate as η, in this case the variable cost function can be set as, "i" represents the occurrence numbers of upstream risk element.

$$C_v(Q, PE_i) = Q\eta\sum_{i=1}^{n} PE_i \qquad i=1,2,\cdots,n \tag{2}$$

If the return can be maintained on a constant level, the Feed-in tariff can be expressed as the (1) and (2),

$$P_g = \frac{\pi_g + (1-\sigma_2)(1-\sigma_3)(C_f + Q\eta\sum_{i=1}^{n} PE_i)}{(1-\sigma_1)(1-\sigma_2)(1-\sigma_3)Q} = k\sum_{i=1}^{n} PE_i + b/Q \tag{3}$$

Of which $k = \eta/(1-\sigma_1)$, $b = \frac{\pi_g + (1-\sigma_2)(1-\sigma_3)C_f}{(1-\sigma_1)(1-\sigma_2)(1-\sigma_3)}$,

If the risk element changes through calculation, and the rising range of electricity price is $k\sum_{i=1}^{n} \Delta PE_i$, in this case, generators can transfer the upstream risk to the Feed-in tariff, and further transfer the risk of the increasing costs to electricity suppliers.

Transfer influence on user price system from upstream risk element changes

By raising the feed-in tariff of risk element in upstream electric power industry chain, generators transfer part of the risk to electricity suppliers. If the electricity suppliers maintain a constant return, the grid company must offset the pressure of rising upstream price by raising terminal sale price. The revenue function of grid company can be expressed as,

$$\pi_s = (1-\delta_2)(1-\delta_3)[P_u Q(1-\delta_1) - P_g'(Q + Q_{loss}) - C_{sf}] \tag{4}$$

Among which C_{sf} stands for fixed operating costs of grid company, P_u presents electricity sale tariff, P_g' is purchase electricity tariff given by power suppliers, Q is electricity sale capacity and Q_{loss} refers to net loss. General net loss can be regarded as a small proportion of total electricity capacity. Supposing the proportion coefficient is λ, then $Q_{loss} = \lambda Q$, δ_1 represents the sales tax and additional extraction proportion, and δ_2 the extraction proportion of power plant income tax, δ_3 refers to the extraction proportion of public welfare and accumulation fund of power plant.

The relation of P_u and P_g' can be deduced from formula (5-4),

$$P_u = \frac{P_g'(Q + \lambda Q)}{Q(1-\delta_1)} + \frac{\pi_s + C_{sf}(1-\delta_2)(1-\delta_3)}{Q(1-\delta_1)(1-\delta_2)(1-\delta_3)} \tag{5}$$

If set $k_s = (1+\lambda)/(1-\delta_1)$, $b_s = \frac{\pi_s + C_{sf}(1-\delta_2)(1-\delta_3)}{(1-\delta_1)(1-\delta_2)(1-\delta_3)}$, then formula(5-5)can be written as,

$$P_u = k_s P_g' + b_s / Q \quad (6)$$

If the purchased electricity price increases $k\sum_{i=1}^{n}\Delta PE_i$ as that of the generator mentioned above, the electricity generated by all the generators can be transferred to the power grid. Since the thermal power unit only plays a part in the total generating quantity, assuming its proportion coefficient is ω, for electricity suppliers, which means the rising range of purchase electricity price is weakened by generators of other forms, then even if the rising range of purchase electricity price P_g' for the electricity suppliers can be roughly expressed as $\omega k\sum_{i=1}^{n}\Delta PE_i$, and even though the power supplier maintains a constant return, the upstream risk element of industry chain will transfer to consumer side and influence its sale price. It can be deduced from formula (5-6) that the increasing range of sale price is $k_s\omega k\sum_{i=1}^{n}\Delta PE_i$. Thus we can see the transfer process of whole upstream risk element of electric power industry chain from upstream electric power industry chain to consumer side's purchasing electricity price.

Case analysis

If the power coal price fluctuates between RMB 300-600 per ton, by risk element transfer model of electric industrial chain, we can calculate the tariff change of thermal generator, or get the purchase price variation of terminal consumer. Supposing the income tax of the model is 33%, the extraction proportion of public welfare and accumulation fund are respectively 10% and 5% of the after-tax margin, comprehensive sales tax is 10% of the sales revenue, the average coal consumption rate of thermal power plants is 360g/KWH, and the proportion of the total installed capacity of thermal power plant is 75%. If the transmission and attribution of electricity power loss rate is 1.7%, the price change can be showed in TABLE 1. The coal price risk element impact trend can be showed in Figure3.

TABLE 1 : The transmission affect of coal price risk element Unit (Yuan)

Coal Price	*Feed-in Tariff*	*User Electricity Price*
300	0.368	0.44
320	0.376	0.450
340	0.384	0.461
380	0.400	0.482
420	0.416	0.502
480	0.440	0.534
540	0.464	0.565
600	0.488	0.596

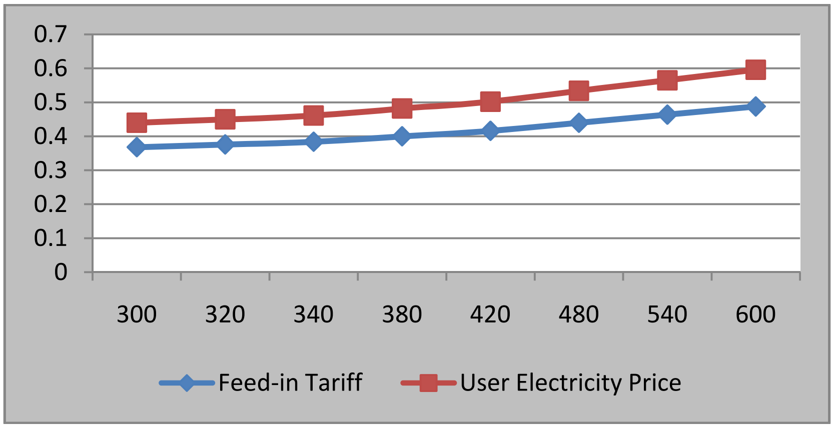

Figure 3 : Coal price risk element impact trend chart

In general, changes of upstream risk element may cause the downstream chain transfer effect. From a macro perspective, the increased cost of generator will inevitably lead to an increase in its feed-in tariff, and the increased feed-in tariff will lead to higher cost of electricity suppliers' purchasing electricity. power suppliers, in order to obtain a certain profit, have to transfer some price rising factors to users, mainly to control the risk of rising cost by increasing the sales price. If a link is controlled, it may cause imperfections in the industry chain, resulting in loss in a certain industry chain. If the loss incurred expands, it will have a huge impact on the entire industry.

CONCLUSION

This paper establishes the transfer model of the electric power industry chain. From the perspective of energy flow direction of electric power industry chain, we analyze the influence of upstream primary energy source and other changes of risk element on the changes of the feed-in tariff and even on the selling price of the electricity suppliers. We analyze the risk element transmission effects caused by the changing price of the primary energy and carbon trading by establishing the revenue function of the generator and electricity suppliers.

ACKNOWLEDGMENT

This research was supported by "the Fundamental Research Funds for the Central Universities". The authors want to thank the work to this paper by all anonymous reviewers.

REFERENCES

[1] J.Barquin, E.Centeno, J.Reneses; Stochastic market equilibrium model for generation planning computing, Probability in the Engineering and Informational Sciences, October, **19**, 533-546 **(2005)**.

[2] E.Zio, T.Aven; Uncertainties in smart grids behavior and modeling: What are the risks and vulnerabilities? How to analyze them?. Energy Policy, **39(10)**, 6308-6320 **(2011)**.

[3] P.P.Varaiya, F.F.Wu, J.W.Bialek; Smart Operation of Smart Grid: Risk-Limiting Dispatch. Proceedings of the IEEE, **99(1)**, 40-57 **(2011)**.

[4] L.Z.Guo, LiL, Z.F.Tan; Time-of-use price designmodels based on fuzzy demand and users' diverse response. East China Electric Power, **05**, 11-15 **(2007)**.

[5] M.Saleh, R.Oliva, C.E.Kampmann et al; A comprehensive analytical approach for policy analysis of systemdynamics models. European Journal of Operational Research, **203(3)**, 673-683 **(2010)**.

[6] X.Li, C.Jiang; Short-term operation model and risk management for wind power penetrated system in electricity market. Power Systems, IEEE Transactions on, **26(2)**, 932-939 **(2011)**.

[7] William Zhu; Relationship among basic concepts in covering-based rough sets. Information Sciences, **179(14)**, 2478-2486 **(2009)**.

[8] Ivana Kockar, Antonio J.Conejo, James R.McDonald; Influence of the Emissions Trading Scheme on generation scheduling. International Journal of Electrical Power & Energy Systems, **31(9)**, 465-473 **(2009)**.

[9] Annela Anger; Including aviation in the European emissions trading scheme: Impacts on the industry, CO2 emissions and macroeconomic activity in the EU. Journal of Air Transport Management, **16(2)**, 100-105 **(2010)**.

[10] Hong-xing Sun, Zhong-Fu Tan; Models of Risk Measurement and Control in Power Generation Investment. Systems Engineering Procedia, **3**, 125–131 **(2012)**.

[11] P.K.Marhavilas, D.E.Koulouriotis; A combined usage of stochastic and quantitative risk assessment methods in the worksites: Application on an electric power provider. Reliability Engineering and System Safety, **97**, 36-46 **(2012)**.

[12] Dongxiao Niu, Yongli Wang, Desheng Dash Wu; Power load forecasting using support vector machine and ant colony optimization. Expert Systems with Applications, **37**, 2531-2539 **(2010)**.

[13] Paroma Sanyal, Laarni T.Bulan; Regulatory risk, market uncertainties, and firm financing choices: Evidence from U.S. Electricity Market Restructuring. The Quarterly Review of Economics and Finance, **51(3)**, 248-268 **(2011)**.