A New Analysis Framework on the Influencing Factors of Grid Management System

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Keywords：Analysis framework, Influencing factor, Grid management, Empirical study

Abstract：Based on the existing research on grid management system focusing too much on single country studies and neglecting universal laws behind grid management system choices, the study constructs a universal analysis framework on the influencing factors of grid management system and makes an empirical research with multi-countries' samples. The study finds that national land area, level of grid management and elasticity of electricity consumption are the three most important factors.

1 Issue the question

Traditionally there are two main modes of grid management system，transmission and distribution integration and transmission and distribution separation. Transmission and distribution integration refers to that transmission grids and distribution grids belong to the same company. Transmission and distribution separation refers to that transmission grids and distribution grids are owned and operated by different companies.

A country's mode of grid management system is not only influenced by the functional properties evolution of modern grid, but also by the country's economic system, political system, energy endowments and other factors. In order to attract investment and to ease pressure on government finances, the Russian government sold the assets of distribution grids after 2003, which led to severe decline in electricity reliability and underinvestment in the last kilometer. In 2012, the Russian government finally re-integrated the transmission grids and distribution grids.[1] In the USA, the ownership of electricity assets are dispersed and there exist power plants, transmission companies, distribution companies and other businesses for a long time. For the historic reason, most states in the USA adopt the transmission and distribution separation system. France and Japan face the problem of inadequate energy supply and they put the electrical safety to a highest position. For the two reasons above, France and Japan choose the transmission and distribution integration system. In Australia the choice of transmission and distribution separation was more affected by the UK's electricity reform, which aimed to enhance operating efficiency of Australian electricity industry. [2]

In China the uneven distribution of energy resources and regional economy determine that China needs a wide range allocation of resources, which will be guaranteed by the transmission and distribution integration system.[3] Meanwhile some scholars found that transmission and distribution separation system will cost China too much and it is optimal for China to stay in the transmission and distribution integration system. [4]

Existing research pay too much emphasis on the individual country's choice of transmission and distribution management system, and lack a unified framework to analyze and empirical research based on multi-country sample. This article attempts to supplement the existing research on the two items above.

2 A new framework

Based on the analysis of the world's major national electricity system reforms and management system choices, the author builds a new framework to accommodate key factors influencing choice

of transmission and distribution management system. Specifically the first level index are constructed from economy, politics, energy, technology, reform and environmental effects, and the second level index are constructed from basic economic system, political system, the degree of energy self-sufficiency and other ten factors.

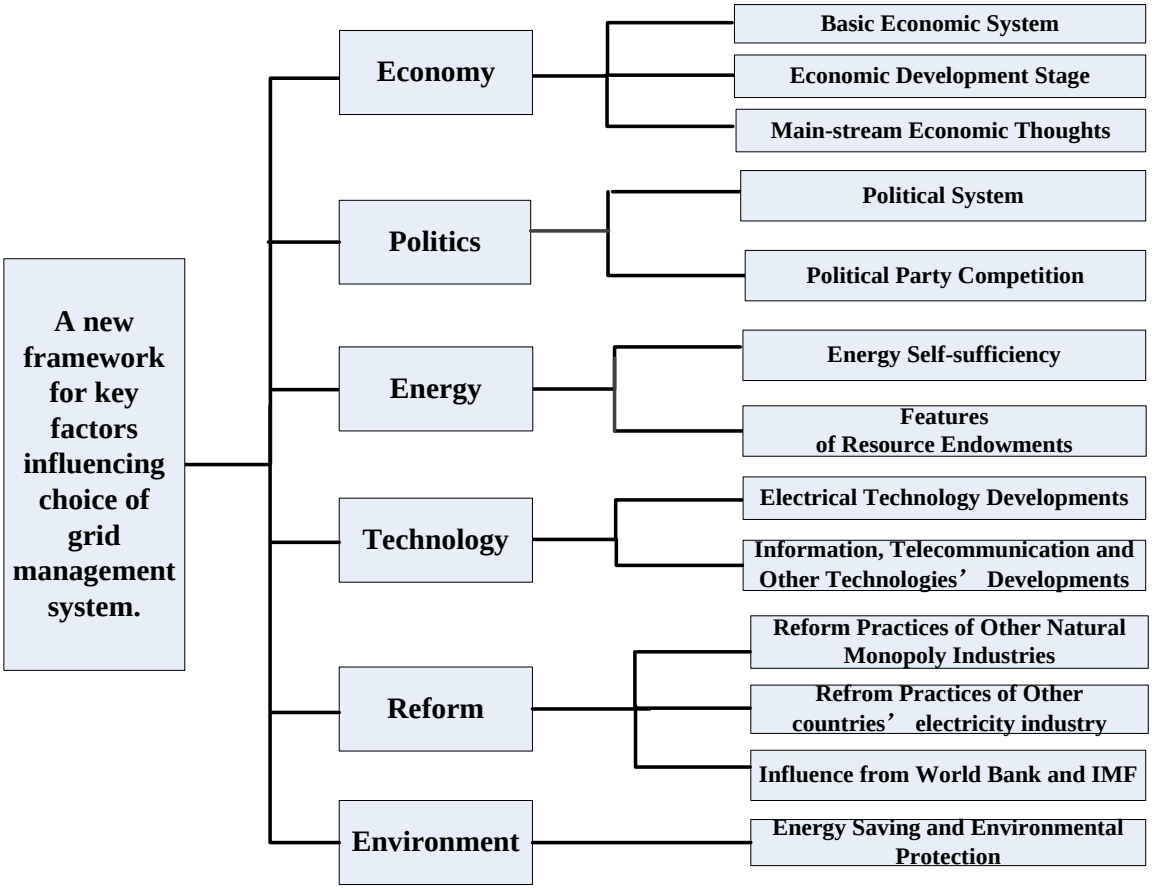

Fig. 1 A new framework for key factors influencing choice of grid management system

3 Empirical Analysis

Based on the new framework above, we built an econometric model and quantitatively analyze the influence of different factors to the choice of grid management system.

(1)Data and Variables

We gather the sample of 21 countries, including Korea, Japan, India, USA, Russia, France, Germany, Brazil, Mexico, China and so on.

The explained variable is "Whether the transmission and distribution grids are separated" (WTDGS). "0" means integration management system and "1" means separation management system. We assign the values according to the situations of related countries in 2014.

The explanatory variables include GDP per capita (GDPPC), GDP growth rate (GDPGR), "Whether the country belong to Commonwealth of Nations" (WCBCN), elasticity of electricity consumption (EEC), line loss rate (LLR), electricity consumption growth rate (ECGR) and national land area (NLA). "Whether the country belongs to Commonwealth of Nations" is valued according to the countries' situations in 2014. "0" means the country does not belong to CN and "1" means the contrary. Other variables are valued according to the situations of related countries in 1990.[1]GDP per capita and national land areas are taken logarithm.

We take the variable "(-1)* line loss rate" as the proxy variable of "the level of grid management" (LGM).

All the data are sourced from "Manual of International Energy and Power Statistics (2013)".

[1] The reason is that almost all the countries have not begun the grid management reform in 1990, which assures that the explanatory variables are not influenced by the reform.

(2)Method

We use the binary choice model to analyze the question above. The specific model is as follow.

$$y_i = 1 - CNORM(-x_i'\beta) + u_i \quad (1)$$

y_i means the values of discrete choices, $CNORM$ means standard normal distribution function, x_i means explanatory variables, β means degree of influence of explanatory variables, u_i is random disturbance.

We use maximum likelihood estimation (MLE) method to estimate β in the model above.

(3)Result

From the empirical analysis on the Table 1, we can make three conclusions.

1) The larger the national land area, the lower the probability of transmission and distribution grids separation.

2) The better the grid management level in pre-reform period, the lower the probability of transmission and distribution grids separation.

3) The larger the elasticity of electricity consumption, the lower the probability of transmission and distribution grids separation.

Table1 Result of regression

Dependent Variable	"Whether the transmission and distribution grids are separated" (WTDGS)					
Explanatory Variables		First Regression	Second Regression	Third Regression	Fourth Regression	Fifth Regression
	NLA	-0.57 (0.26)**	-0.85 (0.44)*	-1.10 (0.55)**	-1.20 (0.59)**	-1.84 (1.07)*
	LGM	-0.56 (0.23)**	-0.70 (0.32)**	-0.68 (0.34)**	-0.75 (0.41)*	-1.00 (0.62)
	EEC	-1.28 (0.62)**	-1.36 (0.68)**	-1.80 (0.97)*	-1.89 (0.99)*	-1.55 (0.91)*
	WCBCN		1.62 (1.37)	1.57 (1.40)	1.85 (1.50)	3.17 (2.30)
	GDPPC			0.22 (0.20)	0.17 (0.18)	0.29 (0.22)
	GDPGR				0.23 (0.20)	0.68 (0.48)
	ECGR					-0.48 (0.38)

"*" means significance at 10% level

"**" means significance at 5% level

4 Conclusion

This study constructs a universal analysis framework on the influencing factors of grid management system and makes an empirical research with multi-countries' samples. This study finds that the larger the national land area, the better the grid operates and the larger the elasticity of electricity consumption, the lower the probability of transmission and distribution grids separation.

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