International Journal of u- and e- Service, Science and Technology
Vol.9, No. 2 (2016), pp.17-28
http://dx.doi.org/10.14257/ijunesst.2016.9.2.03

Research on the Relationship between Electricity Demand and Economic Growth of North China Based on the Co-integration Theory

Huiru Zhao[1], Nana Li[1], Haoran Zhao[1], Fuqiang Li[2] and Yuou Hu[2]

1,School of Economics and Management, North China Electric Power University;
2,North China Grid Company Limited, Beijing Xuanwu District No. 482 Canton Avenue
E-mail of Nana Li: nancyli1007@163.com

Abstract

The research on the relationship between electricity and economy of North China can make a contribution to the development of electric power industry policy. Based on the history data of electricity demand and economic growth from 1986 to 2010 in North China, the grey-relational theory is applied to determine the keyfactors influencing electricity demand. On this basis, the co-integration model and error correction model are employed to establish the relationship model between electricity demand and economic growth of North China. From the perspective of long-term equilibrium, when GDP increases 1%, total electricity consumption increases 0.8270%; when industrial added value of a share of GDP increases1%, total electricity consumption increases1.3011%; when electric power efficiency increases 1%, total electricity consumption increases by 4.5965%; when urbanization rate increases 1%, total electricity consumption increases3.0079%. Therefore, theelectric power efficiency is the main factor to promote the increase of electricity demand.

***Keywords**: Electricity demand, Grey-relational theory, Co-integration theory, Error correction model*

1. Introduction

Electric power industry plays amore and more important role in the development of national economy.Therefore, researches on the relationship between electric power and economy areindispensable in China. On the one hand, it will contribute to the development of electricity planning andindustrial policy. On the other hand, it will promote the sustainable development of electricity and economy, no matter theory aspect or reality aspect.

Since the 1990s, many researches on the relationship between electricity and economic growth have been proposed, which includes electrical elasticity coefficient method[1], granger causality analysis[2], input-output analysis[3], regression analysis[4], *etc*.However, these methods are more or less has some shortcomings.Since the electrical elasticity coefficient is determined by many complex factors, it has been controversialto reflect the relationship between electricity and economy. Granger causality test can only reflect the relationship from the perspective of qualitative, which cannot quantify the relationship between electricity and economy. Input-output analysis model analyzes the role of the electric power industry by revealing relationship of social demand and supply,as well as theindustry input and output. Nevertheless, the researches using input-output analysis are less and not mature enough.Owning to the stationarity of time series, there may be spurious regression problem based on the traditional simple regression analysis model. Thereafter, in the 1970s, the co-integration theory, as an

ISSN: 2005-4246 IJUNESST

effective quantitative analysis tool, was proposed to solve the relationship between time series. In recent years, co-integration and error correction model (ECM) have been widely used in the long-term equilibrium and short-term fluctuation relationshipanalysis between economy development and electricity demand. Literature [5] establisheda long-term equilibrium among electricity demand, GDP, price, population, and efficiency on the strength of the co-integration theory. Literatrue [6] pointed out that the macroeconomic situation, residents living standard, price, and economic structure are the main factors influencing electric power demand in China. Based on these factors, the long-term equilibrium and error correction model between electricity demand and economy are established, so as to analyze the future demand for electricity in China.In the light of the cross section data of regional power consumption, the panel data model was employ in literature[7], which indicated that income and the proportion of secondary industry were major factors determining electricity demand. Therefore, the co-integration theory has been widely used in the analysis of relationship between electricity demand and economic growth.Obviously, many scholars researched on the electricity and economy from the angle of nation. However, the economic developments among different regions are imbalanced. Therefore, the previous researches have no much reference value.

Therefore, in order to analyze the relationship between electricity demand and economic development innorth China, the grey correlation theory is applied to select key factors affecting the regional electricity demand.Thereafter, the co-integration theory is employ to establish the long-term equilibriumrelationship between economy development and electricity demand on the basis of these key factors.

2. Selecting the Influencing Factors of North China Electricity Demand based on Grey Correlation Analysis

Relative researches have indicated that the factors affecting electricity demand involves multiple aspects, such as macro economy, industrial structure, urbanization rate, import and export trade, technological progress, population and resources, and so on. Considering the characteristics of the economic development in north China, the grey correlation analysis is employed in this section to select the key factors influencing the electricity demand in north China.

2.1 Grey Correlation Analysis Model

The basic idea of gray correlation analysis is to determine theassociation degree between factors based on the similarity between the curves. Grey correlation analysis usually compares the data series which reflect changes of each factor[8]. The correlation level between factors is judged by theassociation degree which is obtained by comparing the association between curves[9]. There are six steps in the gray correlation analysis:

(1)Determine the reference sequence and comparative sequence

Suppose $X_0=\left[X_0(1),\ X_0(2),\cdots X_0(n)\right]$ is the reference sequence and $X_i=\left[X_i(1),\ X_i(2),\cdots X_i(n)\right]\left(i=1,2,\cdots,l\right)$ is the comparative sequence.

(2)Calculate sequence X_0 and gray absolute correlation ϕ_{0i} of sequence X_i

Gray absolute correlation is only associated with geometric shapes of sequence X_0 and X_i, which has nothing to do with their relative location. The specific formula is shown as follows:

$$\phi_{0i}=\frac{1+|S_0|+|S_i|}{1+|S_0|+|S_i|+|S_i-S_0|} \tag{1}$$

Where, $k = 1, 2, \cdots, n-1$.

$$|S_0| = \left| \sum_{k=2}^{n-1} X_0^0(k) + \frac{1}{2} X_0^0(n) \right| \tag{2}$$

$$|S_0| = \left| \sum_{k=2}^{n-1} X_0^0(k) + \frac{1}{2} X_0^0(n) \right| \tag{3}$$

$$\begin{cases} X_0^0(k) = X_0(k) - X_0(1) \\ X_i^0(k) = X_i(k) - X_i(1) \end{cases} \tag{4}$$

(3) Calculate the gray relative correlation π_{0i} between X_0 and X_i

Gray relative correlation denotes the relationship between the changing rate of sequence and the starting point.Namely, the closer the changing rate of X_0 and X_i , the greater the gray relative correlation is.

$$\pi_{0i} = \frac{1 + |S_0^{'}| + |S_i^{'}|}{1 + |S_0^{'}| + |S_i^{'}| + |S_i^{'} - S_0^{'}|} \tag{5}$$

Where, $k = 1, 2, \cdots, n-1$.

$$|S_0^{'}| = \left| \sum_{k=2}^{n-1} X_0^{0'}(k) + \frac{1}{2} X_0^{0'}(n) \right| \tag{6}$$

$$|S_i^{'}| = \left| \sum_{k=2}^{n-1} X_i^{0'}(k) + \frac{1}{2} X_i^{0'}(n) \right| \tag{7}$$

$$\begin{cases} X_0^{0'}(k) = \dfrac{X_0(k)}{X_0(1)} \\ X_i^{0'}(k) = \dfrac{X_i(k)}{X_i(1)} \end{cases} \tag{8}$$

(4) Calculate the grey synthetic correlation degree ρ_{0i} between X_0 and X_i .

$$\rho_{0i} = \theta \phi_{0i} + (1-\theta)\pi_{0i} \tag{9}$$

Where, $\theta \in [0,1]$,in general, θ can be 0.5.

(5) Select the key factors according to the calculation results.

Determinethe threshold value for ρ and select the key factors. If synthetic correlation degree ρ_{0i} is bigger than ρ , X_i should be the key indicator.

2.2 Determining the Key Factors Affecting Electricity Demand

Based on the previous literatures, the initial factors influencing electricity demand involves economic growth, industrial structure, population, urbanization, living standard and technology progress. The details are shown as below:

Table 1. Economic Development Indicators Related to Electricity Demand

Economic growth	GDP
	Added value of tertiary industry
	Added value of industrial
Industrial structure	Secundiparity added value of a share of GDP
	Industrial added value of a share of GDP
Population	Total population
Urbanization	Urbanization rate
Living standard	Total exports
Technology progress	Electricity intensity
	Electric power efficiency

(Data source:Statistical yearbook of China from 1986-2012)

The whole society of electricity from 1986-2012 in north China is the reference sequence. Meanwhile, the economic development indicators related to electricity demand from 1986-2012 are the compare sequences. On this basis, the key factors influencing electricity demand are selected based on correlation analysis model.

First of all, the reference sequence and compare sequencesshould be non-dimensionalized.Secondly, compute the absolute correlation degree and relative incidence degree for the reference sequence and compare sequence. And then, the comprehensive correlation between reference sequence and compare sequence are calculated, which are shown in table 2:

Table 2. The Grey Correlation Coefficient between Economic Development Indicators and the Whole Society of Electricity

Economic growth	GDP	0.739012948
	Added value of tertiary industry	0.732291584
	Added value of industrial	0.743268204
Industrial structure	The added value of the second industry share of GDP	0.697007518
	Industrial added value of a share of GDP	0.68741029
Population	Total population	0.706963318
Urbanization	Urbanization rate	0.713547514
Living standard	Total exports	0.635056055
Technology progress	Electricity intensity	0.692774342
	Electric power efficiency	0.706934512

According to analysis results, the grey correlation coefficient of all economic development factors are relative large. Among them, economic growth, industrial structure, population, urbanization rate and the technical progress factor are the key factors influencing the demand for electricity in North China.Therefore, this paper intends to build a relationship model between economic development and electricity demand fromabove several aspects.

3. Analyze the Relationship between Electricity Demand and Economic Growth in North China

3.1 Co-integration Theory

Regression model based on multiple linear regressionmodel may be spurious regression when the time series are not smooth. Co-integration was firstly put forward by Granger in 1981. Engle and Granger proposed the theorem and its concrete operational framework [10].In this theory, if the linear combination of non-stationary time series is stable, there must exista co-integration relationship between these variables, namely the long-term equilibrium relationship.Since the time series of economic indicators are always not smooth, the co-integration theory is applied to analyze the relationship between electricity demand and economic development in north China. On the one hand, a long-term equilibrium model is established based on Stationarity test and Johansen test. On the other hand, a short-term error correction model is computed to analyze the short-term fluctuation relationship.The specific steps are shown as follows:

(1) Stationaritytest[11]

The ADF unit root test is a common method used to test the stability of a time series. The time series variable model isestablished as follows:

$$\Delta X_t = \alpha + \beta t + \delta X_{t-1} + \sum_{i=1}^{p} \theta_i \Delta X_{t-i} + \varepsilon_t \qquad (10)$$

Where, α is constant, t is trend term, p is the optimal lag order number, ε_t is random error term. For a given significance level, when the ADF test value is less than the critical value, the time series is stable.

(2) Co-integration test[12]

Co-integration can be expressed as follows:if*yt~I(d)*, namely *yt*becomes stationary after d times differencing, there must exist $\alpha = [\alpha_1, \alpha_2, ..., \alpha_k]$ makes $Z_t = \alpha X_t{}' \sim I(d-b)$ ($b > 0$). On this basis, $X_{1t}, X_{2t}, ..., X_{kt}$ is co-integration of (d,b) order, namely $X_t \sim C_I(d,b)$, and α co-integrated vector.

TheJJ (Johansen and Juselius) co-integration testis always used to test the co-integration for multiple variables. There are two ways to test the co-integration: TRACE and MAX are commonly two output results in this test.

(3) Vector Error Correction Model

Vector error correction model argues that along-term equilibrium relationshipis established underthe adjustment of short-term fluctuationcontinuously.If there isa co-integration relationship among the whole society power consumption and other economic development indicators, there must be ashort-term error correction mechanismmake the linear combination is a stationary time series,avoiding long-term equilibrium relationshipappearing larger deviation[13-14].

Set $X_t = (X_{1t}, X_{2t}, ..., X_{kt})$ is a k-dimensional random time sequence. Where $t = 1, 2, ..., T$ and $X_{it} \sim I(1), i = 1, 2, ...k$. If X_{it} is not affected by the dimentional exogenous time series, the VAR model could be established as equation (11):

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + ... + A_p X_{t-p} + u_t, t = 1, 2, ..., T \quad (11)$$

Where, x_t is a k-dimensional variable, x_{t-p} is the lag variable of p-order and p is the lag order. A_p is the $k \times k$ order coefficient matrix, and u_t is the random perturbation terms[15].

After the differential treatment for equation(10), $\prod X_{t-1} \sim I(0)$ and equation(11) can be expressed as follows:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + u_t \quad (12)$$

Where, $\beta' x_{t-1} = ecm_{i-1}$ is the error correction term which reflects the long-term equilibrium relationship among variables.Meanwhile, equation(12) can be described by a vector error correction modelas follows:

$$\Delta X_t = \alpha ecm_{i-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + u_i \quad (13)$$

3.2 The Relation Model of Electricity Demand and Economic Development in North China

(1) Time series stationarity test

There are nine influencing factors selected above would be introduced to establish the relation model with thewhole society of electricity. The specific variables are shown as follows: GDP of north China (GDP)(2000 is the based period), urbanization rate (CITY), electric strength (E), electric power efficiency (EF), added value of the second industry share of GDP (M2), the industrial added value of a share of GDP (Mg), total population (POP), gross export (OUT) and the whole society of electricity(Q). What’s more, the statistical period of all variables is from 1986 to 2012.

In order to eliminate the heteroscedasticity of data, Q, GDP, GDP3, GDPg, POP and OUT are logarithmic data. CITY, Mg, and M2 are logarithmic data after multiplying by 100.

Before building co-integration model, stationarity test is neededfor each variable. $\ln Q$, $\ln GDP$, $\ln M2$, $\ln EF$ and $\ln CITY$ are non-stationary sequences under the significance level of 5%. They are integrated of order 1, namely, $\ln Q \sim I(1)$, $\ln GDP \sim I(1)$, $\ln Mg \sim I(1)$, $\ln EF \sim I(1)$, $\ln CITY \sim I(1)$.Therefore, the long-term equilibrium model between electricity demand and economic development would be established based on the five variables.

(2) Co-integration test

The JJ (Johansen and Juselius) test method is used to analyze the co-integration correlation of $\ln Q$, $\ln GDP$, $\ln Mg$, $\ln EF$, and $\ln CITY$. The test result shows that the five variables have a co-integration correlation under the significance level of 5%. The test results as shown in table 3 and table 4.

Table 3. JJ Test Results (Trace Test)

Hypothe-sized No. of CE(s)	Eigenvalue	Trace Statistic	0.05Critical Value	Prob.**
None	0.989160	205.8113	69.81889	0.0000
At most 1	0.926648	97.22303	47.85613	0.0000

At most 2	0.509236	34.52337	29.79707	0.0133
At most 3	0.430886	17.44034	15.49471	0.0252
At most 4	0.150414	3.912138	3.841466	0.0479

Table 4. JJ Test Results (The Maximum Characteristic Root Test)

Hypothesized No. of CE(s)	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05Critical Value
None	0.989160	108.5883	33.87687	0.0000
At most 1	0.926648	62.69966	27.58434	0.0000
At most 2	0.509236	17.08303	21.13162	0.1681
At most 3	0.430886	13.52820	14.26460	0.0651
At most 4	0.150414	3.912138	3.841466	0.0479

Trace method and the max eigenvalue method show the presence of a co-integration relationship between the variables, which indicatesthat $\ln Q$, $\ln GDP$, $\ln Mg$, $\ln EF$, and $\ln CITY$ hold a long-term stable relationship with electricity demand.The Co-integration coefficient of each variable isshown in table 5.

Table 5. JJ Test Co-integration Coefficient

<table>
<tr><td>CointegratingEqua-tion(s):</td><td colspan="2">Log likelihood</td><td colspan="2">464.3303</td></tr>
<tr><td colspan="5">Normalized co-integrating coefficients (standard error in parentheses)</td></tr>
<tr><td>$\ln Q$</td><td>$\ln GDP$</td><td>$\ln Mg$</td><td>$\ln EF$</td><td>$\ln CITY$</td></tr>
<tr><td>1.0000</td><td>-0.827012
(0.00607)</td><td>-1.301117
(0.01480)</td><td>4.596543
(0.13563)</td><td>-3.007933
(0.01548)</td></tr>
</table>

The long-term equilibrium model between electricity power demand and economic development factors are shown as below:

$$\ln Q = 0.8270 \ln GDP + 1.3011 \ln Mg - 4.5965 \ln EF + 3.0079 \ln CITY + 5.7827 \quad (14)$$

The result show that $\ln GDP$, $\ln Mg$, $\ln EF$, and $\ln CITY$ have a long-term equilibrium correlation with $\ln Q$ during the period of 1986-2012.From the perspective of long-term equilibrium, when GDP increases 1%,total electricity consumption increased 0.8270%; when industrial added value of a share of GDP increases 1%, total electricity consumption increases 1.3011%; when Electric power efficiency increases 1%, total electricity consumption increases 4.5965%; when urbanization rate increases 1%, total electricity consumption increases by 3.0079%. Therefore, electric power efficiency is the main factor promoting the increase of electricity demand growth.

(3) Short-term error correction model

On the basis of co-integration test, the optimal lag order of the VAR model is 2. Therefore, a second order short-term error correction model is established to describe the short-term fluctuations among variables.The outputs of the model are shown as below:

Table 6. Vector Error Correction Model

Vector Error Correction Estimates
Date: 04/27/15 Time: 19:18
Sample (adjusted): 1989 2012
Included observations: 24 after adjustments
Standard errors in ( ) & t-statistics in [ ]

CointegratingEq:	CointEq1	CointEq2
LNQ(-1)	1.000000	0.000000
LNGDP(-1)	0.000000	1.000000
LNEF(-1)	-2.789704	-2.184780
	(0.05007)	(0.07067)
	[-55.7148]	[-30.9170]
LNMG(-1)	-2.138873	1.012991
	(0.15053)	(0.21245)
	[-14.2085]	[4.76812]
LNCITY(-1)	-1.376712	-1.972427
	(0.06892)	(0.09727)
	[-19.9746]	[-20.2774]
C	8.883568	-3.749538

Error Correction:	D(LNQ)	D(LNGDP)	D(LNEF)	D(LNMG)	D(LNCITY)
CointEq1	-0.256074	-0.088117	0.065856	0.429198	0.206761
	(0.24206)	(0.07430)	(0.24832)	(0.18008)	(0.24199)
	[-1.05788]	[-1.18596]	[0.26520]	[2.38334]	[0.85441]
CointEq2	-0.052621	-0.180678	-0.018653	-0.128374	0.032418
	(0.10808)	(0.03318)	(0.11088)	(0.08041)	(0.10805)
	[-0.48686]	[-5.44616]	[-0.16823]	[-1.59654]	[0.30003]
D(LNQ(-1))	0.543140	0.204919	0.198698	0.220092	-0.009875
	(0.36811)	(0.11299)	(0.37763)	(0.27386)	(0.36801)
	[1.47547]	[1.81359]	[0.52617]	[0.80367]	[-0.02683]
D(LNQ(-2))	-0.247180	-0.028697	0.165223	0.094492	-0.117402
	(0.29658)	(0.09103)	(0.30425)	(0.22064)	(0.29650)
	[-0.83343]	[-0.31524]	[0.54305]	[0.42826]	[-0.39597]
D(LNGDP(-1))	-0.116033	-0.174580	-0.571524	1.028521	0.758442
	(0.89787)	(0.27560)	(0.92109)	(0.66797)	(0.89760)
	[-0.12923]	[-0.63346]	[-0.62049]	[1.53978]	[0.84496]
D(LNGDP(-2))	-0.656315	-0.429266	-0.289017	-0.505079	-0.164811
	(0.79939)	(0.24537)	(0.82006)	(0.59470)	(0.79915)
	[-0.82102]	[-1.74948]	[-0.35243]	[-0.84930]	[-0.20623]
D(LNEF(-1))	0.253971	-0.137832	0.274888	-0.078988	0.206466
	(0.54022)	(0.16582)	(0.55419)	(0.40189)	(0.54006)
	[0.47013]	[-0.83123]	[0.49602]	[-0.19654]	[0.38230]
D(LNEF(-2))	-0.322507	-0.069196	0.082441	-0.090933	0.122548
	(0.38778)	(0.11903)	(0.39781)	(0.28849)	(0.38767)
	[-0.83167]	[-0.58134]	[0.20724]	[-0.31520]	[0.31611]
D(LNMG(-1))	-0.069911	0.099398	0.226805	0.280835	-0.274787
	(0.35222)	(0.10811)	(0.36133)	(0.26204)	(0.35212)
	[-0.19848]	[0.91939]	[0.62769]	[1.07174]	[-0.78038]
D(LNMG(-2))	-0.001805	-0.028717	-0.084536	0.649985	0.335130
	(0.46335)	(0.14222)	(0.47533)	(0.34471)	(0.46321)

	[-0.00390]	[-0.20192]	[-0.17785]	[1.88561]	[0.72349]
D(LNCITY(-1))	-0.989841	-0.355875	-0.354101	0.554515	0.486524
	(0.58200)	(0.17864)	(0.59705)	(0.43298)	(0.58183)
	[-1.70074]	[-1.99210]	[-0.59308]	[1.28069]	[0.83619]
D(LNCITY(-2))	-0.210274	-0.137682	-0.061897	-0.100409	-0.011334
	(0.42405)	(0.13016)	(0.43502)	(0.31547)	(0.42393)
	[-0.49587]	[-1.05779]	[-0.14229]	[-0.31828]	[-0.02674]
C	0.192045	0.184132	0.090839	-0.095818	-0.044480
	(0.14358)	(0.04407)	(0.14729)	(0.10681)	(0.14353)
	[1.33758]	[4.17817]	[0.61674]	[-0.89706]	[-0.30990]
R-squared	0.679915	0.924096	0.479414	0.728323	0.285588
Adj. R-squared	0.330730	0.841293	-0.088498	0.431948	-0.493771
Sum sq. resids	0.012300	0.001159	0.012945	0.006808	0.012293
S.E. equation	0.033440	0.010264	0.034304	0.024877	0.033430
F-statistic	1.947152	11.16007	0.844169	2.457439	0.366439
Log likelihood	56.85978	85.20587	56.24709	63.95860	56.86686
Akaike AIC	-3.654982	-6.017156	-3.603924	-4.246550	-3.655572
Schwarz SC	-3.016870	-5.379044	-2.965812	-3.608437	-3.017460
Mean dependent	0.094107	0.111860	0.023043	-0.005302	0.032192
S.D. dependent	0.040875	0.025765	0.032880	0.033007	0.027352
Determinant resid covariance (dof adj.)	1.71E-19				
Determinant resid covariance	3.45E-21				
Log likelihood	395.1124				
Akaike information criterion	-26.67604				
Schwarz criterion	-22.99462				

The determination coefficients are 1.71E-19 and 3.45E-21. Accordingly, the AIC and SC are -26.67604 and -22.99462, which shows the vector error correction model is ideal. The short-term error correction between electricity demand and economic development is shown as follows:

$$\begin{aligned}\Delta\ln Q_t = &-0.2561 ecm_{t-1} + 0.5431\Delta\ln Q_{t-1} - 0.2472\Delta\ln Q_{t-2} - 0.1160\Delta\ln GDP_{t-1} \\ &- 0.6563\Delta\ln GDP_{t-2} - 0.9898\Delta\ln CITY_{t-1} - 0.2103\Delta\ln CITY_{t-2} \\ &- 0.0699\Delta\ln Mg_{t-1} - 0.0018\Delta\ln Mg_{t-2} + 0.2540\Delta EF_{t-1} \\ &- 0.3225\Delta EF_{t-2} + 0.1920\end{aligned} \tag{15}$$

The estimation results show that the error correction coefficient is -0.2561, which means that when the whole society power consumption deviates from the long-term equilibrium, the unbalanced state can return back to the equilibrium with an adjustment of -0.2561. As a result, the electricity power demand in north China has a long-term equilibrium correction with the economic development.

4. Conclusion.

In order to select the influencing factors of electricity demand in north China, the grey correlation analysis is employed to compute the grey correlation coefficient between electricity demand variable and other economic development variables. The results show that economic growth, industrial structure, population, urbanization rate and the technical progress factor are the key factors influencing the demand for electricity in north China.

On this basis, a long-term equilibrium model is established among $\ln Q$, $\ln GDP$, $\ln Mg$, $\ln EF$, and $\ln CITY$ based on the co-integration theory. From the perspective of long-term equilibrium, $\ln GDP$, $\ln Mg$ and $\ln CITY$ has a positive correlation relationship with $\ln Q$.

While $\ln EF$ has a negative correlation relationship with $\ln Q$. What's more, the short-term error correction modelproves that there is a long-term equilibrium correlation between the electricity power demand and economic development.

In this paper, the relationship between electricity power demand and economic development in North China is researched. Inthe following research, the electricity power demand should be forecasted combining with the trend of economic development, so as to do a good job in electric power industry planning andthe sustainable development of power industry.

References

[1] N. A. Burney, "Socioeconomic development and electricity consumption A cross-country analysis using the random coefficient method", Energy Economics, vol. 17, no. 3, **(1995)**, pp. 185-195.

[2] P. K. Narayan and R. Smyth, "Multivariate Granger causality between electricity consumption, exports and GDP: evidence from a panel of Middle Eastern countries", Energy Policy, vol. 37, no. 1, **(2009)**, pp. 229-236.

[3] H. C. Park and E. Heo, "The direct and indirect household energy requirements in the Republic of Korea from 1980 to 2000—An input–output analysis", Energy Policy, vol. 35, no. 5, **(2007)**, pp. 2839-2851.

[4] G. K. F. Tso and K. K. W. Yau, "Predicting electricity energy consumption: A comparison of regression analysis, decision tree and neural networks", Energy, vol. 32, no. 9, **(2007)**, pp. 1761-1768.

[5] Y. Jiahai, D. Wei and H. Zhaoguang, "Analysis on cointegration and co-movement of electricity consumption and economic growth in China", Power System Technology-Beijing, vol. 30, no. 9, **(2006)**, p. 10.

[6] P. Xie, Z. Tan and J. Hou, "Analysis on dynamic relationship between urbanization and electricity consumption level in China", Power System Technology, vol. 33, no. 14, **(2009)**, pp. 72-77.

[7] P. Xie, Z. Tan and J. Hou, "Analysis on dynamic relationship between urbanization and electricity consumption level in China", Power System Technology, vol. 33, no. 14, **(2009)**, pp. 72-77.

[8] G. Xu, Y. Yang and S. Lu, "Comprehensive evaluation of coal-fired power plants based on grey relational analysis and analytic hierarchy process", Energy policy, vol. 39, no. 5, **(2011)**, pp. 2343-2351.

[9] J. Wang, J. Guo and X. Lian, "Comparative study on two improved Grey Relational Analysis", Journal of North China Electric Power University, vol. 6, no. 20**(2005)**.

[10] W. Lise and K. Van Montfort, "Energy consumption and GDP in Turkey: Is there a co-integration relationship", Energy Economics, vol. 8, no. 10, **(2006)**.

[11] B. Lin, "Econometric Analysis of Chinese Energy Demand", Statistical Research, vol. 10, **(2001)**, pp. 34-39.

[12] S. Johansen, "Statistical Analysis of Co-integration Vectors", Journal of Economic Dynamics and control, vol. 12, **(1988)**, pp. 231-254.

[13] T. K. Mukherjee and A. Naka, "Dynamic relations between macroeconomic variables and the Japanese stock market: an application of a vector error correction model", Journal of Financial Research, vol. 18, no. 2, **(1995)**, pp. 223-237.

[14] R. C. Maysami and T. S. Koh, "A vector error correction model of the Singapore stock market", International Review of Economics & Finance, vol. 9, no. 1, **(2000)**, pp. 79-96.

[15] B. E. Hansen and B. Seo, "Testing for two-regime threshold co-integration in vector error-correction models", Journal of econometrics, vol. 110, no. 2, **(2002)**, pp. 293-318.

Acknowledgments

This study is supported by the Humanity and Social Science project of the Ministry of Education of China (Project number: 11YJA790217), the National Natural Science Foundation of China (Project number: 71373076), the Fundamental Research Funds for the Central Universities(2015XS31), and Science and Technology Project of State Grid Corporation of China (Contract number: SGHB0000DKJS1400116).

Authors

Huiru Zhao, She received the Ph.D. in technological economics from North China Electric Power University.

From 1988 to 2014, she taught at North China Electric Power University. Her current research interests include Electric power economics and management, technological economics, and energy management. She has applied for several fund projects, such as the national natural fund and Humanity and Social Science project of the Ministry of Education of China.

Nana Li, She received the master degree in technological economics from North China Electric Power University.And she is reading for the Ph.D. in energy management in North China Electric Power University.

From 2012 to 2014, she studied at North China Electric Power University. Her current research interests include Electric power economics and management, technological economics, and energy management.