International Journal of Business, Economics and Managment works
Kambohwell Publisher Enterprises
Vol. 1, Issue 1, PP. 6-11, Nov. 2014
www.kwpublisher.com

# G M (1, 1) Analysis and Forecasting for Efficient Energy Production and Consumption

R.M. Kapila Tharanga Rathnayaka, D.M Kumudu Nadeeshani Seneviratna

***Abstract*****—** Electricity Generation and Forecasting is prerequisite to enhance industrialization, farming and residential requirement of one's nation. It has great impact on both nation's economy and standard of living that can be achieved through new forecasting techniques, enhanced electricity generation methodologies and better electricity conservation techniques. Most of the countries are allocating significant amount for power generation and forecasting from nation's annual budgets. Much research work has been carried out to analyze and propose innovative methodologies for efficient electricity generation and forecasting. In our approach, Grey Model (1, 1) based on grey system has been used for forecasting results. Performance of the proposed technique has been compared with existing Auto regressive moving average forecasting model. Annual power generation and forecasting data in Sri Lanka were used as our case study. Unexpected power demands with non-systematic behaviour patterns motivate to use GM (1, 1) models. MAPE (Mean absolute percentage error), MSD (Mean absolute deviation) and MSE (Mean squared error) accuracy testing result shows that GM (1, 1) is outperformed compared with model fitting and model forecasting.

***Keywords*****—** Grey Models, Auto Regressive Moving Average, Model accuracy, Electricity Demands

## I. Introduction

Electricity forecasting plays a crucial role to enhance one's national economic growth. It has direct impact on both individual's standard of living and industrial enhancements. With advanced technology and automated comfort life, requirement of electricity demand has been growing rapidly. Efficient energy consumption with innovative generation techniques, transition and distribution methodologies will enhance industrialization in a specific era with tardiest electric utilities. Empathise the future requirement of electricity demand is at most important for better electricity conservation that enhances future energy system of one's nation. Forecasting demand plays major role in management studies.

R.M. Kapila Taranga Ratnayaka: School of Economics, Wuhan University of Technology, Wuhan, PR China, kapila.tr@gmail.com

D.M Kumudu Nadeeshani Seneviratna: School of Economics, Wuhan University of Technology, Wuhan, PR China, kseneviratna@gmail.com

## II. Related Work

Various research works has been carried out by numerous researchers from different countries and come up with many proposed electricity demand forecasting results. Different type of quantitative techniques such as Modified Yang's model of Granger- causality test, Box-Jenkins models, Unit root test for co integration, econometric models with regressions and robust statistical models has been wildly used.

In 2012, Ping Zhang and co-workers used fuzzy logic approach to predict energy demands in residual sector with proposed experimental results in [1]. This approach has been practically implemented in China's real energy consumption data. With 20 years of past data, Zaid Mohamed formulated Box- Jenkins ARIMA forecasting model to estimate the electricity consumption demands in New Zealand [2]. Saab and Badr used autoregressive, ARIMA and high pass filters with novel configuration methods for formulating univariate–modelling techniques to evaluated monthly electricity consumption in Lebanon [3]. Hung proposed scrotal energy consumption along with prices in UK using co-integration procedures for 1970 to 1988[4]. Based to collected records, analysis can be classified into two categories namely causal and time series models.

In mid 1980's, Grey modelling methods had been successfully applied to solve time series problems by Prof. Deng Julong [5]. This novel concept has become a very effective approach to solve incomplete, poor and uncertain data. Many Grey forecasting models have been developed rapidly and successfully applied to multidisciplinary systems such as; financial, economic, energy consumption, military, geological and agricultural systems[6]. In our approach, main focus is on electricity demand forecasting problem. In 2011, Li and Liao proposed GAGM (1, 1) cosine model with rolling mechanism to predict the china's oil energy consumption [7]. Experimental results show that proposed approach is better than current techniques. Zhou and team formulated novel GM (1, 1) model with trigonometric residual modification forecasting method [8]. Three statistical measures namely MAD, MSE and MAPE were used to analyse and evaluate prediction accuracy. Kumar and Jain used Grey Markov model with rolling mechanism to develop new grey model for forecasting Crude-petroleum, coal, electricity and natural gas consumption in India [9]. In 2010, Wang and Yang has done case study to find electricity consumption of Jiangsu province, chin [10]. Dynamic GM (1, 1) model based on cubic spline model is used for evaluation results. In 2010, Liu and team developed neural network based GM model to solve energy consumption problem in certain provinces of china [10]. Yao and Ku exposed a new way for grey modelling. GM (1,1) model based on new automated and monitoring control system has been proposed in Taiwan[11]. Proposed algorithm mainly focused on short – term electricity power demands. Grey system theory with dynamical GM (1, 1) model has been applied for the first time to analyse electricity consumption in Sri Lanka. Estimated results were compared with ARMA model and realized from GSISL and ITSM statistical packagers.

The rest of the paper is organized as follows: Section II explains about brief overview of Grey model methodologies. Sections III analyse and compare Sri Lankan electricity consumption results and section IV end up with conclusion and future work.

*A) overview of grey models Accumulation and Test of Row Series: GM (1, 1) Model*

Grey system theory (GST) was pioneered by Prof. Deng Julong in [12] 1982. According to the explanation, first order one variable grey model (GM (1, 1)) plays a significant role in data analysing with relatively less data. This model has only time- varying coefficients.

$$X^{(0)} = \{x^{(0)}(1),\ x^{(0)}(2),\ \ldots,\ x^{(0)}(n) \mid n \geq 4\}$$

Assume that X (0) is an original non- negative row data series, where the subscript (0) represent the original series. The GM (1, 1) modelling algorithm goes through the following steps.

***Step I***

Accumulated generating operation (AGO) series is given by;

$$X^{(1)} = \{x^{(1)}(1),\ x^{(1)}(2),\ \ldots,\ x^{(1)}(n)\} \qquad (1)$$

Where;

$$X^{(1)}(k) = \sum_{m=1}^{k} x^{(0)}(m) \qquad k=1,2,\ldots,n \qquad (2)$$

$$X^{(1)} = AGO(x^{(0)})$$

***Step II***

Establish the first order differential equation for GM (1, 1);

$$x^{(0)}(k) + a\, z^{(1)}(k) = b\ ;\ k = 1,2,\ldots n \qquad (3)$$

Undetermined parameters 'a' and 'b' are called developmental coefficient and grey input respectively. The $z^{(1)}(k)$ is said to be mean series of $x^{(1)}(k)$.

$$z^{(1)}(k) = Mean\ x^{(1)} = 0.5\, x^{(1)}(k) + 0.5\, x^{(1)}(k-1) \qquad (4)$$

***Step III***

Estimating the developing coefficient 'a' and grey input 'b' can be calculated by using Least Square Method (LST). System can be written as an augmented matrix.

$$\begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ . \\ . \\ . \\ x^{(0)}(n) \end{pmatrix} = \begin{pmatrix} -z^{(0)}(2) & 1 \\ -z^{(0)}(3) & 1 \\ . & \\ . & \\ . & \\ -z^{(0)}(n) & 1 \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix}$$

Where $Y_n = BU$ (5)

$$[\hat{a}\,\hat{b}] = (B^T B)^{-1} B^T Y_n$$

***Step IV***

Establish the whitened first – order differential equation for predict the future values.

$$\frac{dx^{(1)}}{dt} + \hat{a}x^{(1)} = u$$

Where;

$x^{(1)}(1) = x^{(0)}(1)$ is a initial condition.

***Step V***

The AGO Grey prediction can be obtain;

$$x^{(1)}(k+1) = \left[x^{(0)}(1) - \frac{u}{\hat{a}}\right] e^{-a(k-1)} + \frac{u}{\hat{a}};\ k = 1,2,\ldots,k \qquad (6)$$

***Step VI***

Substitute AGO (IAGO), $x^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1)$ to step V. The prediction values can be obtained as follows.

$$x^{(0)}(k+1) = \left(1 - e^{-a}\right)\left[x^{(0)}(1) - \frac{u}{\hat{a}}\right] e^{-ak} \qquad (7)$$

***Step VII***

Residual error can be test using following formula;

$$\delta^{(i)}(k) = \frac{|x^{(i)}(k) - \hat{x}^{(i)}(k)|}{x^{(i)}(k)} 100\%;\ k = 1, 2, \ldots, n$$

Where $x^{(i)}(k)$ is actual value and $\hat{x}^{(i)}(k)$ is estimated value.

*B) Accumulation and Test of Row Series: ARMA model*

Autoregressive moving average (ARMA) models often used for discuss the behaviours in stationary data patterns. ARMA model generally written as ARMA (p, q), where p and q represent the order of auto regressive process (MA (q)) and moving average process (AR (p)) respectively [7, 14].

The moving average process can be written as;

$$X_t = z_t + \theta_1 z_{t-1} + \theta_2 z_{t-2} + \ldots + \theta_q z_{t-q} \qquad (8)$$

Where $z_t \sim WN(0, \sigma^2)$ and $\theta_1, \theta_2, \ldots, \theta_n$ are constants.

The auto regressive process can be written as;

$$X_t = \vartheta_1 x_{t-1} + \vartheta_2 x_{t-2} + \ldots + \vartheta_p x_{t-p} + z_t \qquad (9)$$

Where $z_t \sim WN(0, \sigma^2)$ and $\vartheta_1, \vartheta_2, \ldots, \vartheta_n$ are constants.

Considering properties of AR and MA processes, ARMA (p,q) can be written as;

$$\vartheta(B)\ X_t = \theta(B)\ Z_t \qquad (10$$

Where

$$\vartheta(z) = 1 - \vartheta_1 z - \ldots - \vartheta_p z^p$$

$$\theta(z) = 1 + \theta_1 z + \ldots + \theta_q z^q$$

The likelihood estimation method is used for identification and estimation patterns.

### C) *Accuracy Tasting*

Time series forecasting can be comprehensively considered as a method or technique for predicting future aspects of many operations. Numerous methods have been carried out by many research works to accomplish their goals. In our study, Mean absolute deviation (MAD), mean absolute percentage error (MAPE) and mean square error (MSE) were used to compare the prediction accuracy of our approach models[8,11,14]. The accuracy models are define as follows;

$$MAPE(\%) = \frac{1}{n}\sum_{k=1}^{n}\frac{|y(k) - y(k)|}{y(k)} \qquad (11)$$

$$MAD = \frac{1}{n}\sum_{k=1}^{n}|y(k) - y(k)| \qquad (12)$$

$$MSE = \frac{1}{n}\left(y(k) - y(k)\right)^2 \qquad (13)$$

Where; $y(k)$ and $y(k)$ represent observed and forecast Values respectively.

## III. Case Study : Srilankan ELectricity Deman And Consumption

Demand of electricity exceeds its supply which is called epileptic problem facing by most of the developing countries including Sri Lanka. Average rate of electricity demand for Sri Lanka has gone to 6.7% over last twenty five years. According to the records, so many modifications have been done in Sri Lankan energy production from last decade. Before 1990, Hydro electricity played major role in power generating industry. According to World Bank records, before 1990 at least 90% of the grid electrical energy requirements were produced by hydro plants [15, 19]. Unfortunately, hydropower generation had been going downward because of various types of logistic and maintenance problems. Based on above pullback, electricity generation of country has been transitioned to mixed hydro-thermal from 1998 to 2012[20]. Hence new oil power stations and 300MW coal power plant in west coast has introduced from Chinese Government funds [21, 22, 23, 24]. This uncertainty thermal generation have been making huge financial crisis for CEB today[26]. Based on tedious and several other reasons, the problem of electricity demand of Sri Lanka has attracted too many current researchers. In our work, annual power demand data from 1999 to 2011 has been investigated. Intended annual data were obtained from World Bank annual reports [15, 25, 27, 28]. The observations were made from 1999 -2010 which is used for model fitting and 2011-2015 reserved ex- post testing.

### A) *Prediction and Analysis of Sri Lankan Electricity Demand*

GM (1,1) and ARMA (1,1) forecasting models were used for annual power generation in Sri Lanka.

**GM (1,1) Model**

According to GM (1,1) algorithm, the resulting equation can be written as follows.

$\hat{a}$ = -0.05972

$u$ = 4.940408

$x^{(0)}(1)$ = 4.86

The white response of GM (1,1) can be written as;

$$x^{(1)}(k+1) = 87.542\ e^{0.059752\ k} - 82.682 \qquad (14)$$

Where; k=1,2,…,n

TABLE.1.PREDICTION ANALYSIS RESULTS FOR SRI LANKAN ELECTRICITY DEMAND

| Year | Observed value | GM(1,1) | | ARMA | |
|---|---|---|---|---|---|
| | | Forecasted Value | RE (%) | Forecasted Value | RE (%) |
| 1999 | 4.86 | 4.8600 | 0.0000 | 5.2053 | -7.10444 |
| 2000 | 5.51 | 5.3902 | 2.1735 | 5.4377 | 1.31228 |
| 2001 | 6.03 | 5.7221 | 5.1056 | 5.7084 | 5.33263 |
| 2002 | 6.62 | 6.0745 | 8.2407 | 6.0175 | 9.10086 |
| 2003 | 6.36 | 6.4485 | -1.3914 | 6.3649 | -0.07759 |
| 2004 | 6.27 | 6.8455 | -9.1794 | 6.7507 | -7.66633 |
| 2005 | 6.70 | 7.2670 | -8.4634 | 7.1748 | -7.08588 |
| 2006 | 7.31 | 7.7145 | -5.5336 | 7.6372 | -4.47553 |
| 2007 | 8.77 | 8.1895 | 6.6190 | 8.1379 | 7.20753 |
| 2008 | 8.32 | 8.6938 | -4.4924 | 8.6770 | -4.29050 |
| 2009 | 9.81 | 9.2291 | 5.9218 | 9.2544 | 5.66390 |
| 2010 | 9.90 | 9.7973 | 1.0370 | 9.8701 | 0.30197 |
| 2011 | 10.30 | 10.4006 | -0.9767 | 10.5242 | -2.17641 |
| Forecasting results | | | | | |
| 2012 | | 11.0410 | | 11.2166 | |
| 2013 | | 11.6208 | | 11.9473 | |
| 2014 | | 12.4306 | | 12.7164 | |
| 2015 | | 13.0704 | | 13.5237 | |

**ARMA (1, 1) Model**

For this comparison study, we formulated ARMA model for estimated future results.  According to the AR (1,1) model, the resulting mod el can be written as follows.

$$X(t+1) = 0.9393\ X(t) + Z(t+1) \quad t = 1,2,\ldots n. \qquad (15)$$

Table shows the forecasted values as well as the relative errors

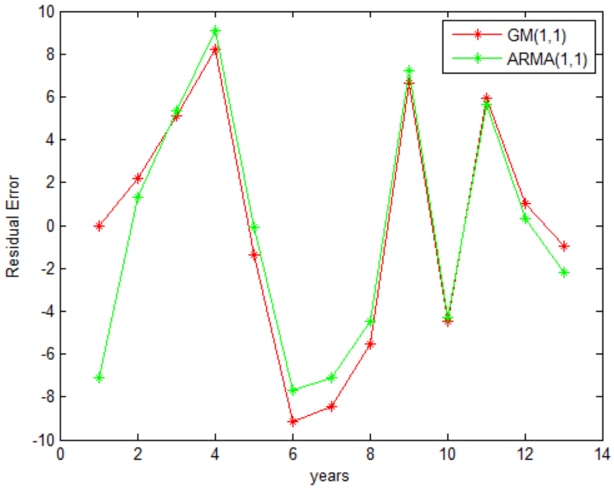


Figure.1. Comparison results of electricity Production

*B) Prediction and Analysis of Sri Lankan Electricity Consumption*

The discrepancy between the amount of electricity generated and the amount consumed is accounted as loss in transmission and distribution. GM (1,1) and ARMA (1,1) models were used to compare the past 10 years electricity consumption in Sri Lanka.

***GM (1,1) Model***

According to the GM (1,1) algorithm, the resulting equation can be write as follows.

$\hat{a} = -0.054094$

$u = 4.675964$

$x^{(0)}(1) = 4.72$

The white response of GM(1,1) can be written as;

$$x^{(1)}(k+1) = 91.164\ e^{0.054094\ k} - 86.4414 \qquad (15)$$

Where k=1,2,….,n

TABLE.2.PREDICTION ANALYSIS RESULTS FOR SRI LANKAN ELECTRICITY CONSUMPTION

| Year | Observed value | GM(1,1) | | ARMA | |
|---|---|---|---|---|---|
| | | Forecasted Value | RE (%) | Forecasted Value | RE (%) |
| 1999 | 4.7200 | 4.7200 | 0.0000 | 5.2053 | -10.2813 |
| 2000 | 5.1200 | 5.0671 | 1.0331 | 5.4377 | -6.2049 |
| 2001 | 5.6000 | 5.3488 | 4.4865 | 5.7084 | -1.9365 |
| 2002 | 6.1600 | 5.6461 | 8.3432 | 6.0175 | 2.3129 |
| 2003 | 5.9200 | 5.9599 | -0.6739 | 6.3649 | -7.5158 |
| 2004 | 5.9800 | 6.2912 | -5.2035 | 6.7507 | -12.8876 |
| 2005 | 6.2300 | 6.6409 | -6.5948 | 7.1748 | -15.1646 |
| 2006 | 6.8000 | 7.0100 | -3.0880 | 7.6372 | -12.3112 |
| 2007 | 8.1700 | 7.3996 | 9.4293 | 8.1379 | 0.3929 |
| 2008 | 6.8800 | 7.8109 | -13.531 | 8.6770 | -26.1188 |
| 2009 | 8.2800 | 8.2451 | 0.4216 | 9.2544 | -11.7678 |
| 2010 | 8.4200 | 8.7034 | -3.3657 | 9.8701 | -17.2222 |
| 2011 | 9.8700 | 9.1872 | 6.9184 | 10.5242 | -6.6279 |
| Forecasting Results | | | | | |
| 2012 | | 9.6978 | | 11.2166 | |
| 2013 | | 10.5369 | | 11.9473 | |
| 2014 | | 11.9964 | | 12.3456 | |
| 2015 | | 12.8831 | | 12.8765 | |

***ARMA(1,1) Model***

According to the AR (1,1) model, the resulting model can be written as follows.

$$X(t) = .9078\ X(t-1) + Z(t) \ ; \ t = 1,2,\ldots n. \qquad (16)$$

Table 2 shows the results of above mention two models and their relative errors.

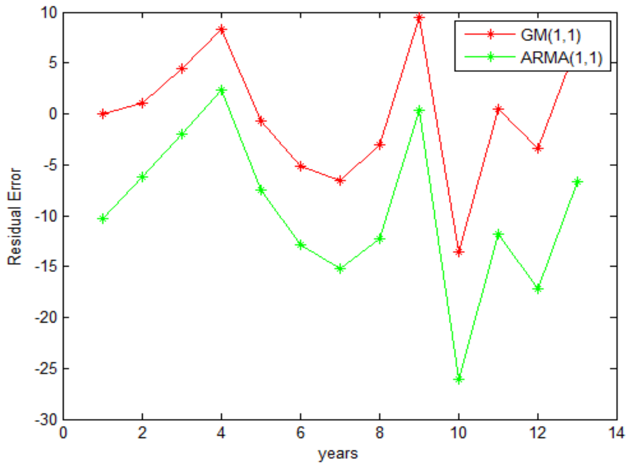


Figure.2. Comparison results of electricity Consumption

*C) Comparative Analysis of Forecasting Error*

The current study has particularly used GM (1, 1) and ARMA (1, 1) models for forecasting electricity demand and consumption data in Sri Lanka. Moreover, accuracy of the models were compared using MAD, MSE and MAPE techniques. The comparison results of the corresponding models show in Table 4.

TABLE.3. COMPARATIVE ANALYSIS OF FORECASTING ERROR

| | Models | MAD | MSE | MAPE (%) |
|---|---|---|---|---|
| Electricity Demand | GM(1,1) | 0.34020 | 0.15600 | 4.3061 |
| | ARMA | 0.34061 | 0.15701 | 4.7535 |
| Electricity Consumption | GM(1,1) | 0.34557 | 0.10378 | 4.8601 |
| | ARMA | 0.34877 | 0.19337 | 4.9444 |

According to the table, accuracy of MAPE is slightly larger than MAD and MSE models. Based on the above comparisons, one can conclude that GM (1, 1) is better than the ARMA model.

## CONCULSION

Figure 3 demonstrates the forecasting data of Sri Lankan's annual electricity production (Kilovolts hours) and annual electricity consumption from 1998 to 2015. Results are estimated through GM (1, 1) model. Before 1995, Power sector of Sri Lanka was heavily depending on the hydro power. Because of some unexpected reasons, most of the things have changed after mid 1990. According to the Figure.3, electricity production and consumption curves have parallel trend up to 2008. However, after 2008 consumption rate has been increased rapidly compared with production rate. When this is the case until 2015, definitely it will make electric distortions in the future. Hence, government should intervene and alternative energy sources must be introduced and implemented for national power grid early as possible.

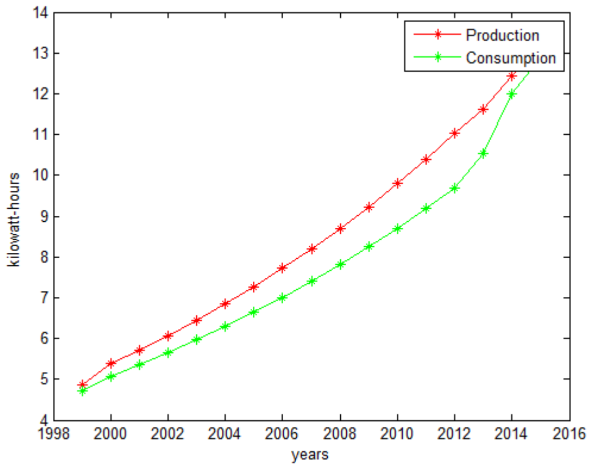

Figure.3. Future demands and consumption

Currently, CEB has already taken some necessary actions to minimize power consumption. They have planned to expand coil fire, fuel – oil and diesel fired thermal power generations in the next decade. However, dependence on these important energy sources could manipulate Sri Lanka into unsustainable economical development path. Because of the tropical temperatures and the islands location, Sri Lanka blessed with several forms of natural and renewable energy source such as wind, solar and biomass energy sources. When we can give much attention for available resources, it is beneficial not only for Sri Lankan economy but also nature.

## REFERENCE


[1] Ping Zhanga, Hui Wang, "Fuzzy Wavelet Neural Networks for City Electric Energy Consumption Forecasting", Energy Procedia, Volume 17, Part B, 2012, Pages 1332–1338

[2] Zaid Mohamed and Pat Bodger, "Forecasting Electricity Consumption: A Comparison of Models for New Zealand",ir. canterbury.ac.nz/ bitstream/10092/821/1/12593635_C47.pdf Michael Silver, 2011

[3] S. Jebaraja and S. Iniyan, "A review of energy models", Renewable and Sustainable Energy Reviews, Volume 10, Issue 4, August 2006, Pages 281–311

[4] Huang M, He Y, Cen H. Predictive analysis on electric power supply and demand in China. Renew Energy 2009;32:1165–7.

[5] Tianxiang Yao; Zaiwu Gong and Hong Gao, "GenerGrey Systems and Intelligent Services (GSIS), 2011 IEEE International Conference , Page(s): 204 - 208 .

[6] R.M Kapila Tharanga Rathnayaka, "Cross-Cultural Dimensions of Business Communication: Evidence from Sri Lanka", International Review of Management and Business Research, 3(3), 1579-1587, 2014; ISSN: 2306-9007, 2014, www.irmbrjournal.com .

[7] Duan Li-zhong, Duan Gu-na,Zhai Guang-qian, Zhang Ying, Xuan Chun-yu,Geng Hao, "The Grey Relational Analysis of influential factors for Chinese medicine in General Hospital ",Grey Systems and Intelligent Services (GSIS), 2011 IEEE International Conference on Digital Object Identifier: 10.1109/GSIS.2011.6044143: 2011 , Page(s): 23 - 29 .

[8] Li Junliang, Liao Ruiquan and Chen Xiaochun, "Generalized accumulated GM(1,1) cosine model and its application ",Grey Systems and Intelligent Services (GSIS), 2011 IEEE International Conference on Digital Object Identifier: 10.1109/GSIS.2011.6044066, Publication Year: 2011 , Page(s): 242 - 245.

[9] Ujjwal Kumar and V.K. Jain, "Time series models (Grey-Markov, Grey Model with rolling mechanism and singular spectrum analysis) to forecast energy consumption in India",2009, Energy 35 (2010) 1709–1716 .

[10] R.M Kapila Tharanga Rathnayaka, D.M. Kumudu Nadeeshani Seneviratne and Zhong- jun Wang, "An Investigation of Statistical Behaviors of the Stock Market Fluctuations in the Colombo Stock Market: ARMA & PCA Approach", Journal of Scientific Research & Reports 3(1): 130-138, 2014; Article no. JSRR, www.sciencedomain.org .

[11] Wang Xiaohuaa, Dai Xiaqingb and Zhou Yuedongb, "Domestic energy consumption in rural China: A study on Sheyang County ofJiangsu Province",2009, Biomass and Bioenergy 22 : 251 – 256

[12] Liu Sifeng, Xie Naiming , Forrest, J, Bin Yu, "On a sort of new grey incidence models", Systems, Man and Cybernetics, 2008. SMC 2008. IEEE International Conference on Digital Object Identifier: 10.1109/ICSMC.2008.4811525 Publication Year: 2008 , Page(s): 1652 - 1657.

[13] R.M. Kapila Tharanga Rathnayaka and Zhong-jun Wang, "Influence of Family Status on the Dietary Patterns and Nutritional Levels of Children", Food and Nutrition Sciences, 2013, http://www.SciRP.org/journal/fns .

[14] Wei Liu,"A Electronic Commerce Risk Evaluation Method Based on AHP and GRA ",Information Science and Engineering (ICISE), 2009 1st International Conference on Digital Object Identifier: 10.1109/ICISE.2009.26, Publication Year: 2009 , Page(s): 2791 - 2793 .

[15] Chow LC-h. A study of sectoral energy consumption in Hong Kong (1984–97) with special emphasis on the household sector. Energy Policy 2008; 29:1099–110.

[16] Ediger VS, Tatlldil H. Forecasting the primary energy demand in Turkey and analysis of cyclic patterns. Energy Convers Manage 2002;43:473–87.

[17] He Y, Bao YD. Grey-Markov forecasting model and its application. Syst Eng 1992;9(4):59–63 [Theory Practice].

[18] R.M. Kapila Tharanga Rathnayaka and Zhong-jun Wang, "Enhanced Greedy Optimization Algorithm with Data Warehousing for Automated Nurse Scheduling System", *E-Health Telecommunication Systems and Networks, 2013*, http://www.SciRP.org/journal/etsn.

[19] Liu Na, Sun Wan-Hua. Research on Improving the Fitting and Prediction Precision of the GM(1,1) model [J].Mathematics in Practice and Theory,2009,38(4):33-39(in Chinese).

[20] Liu Bin, Zhao Liang, Zhai Zhen-Jie, Dang Yao-Guo.etc. Optimum Model of GM(1,1) and Its Suitable Range [J].Journal of NanJing University of Aeronaytics & Astronautics,2003,35(4):451-454(in Chinese)

[21] Chou CH.A variable structure controller based on the grey prediction technology[A].Proceedings of The American Control Conference[C].2001：1506(in English)

[22] Himanshu A. Amarawickrama and Lester C Hunt, "Electricity Demand for Sri Lanka: A Time Series Analysis", ISSN 1749-8384.

[23] R.M. Kapila Tharanga Rathnayaka and P. M. Bandula Jayathileke, “Testing the Link between Inflation and Economic Growth: Evidence from Asia”, Communications and Network, 2013, http://www.scirp.org/journal/me .

[24] Rajaratnam Shanthini, "Could Sri Lanka afford sustainable electricity consumption practices without harming her economic growth?", Paper presented at the 9th Asia Pacific Roundtable for Sustainable Consumption and Production, June 2010.

[25] R.M.K.T Rathnayaka and Zhong-jun Wang, “Prevalence and effect of personal hygiene on transmission of helminthes infection among primary school children living in slums”, International Journal of Multidisciplinary Research Journal; ZENITH, ISSN: 2231-5780, Vol 02, April 2012.

[26] R.M Kapila Tharanga Rathnayaka, SC Nagahawatta and A.D. Naidu “Electricity Demand For Sri Lanka: G M (1, 1) Forecasting Approach”, Wayamba international Conference (winc-2014), Wayaba University of Sri Lanka, Sri Lanka, (2104). www.wyb.ac.lk/publications/research-symposium/wayamba-international-conference-winc-2014 .

[27] L. Ariyadasa, "Current Status of the Energy Situation in Sri Lanka", 2010.

[28] Xiping Wang, "Grey Prediction with Rolling Mechanism for Electricity Demand Forecasting of Shanghai", Proceedings of 2007 IEEE International Conference on Grey Systems and Intelligent Services, November 18-20, 2007, Nanjing, China.