Modeling Trend in Telecommunication in Sri Lanka:

A Case study on Internet and Cellular Connections

K. A. N. K. Karunarathna[1], S. Brindha[1] & P. Paramadevan[1]

[1] Department of Mathematics, Faculty of Science, Eastern University, Sri Lanka

Correspondence: K. A. N. K. Karunarathna, Department of Mathematics, Faculty of Science, Eastern University, Sri Lanka.

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Abstract

The telecommunication is one of the modes of communication, in which most investments are made. It consists of internet, mobile phones, wired and wireless fixed phones, fax, televisions, radio and some other. Among them, demand for internet and cellular phones rapidly increases. For a smooth function of this business, knowledge on demand is much important. Effective forecasts help a business to manage its supply efficiently. This study aimed to find out an accurate mechanism for prediction of demand for internet conections and cellualr phone collections.

Based on the secondary data available in central bank reports from 1996 to 2016, several statistical forecasting models were evaluated for an accurate prediction. There can be seen an increasing demand for both internet and cellular phone connections. Number of internet connections has gone up from 4 110 to 4 921 000, while the usage of cellular phones has developed from 71 228 to 26 228 000 during this period. Rapid growth in internet usage has happened after 2009, while after year 2003, usage of cellular phone has increased rapidly. With compared to models fitted for original form of data, models for log transformed data show better performances. The best performance in prediction of internet connection was given by ARIMA (1,1,1) model fitted for log transformed data, meanwhile ARIMA (0,1,2) model fitted for log transformed data showed the best fit for series of cellular connections. Double exponential smoothing models also show better fit for both series.

Keywords: ARIMA, Cellular phones, Demand, Forecasting, Internet, Telecommunication

1. Introduction

Communication is the process of transferring data and information from a source to a destination. Voice, body language and signs are the simplest modes of the communication. This information may be in the forms of audio, video, graphics, writings, images, gestures, signs and many more.

Advancement in technologies has changed modes of communication over last fifty years, which gave rise to the telecommunication. At present, people communicate through emails, faxes, mobile phones, texting services, video conferences, video chat rooms and social media and many more to evolve in upcoming years. This is known as telecommunication and it is one of the most important and rapid growing industries at the present era. The most significant telecommunication aspects are the internet, satellites and the cellular phones. These modes of communication have increased speed of transferring and exchanging data to a greater distant with a low cost effectively.

The very common form of telecommunication service is the phone service, which is done on either a wired or wireless form. The internet, television, and networking for businesses and domestic purposes are among the other services. These services may not be available in all areas or from all companies. The pricing points for different services vary widely and may be different for residences and businesses. These options are now expanded to wireless connections, while some companies offer both wireless and landline services together. Some service providers are offering television now, with a higher bandwidth speeds available through an improved infrastructure such as fiber optics. Optical fiber has revolutionized the modern telecommunication industry. It helps in transferring information to much greater distance as it provides higher bandwidth with little or no loss in the transmission medium.

1.1 Cellular Usage

Cellular phone was invented in the early 1970s, which was not much noticed. At that time, the use of cell phone was limited to certain areas and the cost was not affordable by everyone. As the technology rises, the phone came down in size, price and weight, which took the attention of the entire nation. The cellphone changed our lifestyles and took place next to our wallets in the pocket. It gives us the instant and constant communication with the mobility we desperately needed. Modern cellphones are designed in such a way it contains all the personalized device which is owned by an individual which includes camera, mp3/mp4 player, games, document folders, etc. Mobile phone’s size is getting bigger and bigger day by day with the high updated technologies in it with inbuilt batteries. Even though the price is higher, adults to teens are buying them to get the full benefit from it. As a result, they do not depend on a landline to communicate. Hence, the usage of landlines and public phone booth is declining.

1.2 Internet Usage

Internet has bought a huge impact in our lives. Since it was found that it has brought information and knowledge on our fingertips. Internet has brought positive impact in our lives and has made it simple and easier than ever. Earlier in search of information, we have to travel all the way to library or get suggestions from the elders, now the use of libraries have reduced to a greater extent due to introduction of the internet services. We are able to access large and excess data in just one click. It helps in utilizing our time in a productive manner. The most important use of internet is that it gives information and education. It provides with various websites and various blogs that give informative and useful content which helps the students in studies. It helps the people to learn various things and people get knowledge which they implement in their daily life. It helps in communication with the people easily and faster than before. We are able to send e-mails, video chatting, texting, watch movies and dramas, shop on e-shopping websites so on. ICT-Information and communication Technology has given wings to empower the use of technology related activities in the educational world. It is growing in a skyrocketing speed. ICT is used in daily life such as in education, banking, business and all the industrial uses. It helps us in e-learning, online banking, access books online, helps in presentation and researching and many more.

1.3 Objectives

Since the technology has improved and changed the telecommunication sector to a greater extend, it is important to identify the trend in the usage of these services. Therefore, this study takes the facts and figures of cellular phones and internet as the sub-indices of tele-communication sector into account for the time analysis of the data. Effective forecasts help a business manage its supply chain more economically and efficiently. Accurate predictions allow a business to manufacture and services more favorably because it has sufficient time to evaluate and plan. An accurate forecast enables a business owner to keep a lower inventory and thus reducing costs and wastages.

1.4 Previous Works

According to David (2011), “Forecasts are educated assumptions about future trends and events”. Demir and Ozsoy (2014), have stated that forecasting is a complicated process as the factors such as innovation in technology, changes in culture and social values, unstable economic conditions, new product, stronger competitors, improved services, etc. There are different models for forecasting and their accuracies are depending on the situations and data considered.

Dhanushka (2013) has examines the growth of the telecommunication sector in Sri Lanka’s by using annual time series. This study consisted of bivariate and multivariate co-integration approach to establish the long run equilibrium relationship and causality testing to detect the direction of this relationship. According to author, this study is the first of its kind to use annual secondary data to examine the long run relationship between telecommunications sector and service sector in Sri Lanka. Also one-way link between telecommunications sector growth and service sector growth was established through causality test. The sample has confirmed that research hypothesis is positive for the collected data. Thus, it has been concluded that increase in telecommunications sector growth increases the long run service sector growth.

Chakaraborty, and Nandi (2003) have examines the relationship between the level of telecommunications infrastructure (measured by telephone mainlines per capita or tele density rate) and economic growth by exploiting a panel co-integration framework. Almost all of these studies have documented a positive correlation between tele density rates and a variety of indices of economic growth. The conclusions are based on simple correlation coefficient and regression analysis. Given the unit root characteristics of time series variables in general, results based on regression analysis, as pointed out by many, are subject to spurious correlation. In addition, the simple regression coefficients fail to establish the causal relationship and its direction between the variables of interest. The study also examines the relationship between the two referred variables for a panel of 12 Asian developing countries that vary in terms of stages of development. Canning, and Pedroni (2004), TatyanaPalei (2014), Farhadi, Ismail, Fooladi (2012), Lee, and Alford (2017) also have shown the impact of telecommunication on economic growth in different regions.

It seems that studies on modeling usage of cellular and internet connections in literature are lacking. But, studies on modeling some other responses are available. Fatai *et. al.* (2003), has used Engle-Granger’s error correction model(ECM), and the autoregressive distributed lag regression approaches(ARDL) to model the demand for electricity in New Zealand.

Abraham and Nath (2001) have used Box-Jenkins autoregressive integrated moving average (ARIMA) approach in modeling electricity in the state of Victoria, Australia. Monthly electricity consumption in Pakistan has been analyzed by Yasmeen and Sharif (2015), by using both linear and nonlinear modeling techniques including ARIMA, Seasonal ARIMA (SARIMA) and ARCH/GARCH models. This study evaluated some of these models and some other for modeling usage of internet and cellular phones.

2. Method

2.1 Data Collection

Secondary data, available in Sri Lankan central bank’s annual reports, were used for this study. Number of internet connections and cellular connections are in use were recorded with year for the period from year 1996 to year 2016. Data in required form were not available for early period.

2.2 Statistical Models

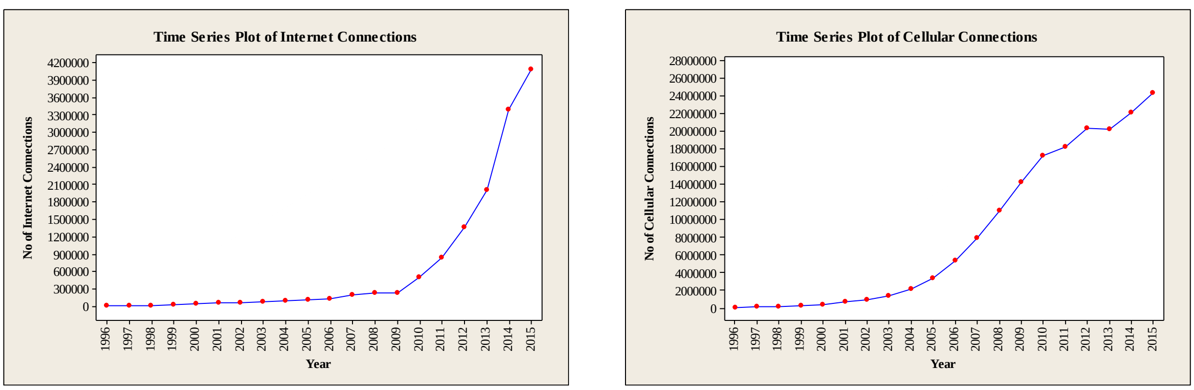
There are several statistical models that can be used to explain trends in a series. Among them, Single exponential smoothing model (SESM), double exponential smoothing model (DESM), growth curve model(GCM), quadratic trend model(QTM), auto regressive model (ARM), moving average model(MAM), auto regressive moving average model(ARMAM), auto regressive integrated moving average model(ARIMAM) were evaluated to model the number of internet connections, and cellular phone connections. These models were tested for both original form and transformed form of data. As the transformation, natural logarithm was used. In addition to the above models, linear trend models (LTM) were also evaluated only for log transformed data.

In fitting Box Jenkins AR, MA, ARMA, and ARIMA models, stationarity of series was tested with the help of autocorrelation and partial autocorrelation functions. When the series was not stationary, by taking the first differences, series was made stationary.

As the accuracy measures of forecast of each model, mean absolute percentage error(MAPE), mean absolute deviation(MAD), mean squared deviation(MSD) were used in case of SESM, DESM, GCM, QTM, LTM while the sum of square errors(SS), mean square error(MSE) were used additionally in case of MA, AR, ARMA, and ARIMA models. For the analysis, 14th version of the statistical package, Minitab, was used.

3. Results

Trend in usage of internet and cellular phones is exhibited in Figure 1(a) and Figure 1(b) respectively during the period from1996 to 2015. Both series of internet and cellular connections show increasing patterns during the period considered. Number of internet connections has gradually increased during this period. However, two different phases can be observed in this pattern. During the period from 1996 to 2009, number of internet connections has increased almost linearly from 4 110 to 240 000 with a rate of 18 145 per year. Number of internet connection has developed from 240 000 to 4 091 000 in the period from 2009 to 2015. In this period, average increment in number of internet connections per year is about 641 833.



(a) Internet (b) Cellular

Figure 1. Trend in series of Internet and Cellular connections

Numbers of cellular connections also have increased year by year during this period except in year 2013. Number of cellular connections in 2013 has decreased than the preceding year. In the series of number of cellular connection also, two phases can be observed depending on the trend. From 1996 to 2002, number of cellular connections has developed from 71 228 to 931 580, on average, at a rate of 102 815 per year, while number of cellular connections has developed from 931 580 to 24 385 000 in the period from 2002 to 2015 with an average rate of 1 804 109 per year. However, it is not a linear increment.

Details, related to the best model selected from SESM, DESM, GCM, QTM for internet connections, are given in Table 1 below, while details of fitted ARIMA models given in Table 2. Even though, a model from each SESM, DESM, GCM, QTM, MAM, ARM could be fitted, an ARIMA model could not be found for the original form of data.

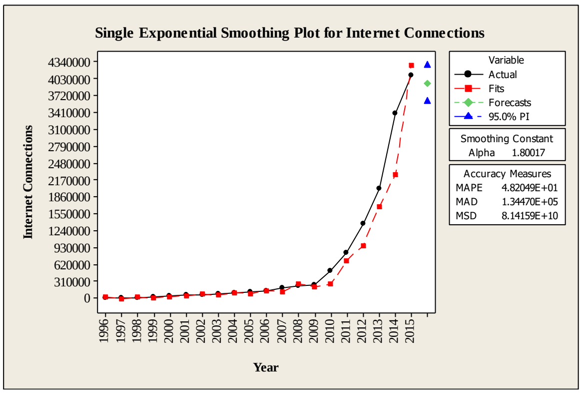
Table 1. Models for series of Internet connections

Series	**Model**	**Alpha**	**Gamma**	**MAPE**	**MAD**	**MSD**
Original Series	SESM	1.8001	-	4.82E+01	1.34E+05	8.14E+10
	DESM	0.1333	8.9569	1.38E+02	1.03E+05	2.97E+10
	GCM	-	-	3.00E+01	1.63E+05	1.16E+11
	QTM	-	-	9.39E+02	3.44E+05	1.57E+11
		SS	**MS**	**MAPE**	**MAD**	**MSD**
	ARIMA (0,1,1)	1.63E+12	9.04E+10	3.05E+01	1.14E+06	8.56E+10
	ARIMA (1,1,0)	1.07E+12	5.93E+10	1.54E+01	1.18E+05	5.62E+10
	Model	**Alpha**	**Gamma**	**MAPE**	**MAD**	**MSD**
Log series	SESM	1.8995	-	2.3033	0.2664	0.1000
	DESM	0.8725	0.6144	1.8238	0.2035	0.0672
	LTM	-	-	2.4616	0.2809	0.1091
	GCM	-	-	2.2815	0.2463	0.1057
	QTM	-	-	2.3635	0.2623	0.1047
		SS	**MS**	**MAPE**	**MAD**	**MSD**
	ARIMA(0,1,1)	1.7199	0.0956	2.1462	0.2573	0.0905
	ARIMA(1,1,0)	1.1270	0.0626	1.5564	0.1872	0.0593
	ARIMA(1,1,1)	1.0211	0.0601	1.5231	0.1797	0.0537

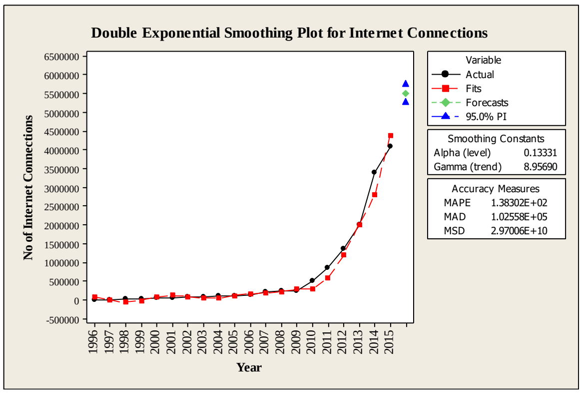
Table 2. ARIMA Models for series of Internet connections

Series	**Model**	**Coef**	**SE**	**P-value**
Original Series	ARIMA (0,1,1)	-0.8002	0.255	0.0060
	ARIMA (1,1,0)	0.8917	0.1465	0.0000
Log Series	ARIMA(0,1,1)	-0.8995	0.1096	0.0000
	ARIMA(1,1,0)	0.9301	0.1220	0.0000
	ARIMA(1,1,1)	0.9981	0.0613	0.0000
		0.5181	0.2141	0.0270

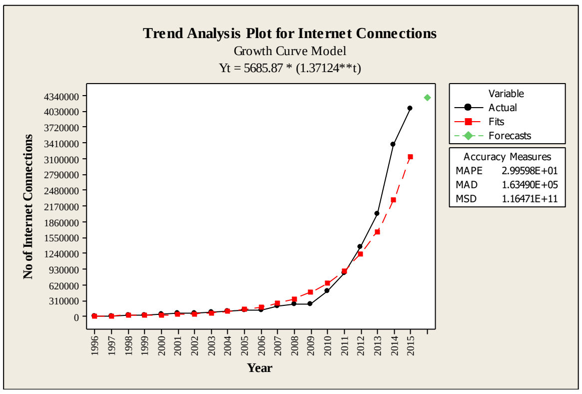
SESM and DESM are depending on some parameters called “alpha” and “gamma” and optimal values of them are given in Table 1. Among the models SESM, DESM, GCM, and QTM, GCM shows the minimum MAPE while QTM shows the highest. However, DESM and QTM show the minimum and the maximum of MAD respectively. DESM shows the least MSD. Models ARIMA (0,1,1) and ARIMA (1,1,0) only could be fitted for the series of the internet connections. Out of these two models, ARIMA (1,1,0) model shows the minimum for SS, MS, MAPE, MAD, and MSD.



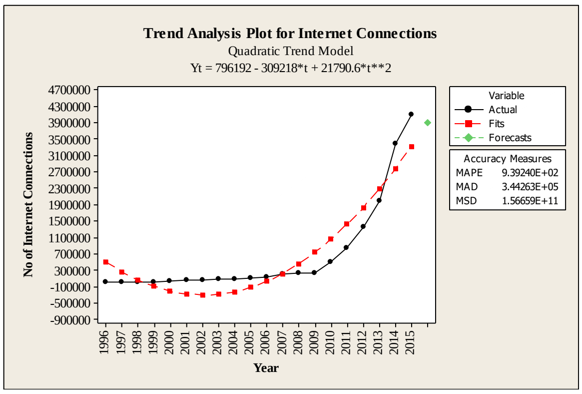
(a) SESM



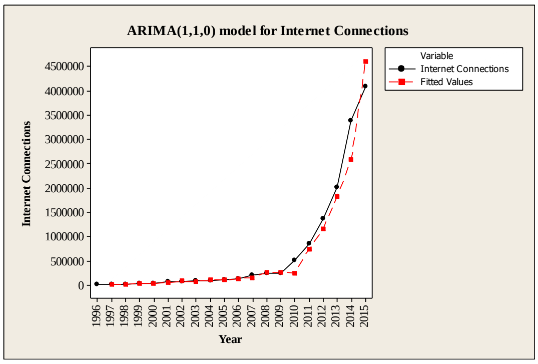
(b) DESM



(c) GCM



(d) QTM

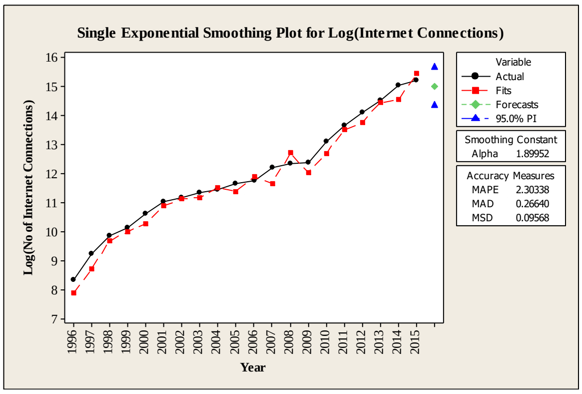


(e) ARIMA (1,1,0)

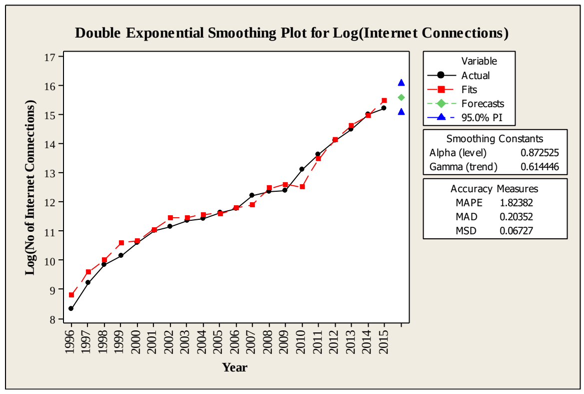
Figure 2. Plot of observed and fitted values of each model for internet connections

Fitted values with each model alone with the observed values are plotted in Figure 2. Those plots show how far fitted values are closer to the observed values under each model. According to them, it can be seen that DESM and ARIMA (1,1,0) give better estimates for observed values.

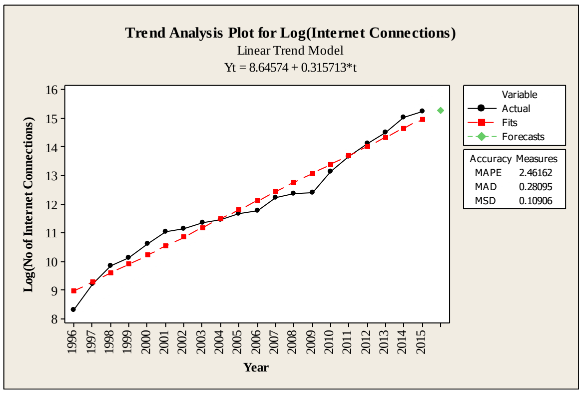
Details of models that fitted for log transformed number of internet connection are also given in the Table 1. DESM shows the minimum MAPE (1.82382) while the other models are having a higher almost the same MAPE. In case of MAD, DESM shows the minimum while LTM shows the highest. MSD of DESM shows the least while other models show little higher similar values.



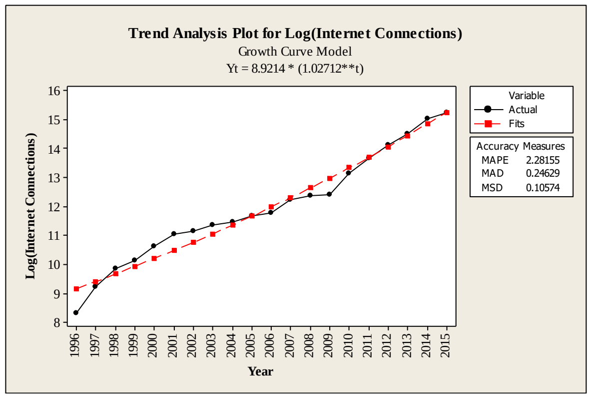
(a) SESM



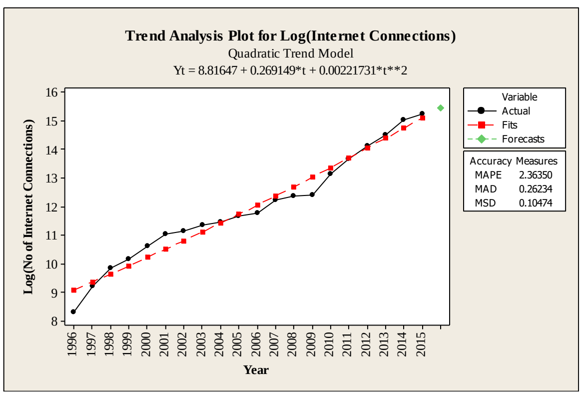
(b) DESM



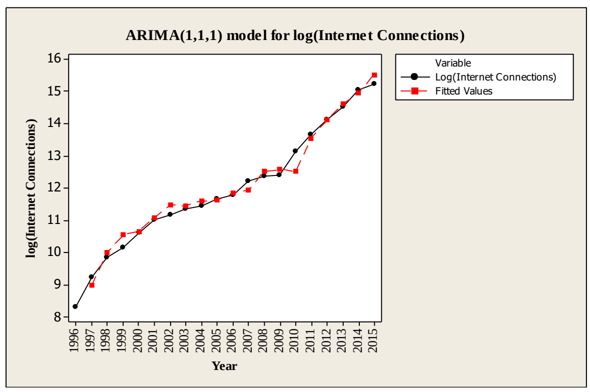
(c) LTM



(d) GCM



(e) QTM



(f) ARIMA(1,1,1)

Figure 3. Plot of observed and fitted values of each model for log(internet connections)

For series of the first differences of log transformed number of internet connections, MA (1) [ARIMA (0,1,1)], AR (1) [ARIMA (1,1,0)] and ARIMA (1,1,1) models could be fitted without a constant. Details are in the Table 1 above. With compared to ARIMA (0,1,1) and ARIMA (1,1,0) models, ARIMA (1,1,1) has given the lowest SS, MS, MAPE, MAD, and MSD. Plots of observed and fitted values obtained from each model are exhibited in Figure 3. It is clear that DESM and ARIMA (1,1,1) gives better prediction with compared to the other models.

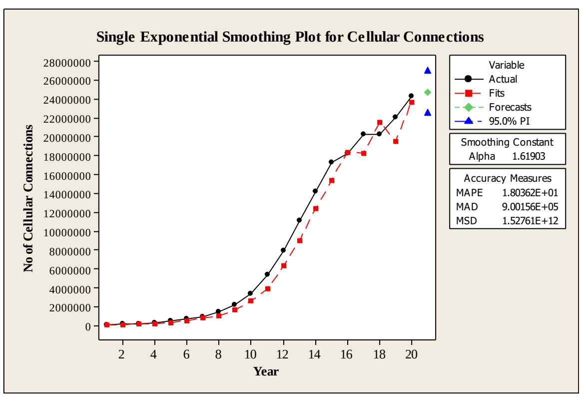
Table 3. Models for series of Cellular connections

Series	Model	Alpha	Gamma	MAPE	MAD	MSD
Original Series	SESM	1.6190	-	1.80E+01	9.00E+05	1.53E+12
	DESM	0.1519	11.5293	3.63E+01	4.11E+05	3.53E+11
	GCM	-	-	3.97E+01	4.80E+06	9.71E+13
	QTM	-	-	1.29E+02	1.29E+06	2.31E+12
		SS	**MS**	**MAPE**	**MAD**	**MSD**
	ARIMA(0,1,2)	1.58E+13	9.35E+11	4.12E+01	7.43E+05	8.36196E+11
	ARIMA(1,1,0)	1.35E+13	7.52E+11	9.76E+00	5.89E+05	7.12044E+11
Log series	**Model**	**Alpha**	**Gamma**	**MAPE**	**MAD**	**MSD**
	SESM	1.9126	-	1.2686	0.1796	0.0400
	DESM	0.9318	1.0171	0.4584	0.0671	0.0055
	LTM	-	-	2.4510	0.3660	0.1864
	GCM	-	-	3.0596	0.4589	0.2943
	QTM	-	-	-	-	-
		SS	**MS**	**MAPE**	**MAD**	**MSD**
	ARIMA(0,1,2)	0.2621	0.0154	0.6843	0.0991	0.0138

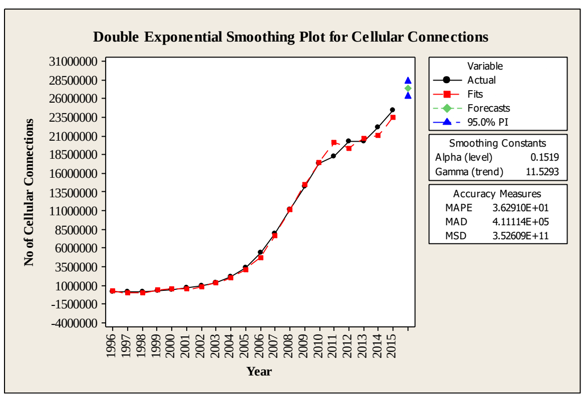
Same models were tested for the series of number of cellular connections. Both series of original form of data and transformed data were modeled. Details of the selected models are given in the Table 3 and Table 4. A SESM with an alpha value 1.619 could explain the series better than SESM with other alpha. Among DESM with different alpha and gamma, a model with alpha of 0.1519 and gamma of 11.5293 could be selected as the best DESM for series of original data of cellular connections. Among the models SESM, DESM, GCM, QTM fitted for the original form of cellular connections, the minimum MAPE is given by SESM while DESM gives the minimum of MAD and MSD. Further, ARIMA (0,1,2) and ARIMA (1,1,0) models could be fitted as the best models from each type for this series. According to SS, MS, MAPE, MAD, and MSD, ARIMA (1,1,0) model is better than ARIMA (0,1,2) for cellular connections.

Among the models fitted for log transformed cellular connections, DESM gives the minimum of MAPE (0.4584) while it gives the minimum for MAD also. In case of MSD also, DESM shows the least. No any AR, MA or ARMA models could be fitted for the log transformed data of cellular connections.

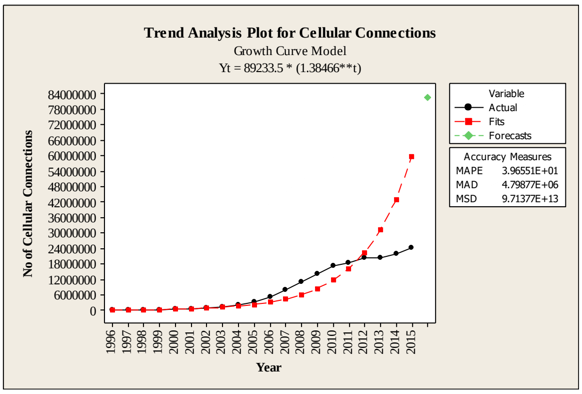
However, only ARIMA (0,1,2) model could be fitted for the series of log transformed data. It shows a SS of 0.2621 and MS of 0.0154, while it gives low values for MAPE, MAD, and MSD.



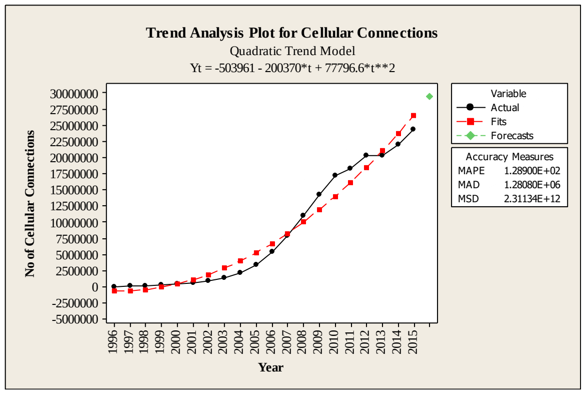
(a) SESM



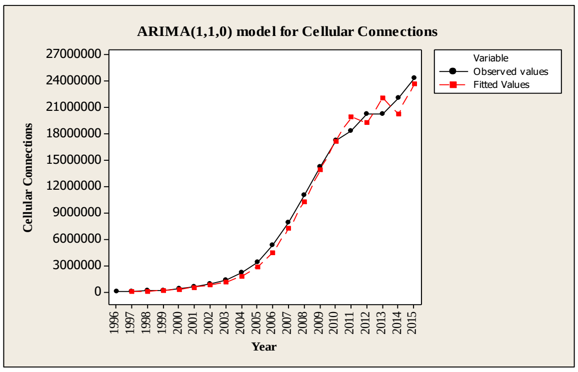
(b) DESM



(c) GCM



(d) QTM



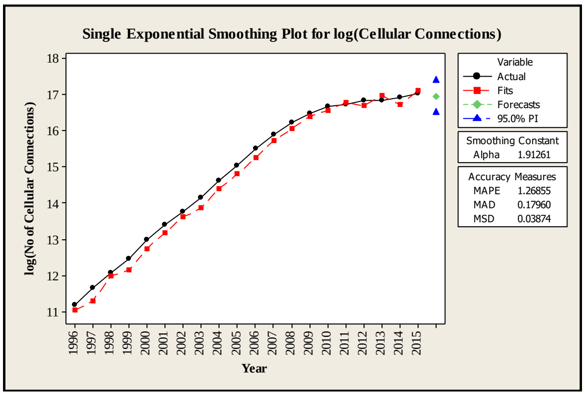
(e) ARIMA (1,1,0)

Figure 4. Plot of observed and fitted values of each models for cellular connections

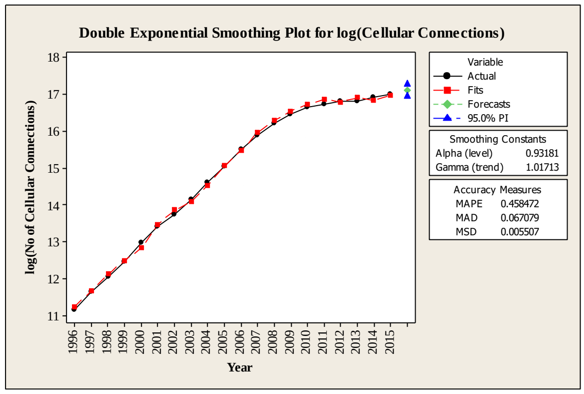
Table 4. ARIMA models for series of Cellular connections

Series	Model	Coef.	SE	P-value
Original series	ARIMA(0,1,2)	-0.5228	0.2332	0.0390
		-0.8786	0.2332	0.0020
	ARIMA(1,1,0)	0.9125	0.1223	0.0000
Log series	ARIMA(0,1,2)	-1.5229	0.1762	0.0000
		-0.9361	0.1710	0.0000

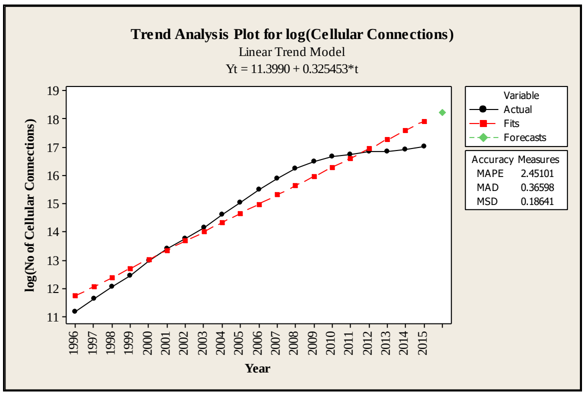
Plot of fitted values from selected models and observed values of log transformed cellular connections are given in Figure 5. It is clear that DESM and ARIMA (0,1,2) fit data well with compared to other models.



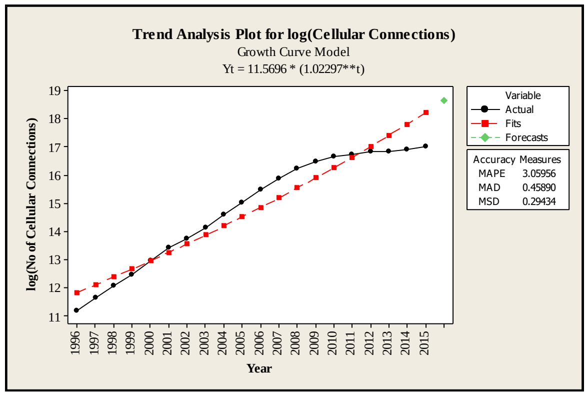
(a) SESM



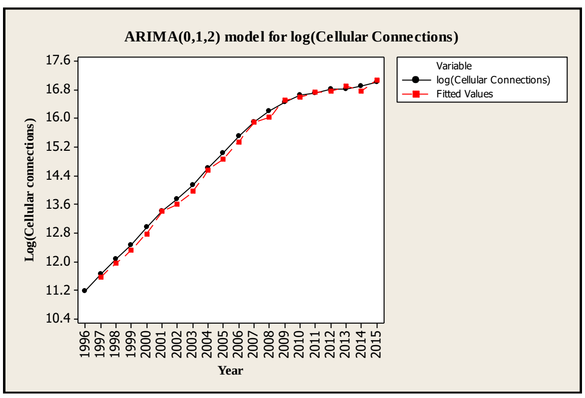
(b) DESM



(c) LTM



(d) GCM



(e) ARIMA (0,1,2)

Figure 5. Plot of observed and fitted values of each model for log (cellular connections)

Based on the most suitable models, predictions were made for year 2016. Forecasted values from each selected model, forecasting error as a percentage and 95% confidence intervals are given in the Table 5.

Table 5. Forecasted values of selected models

Series	Selected Model	Predicted value	Prediction Error (%)	95% Confidence Interval of Predicted Value
Internet	DESM	5 495 397	-11.6723	(5 244 135, 5 746 659)
	ARIMA(0,1,2)	4 221 454	14.2155	(3 718 076, 4 724 833)
log(Internet)	DESM	5 877 252	-19.4321	(3 569 728, 9 676 395)
	ARIMA(1,1,1)	5 726 413	-16.3669	(3 541 638, 9 258 012)
Cellular	DESM	27 394 084	-4.4459	(26 386 874, 2 840 129)
	ARIMA(0,1,2)	26 141 188	0.3309	(24 246 010, 2 836 366)
log(Cellular)	DESM	26 923 228	-2.6507	(22 844 021, 31 734 024)
	ARIMA(0,1,2)	25 610 167	2.3556	(20 075 284, 32 667 785)

According to the prediction error corresponding to year 2016, DESM gives the minimum error of prediction for series of internet, while ARIMA (1,1,1) model gives a higher error. In case of cellular connections, ARIMA (0,1,2) model fitted for original form of data gives the minimum while ARIMA (0,1,2) model fitted for log (cellular connections) gives relatively a lager error.

4. Discussion

This study aimed to find a suitable statistical model that fit well with number of internet connections and number of cellular connections. Several models were evaluated for original and log transformed data of these series. With compared to models fitted for original form of data of both internet and cellular connections, models fitted for log form of data performed well.

There is an increasing trend in usage of both internet and cellular phones during the period from 1996 to 2015. However, there is a rapid growth in usage of internet after year 2009 while a rapid development in cellular phone can be seen after years about 2003, 2004. Model ARIMA (1,1,1) fitted for log transformed data can fit the behavior of the series of internet connections and this model can be used for the predictions. In addition to this model, double exponential smoothing model, fitted for log-transformed data with alpha of 0.8725 and gamma of 0.6144, also can explain data well.

Fluctuations of series of cellular connections could be explained by using ARIMA (0,1,2) model with log transformation. As an alternative model, double exponential smoothing model with alpha of 0.9318 and gamma of 1.0171 also could be used for prediction with log-transformed data.

In selecting the best model, it is necessary to compare accuracy measures of each model fitted for data in different forms (original form and log form). Model that gives the minimum for those measures, is supposed to be the best. Models fitted for log-transformed data, produced small values for summary measures. Then, it was difficult to make comparisons with the summary measures of models fitted for original data, which are large. Parallel to the accuracy measures, prediction errors also should be taken into account in selecting a model. However, in this study, priority was given to the accuracy measures mentioned above because they are on averages and forecasting error in Table 5 is a just single value.

Since there are some similarities in trends of these two series, there seems to be a possibility for multivariate approaches such as multivariate regression, and vector autoregressive models. They are to be evaluated at the next step.

5. Conclusions

During this period concerned, usage of internet connections has increased from 4 110 to 4 921 000, while the usage of cellular phones has gone up from 71 228 to 26 228 000. After 2009, a significant growth in internet usage could be observed, while usage of cellular phone has increased rapidly after year 2003. Among all models considered, models fitted for log transformed data show better performances. ARIMA (1,1,1) model fitted for log transformed data showed the best performance in prediction of internet connection, while ARIMA (0,1,2) model fitted for log transformed data showed the best fit for series of cellular connections. Double exponential smoothing models also show better fit for both series.

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