RASHI 1 (2) :7-15 (2016)

Web ECGR: Web Solution for Estimation of Compound Growth Rates using Parametric and Nonparametric Methodologies

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ABSTRACT

Compound growth rate is a key indicator of agricultural growth in terms of production or productivity. It has major implication in formulating import and export policy of agricultural commodities of a country. The procedures for estimating this growth rate include both parametric and nonparametric methodologies which are quite complex to comprehend and compute. However, there is no ready- made statistical software which can be used to solve this purpose. Towards this direction, a user-friendly online application WebECGR has been developed in mitigating this challenge. This web-based solution is developed using Microsoft's ASP.NET technology combined with statistical software R. It is available through internet with web-address http://www.iasri.res.in/cgr. This website provides some easy-to-follow steps to compute compound growth rates with minimum user intervention. A comprehensive step-by-step guideline is provided for the users to ease out the computational procedure. Provision is also kept to enquire doubt regarding this application at any point of time.

Keywords: ASP.NET, Nonparametric, Parametric, R software, statconnDCOM, WebECGR.

1. Introduction

Compound growth rate is a key indicator to measure agricultural growth and can be used for forecasting production, productivity, area, *etc*. of various commodities. This, in turn, plays a vital role in framing optimal agricultural policies, like import and export policies for various agricultural commodities.

Prajneshu and Chandran (2005) described the procedure to estimate the compound growth rates by using some realistic nonlinear growth models, *viz*. monomolecular, logistic and Gompertz models which consist of parameters having certain biological interpretations. Apart from these, there exists some more advanced parametric non-decreasing nonlinear growth models, like Richards model and mixed-influence model which have been employed in the present study to estimate the compound growth rate. For non-monotonic situations, the growth models which are suitable in capturing the scenario are over-damped, under-damped and critically-damped models based on a second-order homogeneous differential equation (Gilligan, 1990). In case of increasing and decreasing behaviour of the response variable over the time-period as this scenario is prevalent particularly in the field of agriculture in terms of production/ productivity *etc*., nonparametric methodologies are found most suitable in estimating the compound growth rates. In nonparametric estimation procedure, there can be two separate approaches *viz*. time domain (Chandran and Prajneshu, 2004, Ray and Tsay, 1997) and state domain (Fan and Gijbels, 1996).

The algorithms of the methodologies discussed above, are complex in nature, particularly the nonparametric ones. Moreover, there is no provision in the software presently existing, to estimate the compound growth rates directly. It is therefore needed, to comprehend the underlying statistics first and then to develop algorithms to come out with the computer program to estimate this growth rate. This is a cumbersome process in addition to the complicacies associated with developing such algorithms and computer program as well. A way out to resolve this issue is WebECGR, a complete user-friendly online application which has been developed integrating ASP.NET, a Microsoft tool for creating web application with statistical software R.

2. MATERIALS AND METHODS

Web ECGR Architecture and Requirements:

WebECGR is accessible over the internet through web address *http://www.iasri.res.in/cgr*. This web-based solution has been developed employing ASP.NET with .NET Framework Version 4.0 (Walther *et al.*, 2011) using programming language C#. The statistical software *R for Windows 2.15.2* has been integrated into .NET environment by using noncommercial version of *statconnDCOM3.5-1B2*. statconnDCOM is a server which allows to seamlessly integrate R into other applications. In the present study, a R package *rscproxy* has been used in the statconn (D)COM Server. Here R is used as background engine to perform all the statistical computations using the DCOM technology (Baier and Neuwirth, 2007). WebECGR is hosted from the server having Internet Information Services (IIS) installed in it. The other prerequisites for running this web

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application include R software, statconn DCOM Server and .NET Framework, version 4.0. statconnDCOM implements StatConnectorSrv, which is a (D)COM server which allows any COM client (C# programs here) to access R as a computational engine. The following references have been added in the ASP.NET application, as well as these namespaces in the class: *STATCONNECTORCLNTLib*, *Stat Connector CommonLib* and *STATCONNECTORSRVLib*. The only requirement at the client side is a web-browser.

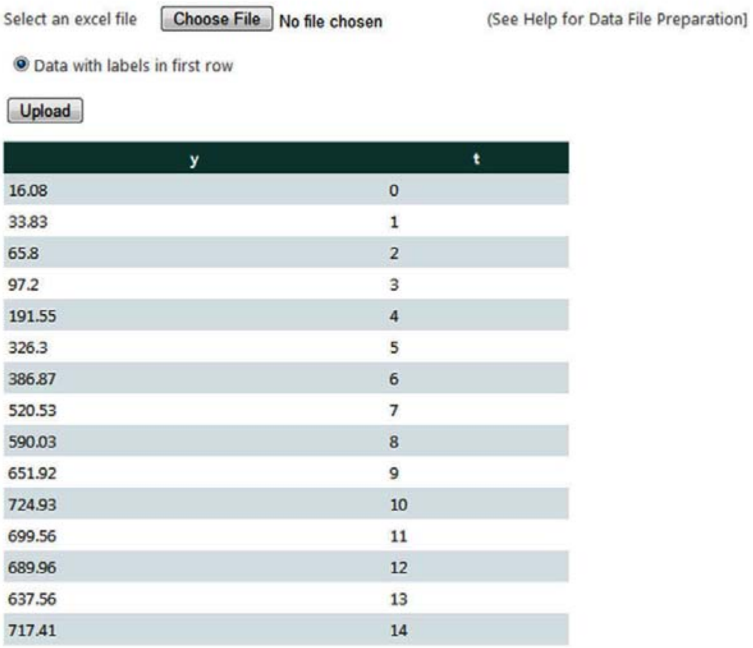
Functionalities and Description of WebECGR

In WebECGR, R function nls() (Ritz and Streibig, 2008) has been used to obtain nonlinear least-squares estimates of the parameters of nonlinear growth models. In this function, Gauss-Newton algorithm has been used to solve the nonlinear least squares estimation problem. For the nonparametric methodologies, individual programs have been written in R for statistical analysis and those programs have been entangled into .NET environment using C# programming language.

WebECGR package is comprised of the following web pages: Home, About WebECGR, Analyze, Help, Sample Data, Disclaimer and Contact Us. WebECGR home page is shown in Fig. 1.

Fig. 1 : Home Page of WebECGR

The general information about WebECGR is described in 'About WebECGR' page. The compound growth rates can be estimated in the 'Analyze' tab of WebECGR. At first, users need to provide data for the analysis in the .xls or .xlsx format to be uploaded into the website and shown in Fig. 2. The uploaded data are represented through a graph (Fig. 3) so that users can have an idea about pattern of the data. To estimate compound growth rate, either 'Parametric' or 'Nonparametric' methodology is to be selected. On selection of parametric, a panel which depicts all the nonlinear growth models along with the respective growth curve is appeared (Fig. 4). To estimate compound growth rates, the following parametric growth models are available in WebECGR: i) 3-parameter model: Monomolecular, Logistic, Gompertz and Critically-damped models, ii) 4-parameter model: Richards, Mixed-influence, Under-damped and Over-damped models. Users need to select the number of parameters and the growth model from the drop down list. Also, the initial parameter values are to be given by the user (Fig. 4).



Select an excel file Choose File No file chosen (See Help for Data File Preparation)

Data with labels in first row

Upload

y	t
16.08	0
33.83	1
65.8	2
97.2	3
191.55	4
326.3	5
386.87	6
520.53	7
590.03	8
651.92	9
724.93	10
699.56	11
689.96	12
637.56	13
717.41	14

Fig. 2 : Uploading of data into WebECGR

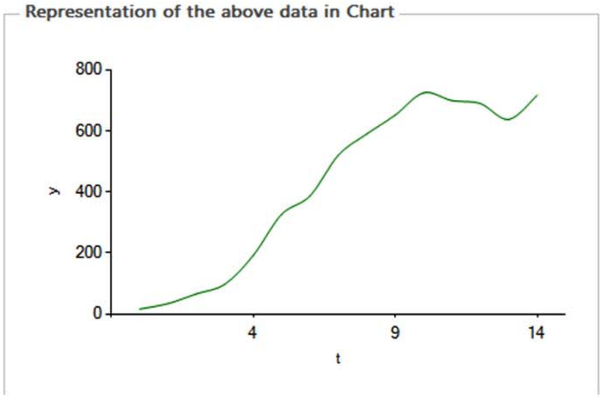


Fig. 3 : Representation of data into chart

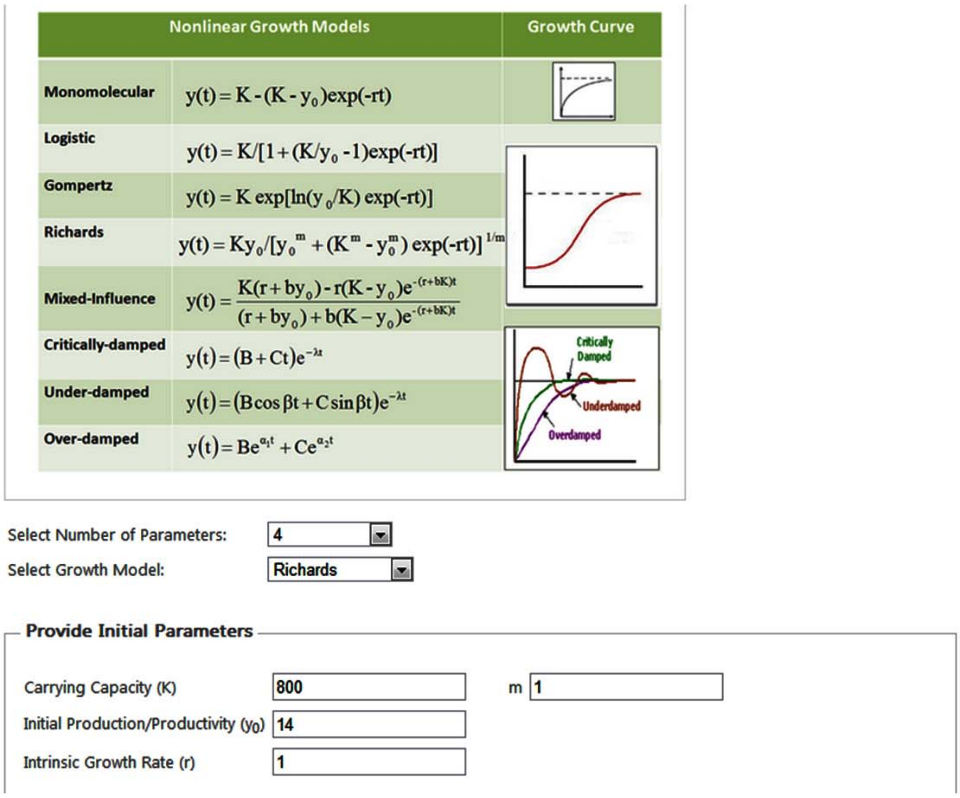


Fig. 4 : Selection of model and parameter value initialization

3. RESULTS AND DISCUSSION

After data uploading and selection of model with the given initial parameter values, compound growth rate is estimated by pressing the 'Estimate Compound Growth Rate' button and the results are displayed in the same web page. This page also provides the results of several statistical computations related to growth rate estimation through tabular and graphical representations. In case of parametric growth rate estimation, the following tables are generated as shown in Fig. 5: i) A table containing the parameters of the growth model along with their estimates and standard errors. ii) An ANOVA table having sources of variances, their sum of squares, corresponding degrees of freedom and mean square values. iii) A table consisting of observed, estimated and residual values of the response variable at different time points.

A run test is performed to check assumption of independence of residuals. A graph is also generated to plot the observed values along with the estimated fitted line as depicted in Fig. 6. Another table containing the annual compound growth rates at different time points is also populated and shown in Fig. 7.

Estimate Compound Growth Rate

Estimated Compound Growth Rate is: 25.556%

Statistical Computations

Parameter Estimates

Parameter	Estimate	Std. Error
K	699.6488	16.3113
y_0	20.2924	10.7267
r	0.7593	0.1956
m	1.2782	0.6876

ANOVA

Source	Sum of Squares	df	Mean Squares
Regression	3,755,417.7610	4	938,854.4403
Residual	8,793.1743	11	799.3795
Uncorrected Total	3,764,210.9347	15	
Corrected Total	1,076,442.1866	14	

Dependent Variable: y

t	Observed y	Estimated y	Residuals
0	16.0800	20.2924	-4.2124
1	33.8300	36.4057	-2.5757
2	65.8000	64.6319	1.1681
3	97.2000	112.3389	-15.1389

Fig. 5 : Tabular output using parametric growth model

13	637.5600	697.0788	-59.5188
14	717.4100	698.4435	18.9665

Run Test

	Residuals
Total Cases	15
Number of Runs	8
Z	0.018
Asymp. Sig. (2-tailed)	0.986

Assumption of independence of errors is not rejected at 5% level of significance

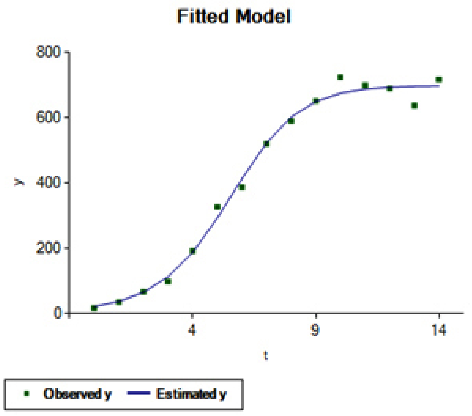


Fig. 6 : Run test and graph of fitted model using parametric growth model

Computation of compound growth rates

t	Annual compound growth rate
0	0.5893
1	0.5817
2	0.5651
3	0.5464
4	0.4806
5	0.3700
6	0.3155
7	0.1870
8	0.1163
9	0.0513
10	-0.0276
11	0.0001
12	0.0105
13	0.0665
14	-0.0193
	Average of annual compound growth rates: 0.25556

Fig. 7 : Annual compound growth rates using parametric growth model

Under nonparametric methodology, the following procedures are available to estimate the compound growth rates: i) Time Domain and ii) State Domain. Under time domain, any of the techniques *viz*. 'Moving Average: Cross Validation', 'Moving Average: Bootstrapping', 'Kernel Smoothing' (under Dependent Error) and 'Local Linear Smoothing' (under Dependent Error) can be used. The optimal bandwidth under state domain smoothing is estimated using cross validation technique.

The output, obtained by using nonparametric methodology consists of the following: i) A table consisting of observed, estimated and residual values of the response variable at different time points as shown in Fig. 8. ii) A graph to plot the observed values along with the estimated fitted line as depicted in Fig. 9. iii) Another table containing the annual compound growth rates at different time points is also populated as shown in Fig. 10.

Nonparametric

Select Procedure: Time Domain

Select Technique: Moving Average:Bootstrapping

Estimate Compound Growth Rate

Estimated Compound Growth Rate is: 26.627%

Statistical Computations

t	Observed y	Estimated y	Residuals
3	97.2000	105.4148	-8.2148
4	191.5500	144.5702	46.9798
5	326.3000	270.7838	55.5162
6	386.8700	443.9901	-57.1201
7	520.5300	481.6356	38.8944
8	590.0300	603.6334	-13.6034
9	651.9200	659.9324	-8.0124
10	724.9300	688.6604	36.2696
11	699.5600	736.1628	-36.6028
12	689.9600	712.9532	-22.9932

Fig. 8 : Tabular output using nonparametric estimation procedure

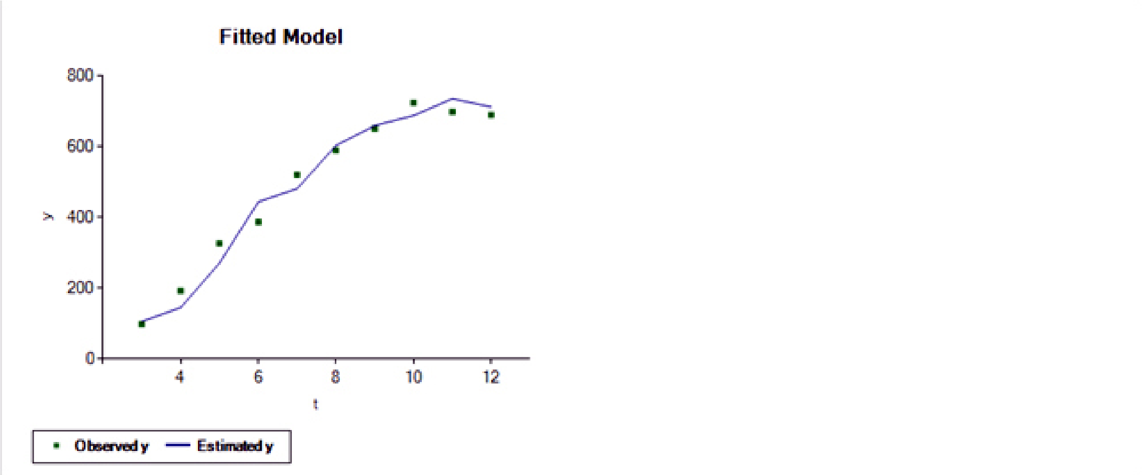


Fig. 9 : Graph of fitted model using nonparametric estimation procedure

Computation of compound growth rates

t	Estimated Compound Growth Rate
4	0.3714
5	0.8730
6	0.6396
7	0.0848
8	0.2533
9	0.0933
10	0.0435
11	0.0690
12	-0.0315
	Average of annual compound growth rates: 0.26627

Value of MSE: 1,356.5291
Value of MAE: 32.4207
Procedure and/or technique in which both MAE and MSE values are minimum is most appropiate among nonparametric methodologies in estimating compound growth rate for the data set currently in use provided the errors are distributed independently.

Fig. 10 : Annual compound growth rates using nonparametric estimation procedure

In WebECGR, 'Help' page (Fig. 11) guides users for preparing input data file as well as estimating compound growth rates by providing step-by-step procedures. A document comprising of the brief description of nonlinear growth models and parameter initialization for the models is available in the help section. This can be downloaded from the website into users' local machine. This document can provide guidance to the users regarding initial parameter values for the nonlinear growth models.

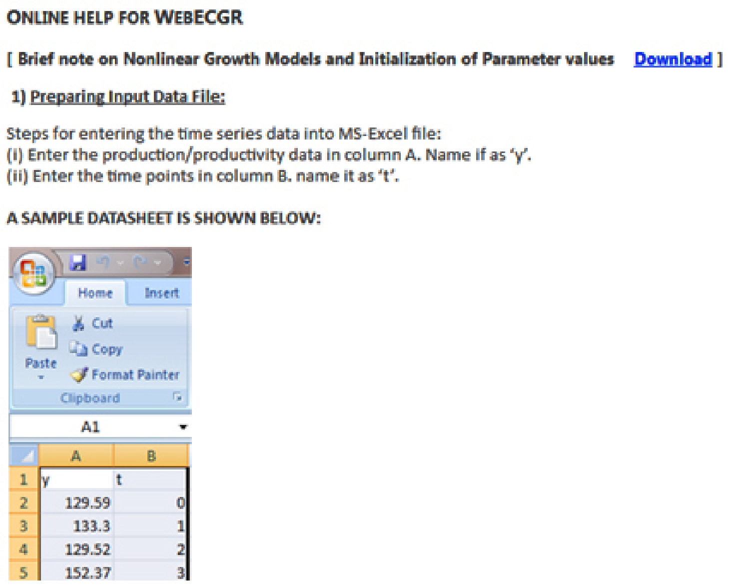
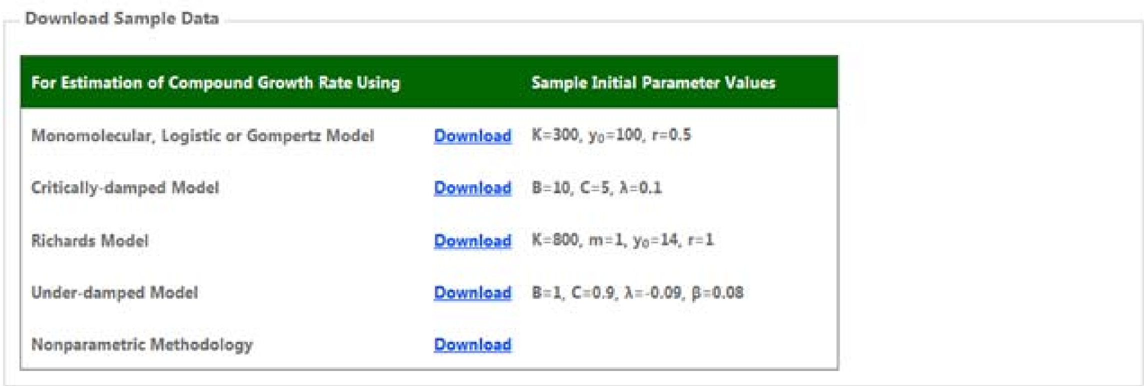


Fig. 11 : WebECGR Help Page

WebECGR has provision to download sample data for estimating the compound growth rates based on the datasets in the 'Sample Data' page (Fig. 12). Initial parameter values corresponding to the growth models have also been mentioned along with these sample datasets.


Download Sample Data

For Estimation of Compound Growth Rate Using		Sample Initial Parameter Values
Monomolecular, Logistic or Gompertz Model	Download	K=300, y_0=100, r=0.5
Critically-damped Model	Download	B=10, C=5, λ=0.1
Richards Model	Download	K=800, m=1, y_0=14, r=1
Under-damped Model	Download	B=1, C=0.9, λ=-0.09, β=0.08
Nonparametric Methodology	Download	

Fig. 12 : 'Sample Data' Page

Users can get the email id of the concerned person related to this web application in 'Contact Us' page. In case of any query related to WebECGR package, users may send email to the development team. There is also a disclaimer page in WebECGR which provides general guidelines for using this web application.

4. CONCLUSION

WebECGR is an online application to estimate compound growth rates employing both parametric and nonparametric methodologies. This web solution offers a user-friendly interface for its easy operability. It requires minimum level of user intervention to get the output with no computational effort. Agricultural scientists and policy makers can effectively use this web application to obtain research output and decide policy matter respectively. There is ample scope of incorporating new methodologies for estimating the compound growth rates into this system in future also.

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