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Modeling the Growth of Food Science and Technology Literature in India

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Abstract

Purpose: The purpose of the research paper is to find the most appropriate growth model in the field of Food Science and Technology in India.

Design/Methodology/Approach: The Growth rate functions α1 and α2 methodology suggested by Egghe and Rao.

Findings: The research shows that Growth of the Food Science and Technology Literature is viable in terms of Publications as well as in Citations.

Research Limitations/ Implications: The research area is limited to Food Science and Technology area in India only.

Originality/Value: The growth rate functions in the field of food science and technology particularly in India is not performed earlier.

Keywords: Scientometrics; Growth Modeling; Growth Rate Functions; Food Science and Technology

1. Introduction

Today India is not only self-sufficient but also exports food and has a reserve because of advances in Food technology. "During the last decade many indigenous developments have taken place in the field of food technology reducing dependence on imported know- how. During these years increased industrialization and its social consequences accelerated the development of food technology. As a result, food industries took birth and shape. Food processing is generally regarded as a traditional industry but advances in microelectronics, instrumentation and control, new materials, bioprocessing and biotechnology beginning to propel the industry at a faster rate"(Srilakshmi, 2006). In present scenario, Indian's food ecosystem offers huge opportunities for investment with growth in food retail sector. "The Government of India through the Ministry of Food Processing Industries (MoFPI) is also taking all necessary steps to boost investments in the food processing industry. The government has sanctioned 42 Mega Food Parks (MFPs) to be set up in the country under the Mega Food Park Scheme. Currently, 17 Mega Food Parks have become functional."(Investindia.gov.in)

2. Review of Literature

Many studies have been carried out to study the best of fit of growth models and some of the prominent studies are mentioned here: Calvino (2006) examined 48 journals of Iberian American (IA) countries in the food science and technology field indexed in Science Citation Index and identified the different patterns of collaboration and growth rate. Zhou et.al. (2013) investigated international collaboration between China and the UK in food and agriculture. They have create new method i.e. Integrated Impact Indicator (I3) to evaluate publication impact. Morooka and Nathaniel (2014) focused on the structure of interdisciplinary in Japanese rice research by using compiled bibliography on Japanese rice which consists of 19389 articles in 1611 journals for the period of 1990-2000. They depicted relationship among disciplines by the frequency distribution of articles among journals based on the law of scattering, identified by Bradford. Seetharam and Rao (1999) tried to trace and compare the growth trends in Food Science and Technology literature produced by Indian

as well as world food scientist for the period between1950 and 1990. They have tried to identify the best fitting growth models, t t and t~2t analysis and compare growth rates.Sharma, Gupta and Kumar (2002), discussed the application of growth models in physics, chemistry, and electrical and electronic engineering research from the international databases of the fields for the period of 1907-1994, using the growth rate functions suggested by the Egghe and Rao.Sangam, Liming and Ganjihal (2010), described the application of growth models in the field of liquid crystals research of Indian and Chinese publications for the period of 1997-2006. The results obtained from the statistical fit of growth models reveals that the power and growth models are fit for the growth of Indian publications and Linear, power and growth models are applicable for the Chinese liquid crystals literature. Gururaj and Gavisiddappa (2015), studied the growth of neurology literature for the period of 1961-2010 on the 291702 records reflected from the Science Direct, using Relative Growth Rate (RGR) and Doubling Time (Dt) to check the growth model of neurology literature. The results shows that neurology literature fits closely to exponential growth model. Gupta, Kumar and Sangam (2002), conducted a study to find the application of growth models in the disciplines of social science namely anthropology, economics, history, political science, psychology, and sociology in the world and to verify the criteria for selecting the most appropriate growth model suggested by Egghe and Rao. They concluded from the study that power model followed by logistic model are describing the best the cumulative growth of publications in the sub disciplines of social science. The study also reveals that growth rate functions methodology supports the results obtained by from the actual applications of models to some extent. Nayak and Bankapur (2017), mapped the growth of the literature published from 1930 to 2016 on agriculture in global and national levels using various scientometric indicators such as Relative Growth Rate (RGR), Doubling time (Dt), Skewness, Kurtosis, Regression, along with different growth models to check the most appropriate growth model of the literature. The results of the study revealed that the world agriculture literature follows the linear and exponential growth model.

3. Objectives of the Study

The study is carried out to achieve the following objectives of the study:

(i) To find out the pertinence of the growth models to the growth of Indian publications in the area of food science and technology;

(ii) To verify the basis for selecting the most appropriate growth model from linear, logistics and exponential growth model.

4. Methodology

Web of Science is a core collection of Social Science Citation Index, Science Citation Expanded Index, and Humanities Index. The current study restricted its search strategy to Science Citation Expanded Index with a time frame of 1989-2018 and used subjectWC= Food Science & Technology AND CU= India. The search is refined by excluding DOCUMENT TYPES: (CORRECTION OR LETTER OR BOOK CHAPTER OR EDITORIAL MATERIAL OR RETRACTED PUBLICATION OR BOOK REVIEW OR NOTE OR MEETING ABSTRACT OR REPRINT OR SOFTWARE REVIEW OR PROCEEDINGS PAPER.There are other databases dedicated to Food science and Technology i.e. FASTA but instead of that WOS was chosen because the coverage of WOS is much more than FASTA and it covers all the journals which are covered by FASTA as well. Moreover in WC, the field Food Science and Technology is clearly defined. The search was conducted on 12th September 2019 and it produces 16255 data results. The data has been download in excel sheet for further analysis. The analysis have been carried out by using SPSS IBM 22.

The methodology suggested by Egghe and Raofor growth modelsapplied on the data in terms of growth of references on a specific topic, and to identify the model explaining the growth of literature, references by using growth rate functions i.e. α1 and α2 (as proposed by Egghe and Rao,1992). Later the values of two growth rate functions to find the best suitable model of the study. Table 1 is describing the classification of growth models based on the first growth rate function i.e. α1 and second growth rate functions i.e. α2. In order to get the best growth model; growth rates are visualized in terms of classification types, Type-1 increasing; Type-2 constant; Type-3 decreasing; and Type-4 increasing and then decreasing as shown in Table 1.

Table 1: Classification of mathematical growth models based on growth rate functions

Type of model	First growth rate function	Second growth rate function
Exponential	Type II	Type I
Logistic	Type III	Type IV
Power (a>0, 0<b≤1)	Type III	Type I
Power(a>0, b>0)	Type IV	Type I
Power(a=0)	Type III	Type II

Type I=Increasing; Type II=Constant; Type III=Decreasing; Type IV=Increasing then Decreasing.

5. Data Analysis

5.1 Growth Modeling of Publications of Food Science and Technology

Table 2 describes the growth of literature of Food science and Technology using two growth rate functions given by Egghe and Rao (1992) during the period of 1989-2018. Two growth rate functions are α1 and α2, where α1(t) is the first growth rate functions which demonstrates the growth rate after each year and α2(2t) is the second growth rate function which compares the growth after double time period (from t to 2t period).

$\alpha1(t) = f(t+1)/f(t)$

$\alpha2(t) = f(2t)/f(t)$ for t = 1,2,3,4

The relation between α1 and α2 is given by the following equation:

α2 (t) = α1 (2t-1) α1 (2t-2).....α1(t)…..

If there are in total N observations (i.e. t=0, 1, 2, 3,…), there would be N-1 values for α1 and N/2 values for α2.

Table 2: Growth of Literature of Food Science and Technology in terms of Publications

S.No.	Year	Number of Publications	Cumulative number of publications	α1	α2
1	1989	211	211		
2	1990	213	424	2	2
3	1991	211	635	1.49	
4	1992	230	865	1.36	2.04
5	1993	237	1102	1.27	
6	1994	225	1327	1.2	2.08
7	1995	216	1543	1.16	
8	1996	226	1769	1.14	2.04

9	1997	263	2032	1.14	
10	1998	287	2319	1.14	2.1
11	1999	309	2628	1.13	
12	2000	337	2965	1.12	2.23
13	2001	349	3314	1.11	
14	2002	371	3685	1.11	2.38
15	2003	409	4094	1.11	
16	2004	458	4552	1.11	2.57
17	2005	469	5021	1.1	
18	2006	572	5593	1.11	2.75
19	2007	698	6291	1.12	
20	2008	658	6949	1.1	2.99
21	2009	689	7638	1.09	
22	2010	804	8442	1.1	3.21
23	2011	795	9237	1.09	
24	2012	791	10028	1.08	3.38
25	2013	830	10858	1.08	
26	2014	1077	11935	1.09	3.6
27	2015	1256	13191	1.1	
28	2016	975	14166	1.07	3.84
29	2017	1075	15241	1.07	
30	2018	1014	16255	1.06	3.97

It is observed from the table 2, figure 1 and figure 2 as well, that $\alpha 1$ is showing decreasing trend as it decreases till 1.06 in 2018 which is 2 in 1990 whereas $\alpha 2$ is showing increasing trend over the years. It indicates the suitability of Power model on the growth of food science and technology literature as it showing the $a>0$, $0<b\leq 1$, specifications. However all the three models i.e. exponential model, power model, and logistic model on observed data of the Food science and technology area, using curve estimation method. On the basis of Cumulated publications we have plot the graph figure 3,4 and 5 respectively for all the growth models i.e. Exponential, Logistics, and Power using SPSS IBM 22 version.

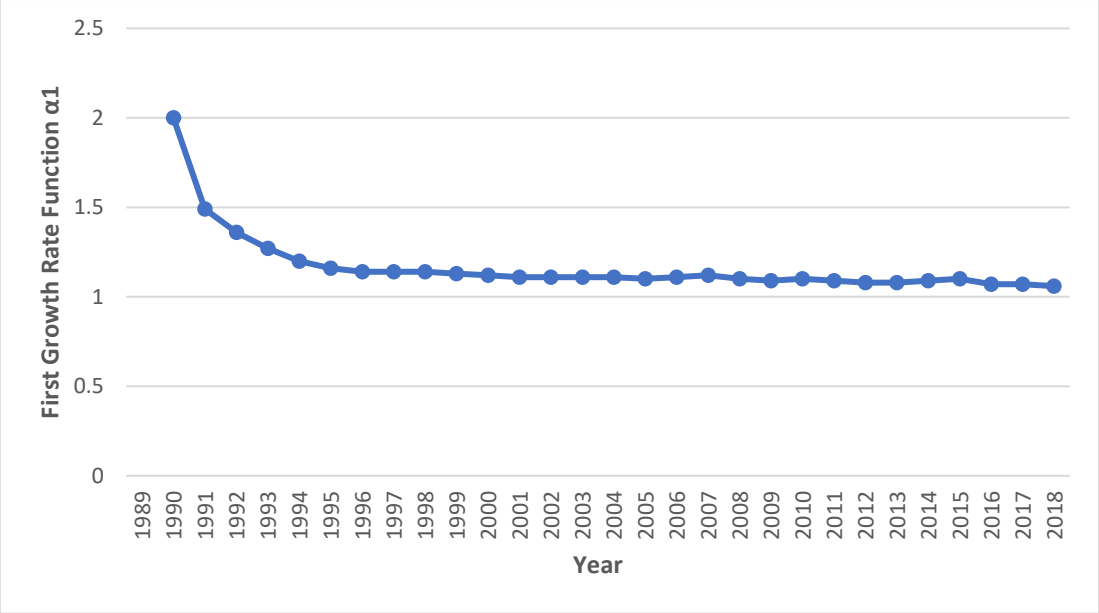

Figure1: Graphical Presentation of First Growth Rate Function for α1

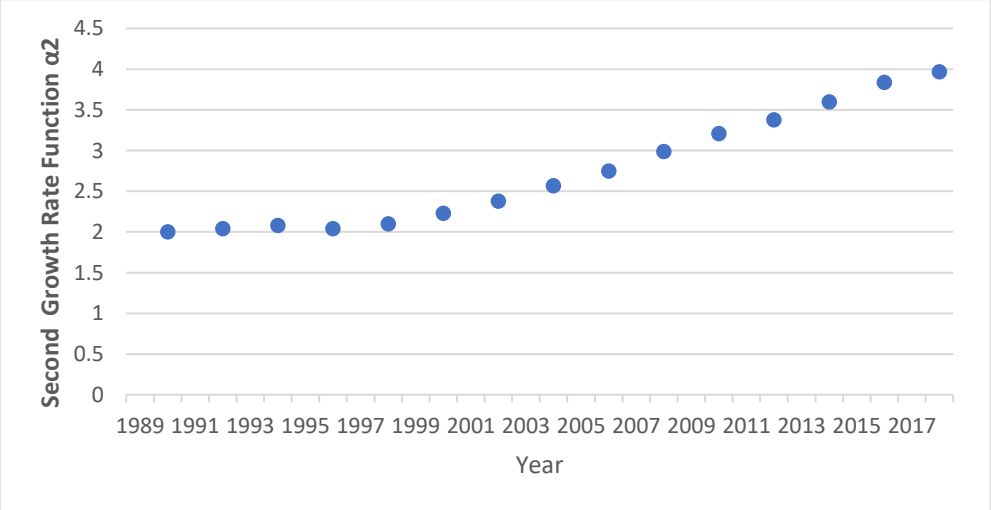

Figure 2: Graphical Presentation of Second Growth Rate Function for α2

Table 3: Parameter Values and Fit Statistics Obtained from Application of Various Growth Model on Food Science and Technology Literature

Model	Parameters values		Fit Statistics		Doubling Time
	a	***b***	R^2	***F***	
Exponential	2.40E-105	0.124	0.942	457.116	5 Years
Logistic	4.150E+104	0.883	0.942	457.116	
Power	0.000	249.187	0.943	463.350	

Table 3 depicts the parameter values and fit statistics obtained from the application of various growth models on Food Science and Technology Literature. The R^2 ,indicates the range of variation explained in the model, for Exponential, Logistics and Power growth

models is observed as 0.942,0.942 and 0.943 respectively. So, it can be observed from the values that the growth of the Food Science and Technology Literature can be explained from any of the mentioned models. However, Doubling Time is the period of time required for a quantity to double in size or value.

Doubling time and Relative Growth Rate has a direct relation between them.The Relative Growth Rate (RGR) is the increase in number of articles or pages per unit of time. Themean relative growth rate (R) over the specific period of interval can be calculated from the followingequation:

1-2R = LogeW2 – LogeW1/ T2-T1

Where,
1 - 2R – Mean relative growth rate over the specific period of interval
LogeW1 – log of initial number of articles
LogeW2 – log of final number of articles after a specific period of interval
T2-T1 – Unit difference between the initial time and the final time

RGR= (t2-t1) = ln(16255)- ln (211)/ 29-0
= 0.14
Dt = ln(2)/ R
= 0.693/0.14
= 4.95 ~ 5 years
The computed value of Doubling Time indicates that 5 years is an approx. time period required to double the literature in the area of Food Science and Technology.

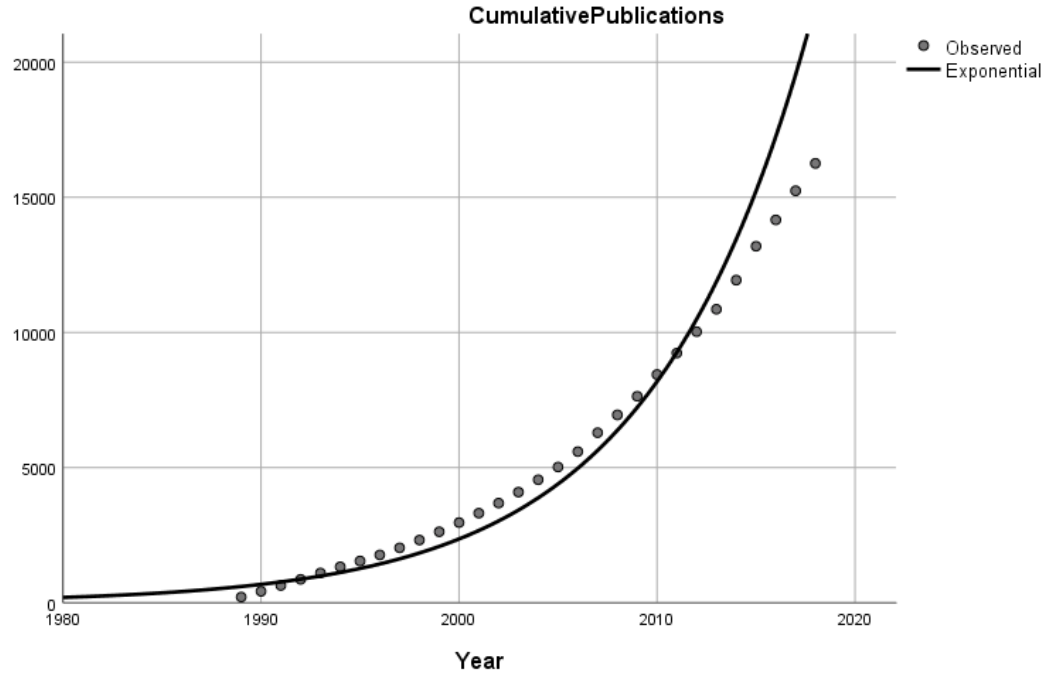

Figure 3: Exponential Curve Estimation for the Cumulative Publications of Food Science Literature

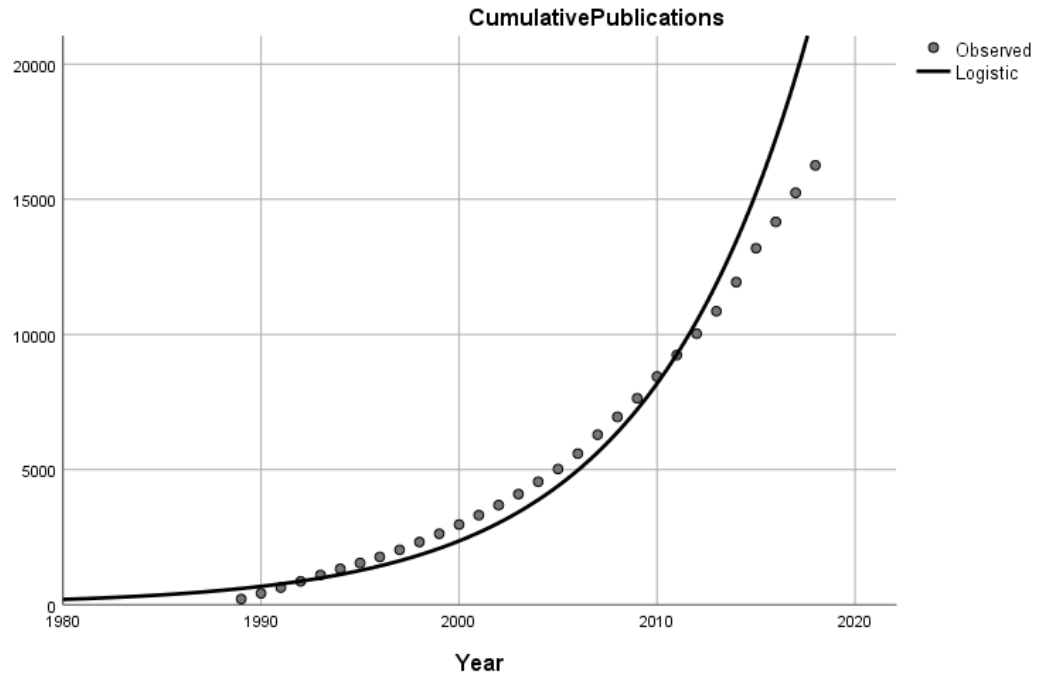

Figure 4: Logistics Curve Estimation for the Cumulative Publications of Food Science Literature

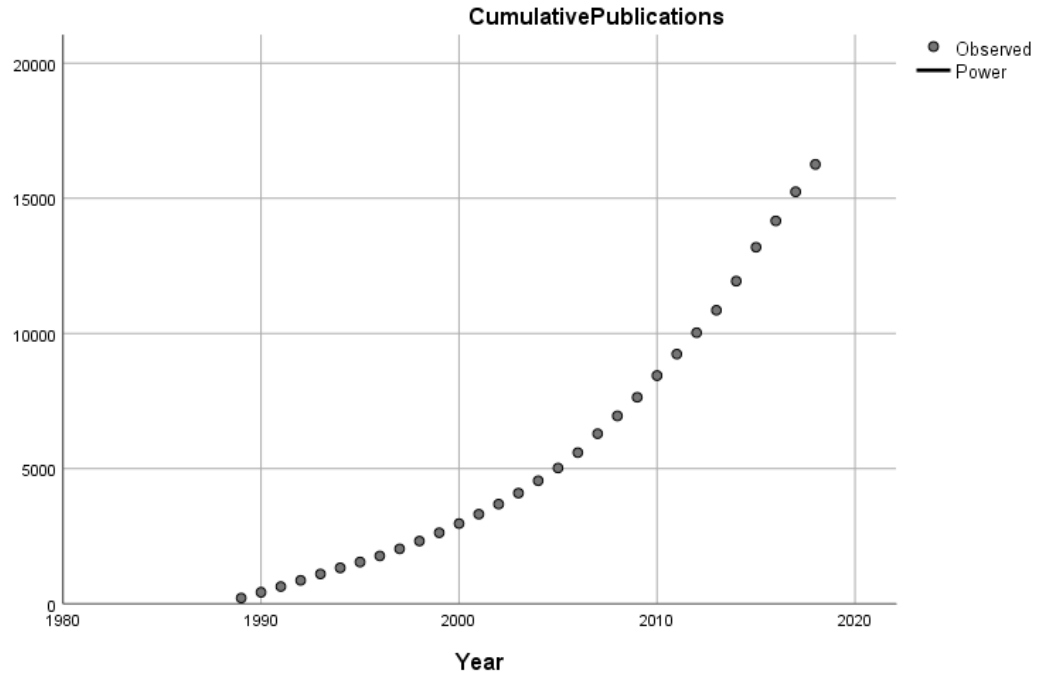

Figure 5: Power Curve Estimation for the Cumulative Publications of Food Science Literature

5.2 Growth of Citations

Table 4: Growth of Citations in Food Science and Technology

S.No.	Year of Publications	Number of Citations	Cumulative Number of Citations	α1	α2
1	1989	2479	2479		
2	1990	2085	4564	1.84	1.84
3	1991	2250	6814	1.49	
4	1992	2241	9055	1.32	1.98
5	1993	2446	11501	1.27	
6	1994	2534	14035	1.22	2.05
7	1995	2586	16621	1.18	
8	1996	3388	20009	1.2	2.2
9	1997	3948	23957	1.19	
10	1998	4442	28399	1.18	2.46
11	1999	5224	33623	1.18	
12	2000	4894	38517	1.14	2.74
13	2001	7841	46358	1.2	
14	2002	9239	55597	1.19	3.34
15	2003	10076	65673	1.18	
16	2004	10674	76347	1.16	3.81
17	2005	11422	87769	1.14	
18	2006	15375	103144	1.17	4.3
19	2007	20594	123738	1.19	
20	2008	13856	137594	1.11	4.84
21	2009	15155	152749	1.11	
22	2010	17576	170325	1.11	5.06
23	2011	15859	186184	1.09	
24	2012	14312	200496	1.07	5.2
25	2013	12329	212825	1.06	
26	2014	13239	226064	1.06	4.87
27	2015	13444	239508	1.05	
28	2016	8336	247844	1.03	4.45
29	2017	4904	252748	1.01	
30	2018	2373	255121	1	3.88

It is observed from the table 4, figure 6 and figure 7 as well, that α1 is showing decreasing trend as it decreases till 1 in 2018 whereas α2 is showing increasing trend over the years, as it reaches to 3.88 in 2018. It indicates the suitability of Power model on the growth of food science and technology literature as it showing the $a>0$, $0<b\leq 1$, specifications. However all the three models i.e. exponential model, power model, and logistic model on observed data of the Food science and technology area, using curve estimation method. On the basis of Cumulated Citations we have plot the graph figure 8, 9 and 10 respectively for all the growth models such as Exponential, Logistics, and Power using SPSS IBM 22 version.

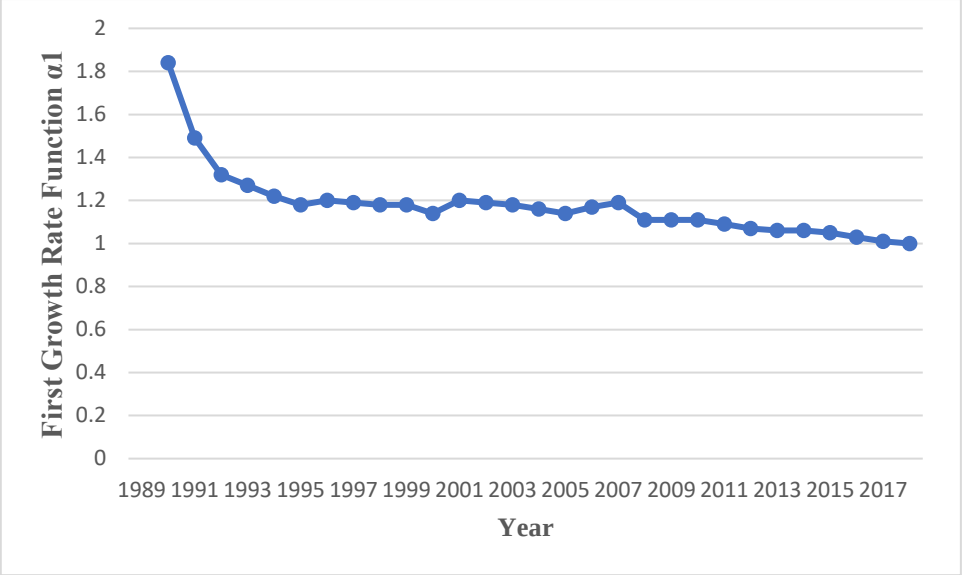

Figure 6: Graphical Presentation of First Growth Rate Function for α1

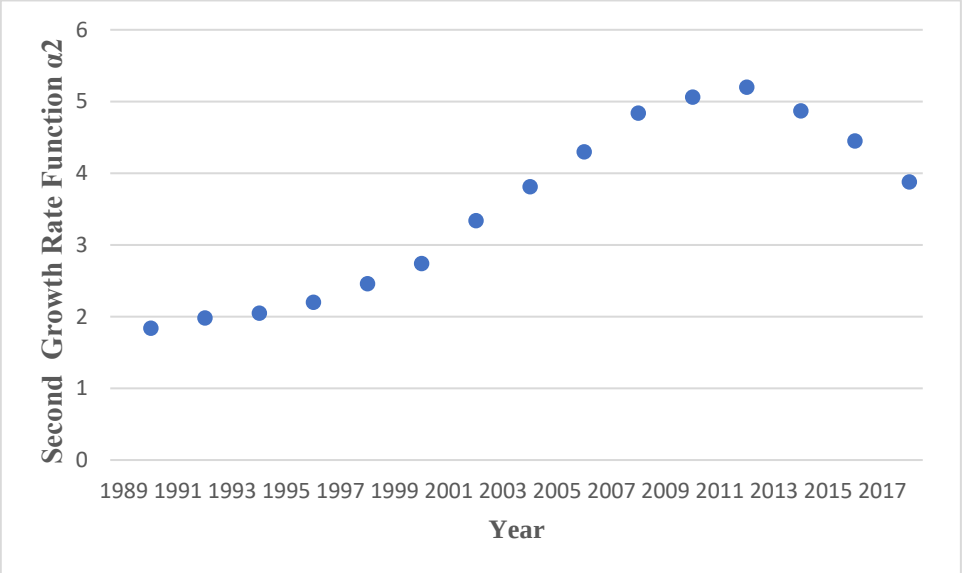

Figure 7: Graphical Presentation of Second Growth Rate Function for α2

Table 4: Parameter Values and Fit Statistics Obtained from Application of Various Growth Model on Food Science and Technology Literature Citations

Model	Parameters values		Fit Statistics		Doubling Time
	a	***b***	R^2	***F***	
Exponential	2.335E-125	0.49	0.948	515.320	5 Years
Logistic	4.283E+124	0.862	0.948	515.320	
Power	0.0000	238.002	0.949	523.980	

Table 4 depicts the parameter values and fit statistics obtained from the application of various growth models on Food Science and Technology Literature Citations. The R^2 ,indicates the range of variation explained in the model, for Exponential, Logistics and

Power growth models is observed as 0.948,0.948 and 0.949 respectively. So, it can be observed from the values that the growth of the Food Science and Technology Literature Citations can be explained from any of the mentioned models. However, Doubling Time is the period of time required for a quantity to double in size or value, which is observed as 5 years of the studying data.

RGR= (t2-t1) = ln (255121)- ln(2479)/ 29-0
= 12.44- 7.81/29
= 0.15

Doubling Time = ln(2)/ R
= 0.693/ 0.15
= 4.62~ 5 Years

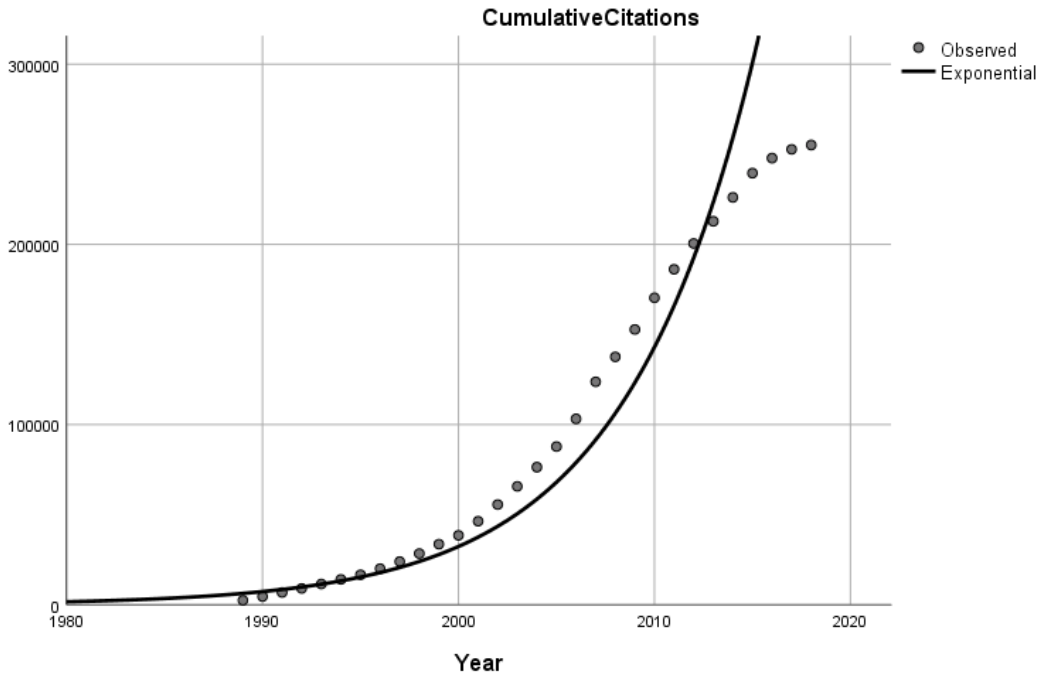

Figure 8: Exponential Curve Estimation for the Cumulative Publications of Food Science Literature Citations

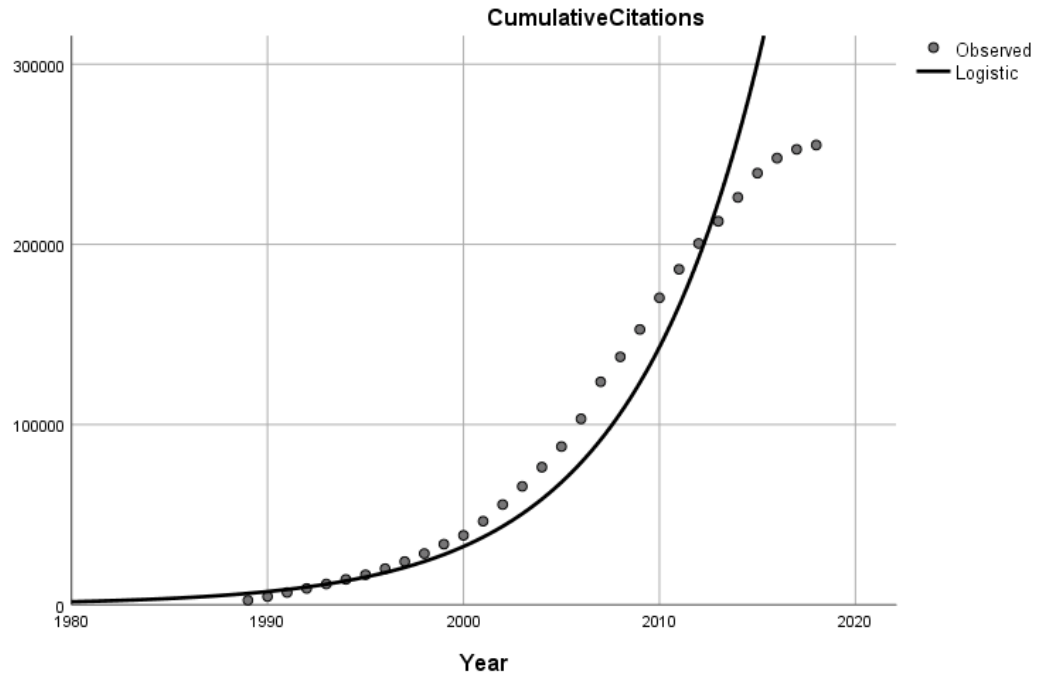

Figure 9: Logistic Curve Estimation for the Cumulative Publications of Food Science Literature Citations

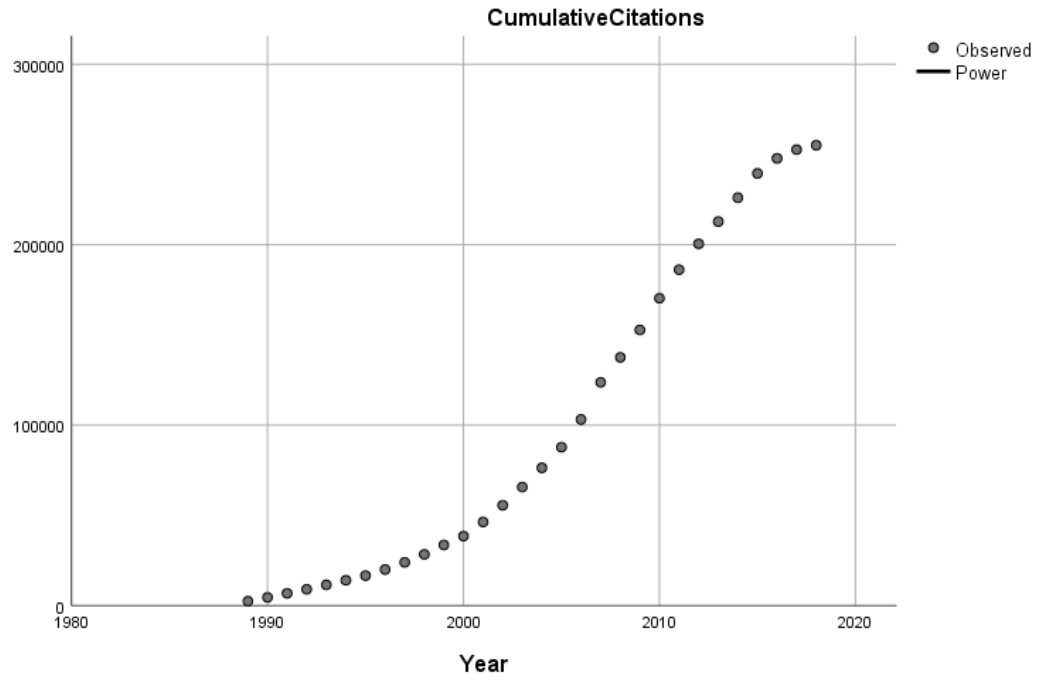

Figure 10: Power Curve Estimation for the Cumulative Publications of Food Science Literature Citations

6. Conclusion

The Modeling of growth study is been done to identify the nature of the growth of literature in any particular field by using various growth models such as Exponential, Logistics, and Power. Growth Rate functions methodology using $\alpha 1$ and $\alpha 2$ devised by Egghe and Rao (1992) which is derived by using mathematical formula. Although this methodology is not upto the mark to explain the best fit of the model but till date it is following. There is a need of more analysis to determine the methodology for the best fit model for any literature. The present study is carried out to determine the best fit model in the field of Food Science and Technology. It has been observed that in case of Publications as well as citations all the models can explain the growth of literature and citations. So, it can be concluded that there is viable growth in the Food Science and Technology field.

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