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Performance of trend models of ginger production

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ABSTRACT

Ginger (Zingiber officinale) is a cash crop for small farmers, and its health benefits make it an important spice. In this study, we want to look at various trend models for ginger production over time and see how they perform. Data for ginger production in Bangladesh are gathered from the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) website from 1971 to 2020. We examine the performance of eight trend models using the coefficient of determination (R^2) and adjusted R^2. The maximum R^2 and maximum adjusted R^2 values have been found for both the compound and growth model. MAPE and MAD values are also used to assess the accuracy of fitted models. The value of MAPE and MAD for the estimated compound and growth model is same, which are 12.14% and 6057.54, respectively. Following statistical diagnostics, the compound and growth models were determined to be more appropriate for this dataset, with the compound growth rate of ginger production being 1.019 per year.

***Key Words**: Ginger production, Accuracy, Trend, MAPE and MAD.*

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I. Introduction

Since ancient times, ginger (*Zingiber officinale*) has been used as a medicine, herbal and a vital cooking spice worldwide (Nour and Yap, 2017). Ginger is a herbaceous plant native to Southeast Asia (Kumar et al., 2018 and Bijaya, 2018). As a folk medicinal plant, ginger has its application in Southeast Asia, Africa, China, India etc. (Bhatt et al., 2013). Ginger consumption benefits heart disease, cancer, high blood pressure, bacterial disease, obesity, blood sugar and osteoarthritis. Ginger is a low-cost, easily accessible herbal medicine that can easily replace rare and expensive chemical medications while posing fewer risks. Ginger is a widespread and widely used spice in Bangladesh. Furthermore, ginger production in Bangladesh was net 1.73 million tons in 2018-19, while demand was nearly three million tons, with imports accounting for 42 to 45 percent of the total (TBS, 2020). There are several reasons why ginger production in Bangladesh is low and those shortcomings must be identified for appropriate research outcomes and policy invocation. Smaller efforts to produce ginger may result in increased production. For sustainable ginger farming in Bangladesh, establishing an efficient marketing organization is necessary (Hasan et al., 2017). It has several varieties as a horticultural crop and farmers use them to produce ginger. The ginger market is extremely volatile, which may discourage farmers from producing ginger (Geta and Kifle, 2011). Ginger is a spice that is becoming more and more popular worldwide and in Bangladesh. Therefore, it needs to focus more on researching ginger production. About Bangladesh's production of ginger, very little literature has been discovered yet. Again no study compares trend models or assesses the accuracy of the model of ginger production in Bangladesh. In order to compare these models for the production of ginger in Bangladesh, we tried to research numerous trend models from literature for other crops that are available. Statistical diagnostics should be used to ensure that the fitted model is accurate. In this regard, we attempted to assess the dependability of various trend models. This research aims to compare different trend models and, based on their performance, determine the best trend model for ginger production in Bangladesh.

II. Materials and Methods

We used secondary datasets obtained from FAOSTAT (FAOSTAT, 2012). The dataset covers ginger production in Bangladesh from 1971 to 2020. In the literature, we have found various trend models (Gupta et al., 1999 and Wankhade et al., 2019). In this study, we have applied eight trend models for the dataset as logarithmic, inverse, quadratic, cubic, compound, power, S curve and growth model.

Trend Model

The eight trend models are as follows

1) Logarithmic trend model $Y_t = \alpha + \beta \log t_i + e_i$
2) Inverse trend model $Y_t = \alpha + \beta / t_i + e_i$
3) Quadratic trend model $Y_t = \alpha + \beta t_i + \beta t_i^2 + e_i$
4) Cubic trend model $Y_t = \alpha + \beta t_i + \beta t_i^2 + \beta t_i^3 + e_i$
5) Compound trend model $Y_t = \alpha \beta^{t_i} + e_i$
6) Power trend model $Y_t = \alpha t_i^{\beta} + e_i$
7) S-curve model $Y_t = e^{\alpha + \beta / t_i} + e_i$
8) Growth model $Y_t = e^{\alpha + \beta t_i} + e_i$

Here,
t is the time (in year) and
e_i is the error term.

Model Selection

To select model, we applied maximum R^2 (coefficient of determination) and maximum adjusted R^2 as the criteria of model selection (Imon, 2017).

Maximum R^2 $R^2 = 1 - \frac{SSE}{SST}$

Maximum Adjusted $R^2 = 1 - \frac{SSE/(n-k-1)}{SST/(n-1)}$

Where,

SST = total sum of squares
SSE = error sum of squares
n = number of observation
k = number of parameter in the model

Mean absolute percentage error (MAPE) and mean absolute deviation (MAD) are the measurement of accuracy of the estimated models (Imon, 2017 and Raza et al., 2015). For the MAPE and MAD, the lower values recommended a better fitted model (Karim et al., 2010).

$$MAPE = \frac{\sum |(y_t - \hat{y_t})/y_t|}{T} \times 100$$

$$MAD = \frac{\sum |y_t - \hat{y_t}|}{T}$$

Where,
y_t = actual observation
$\hat{y_t}$ = fitted observation
T = number of observation

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III. Results and Discussion

To determine which trend model is appropriate for this dataset, descriptive statistics are presented and eight trend models are checked for their performance on ginger production data during the time by R^2, adjusted R^2 and F statistics value. Also, the accuracy of different fitted trend models are examined by MAPE and MAD value. A scatter diagram is presented between time (in years) and ginger production (in tone) in Figure 01. There is a violation of linearity in the scatter diagram between time and production. The graph shows that there is no straight line pattern between the points. In this regard, trend models other than the linear model can be used.

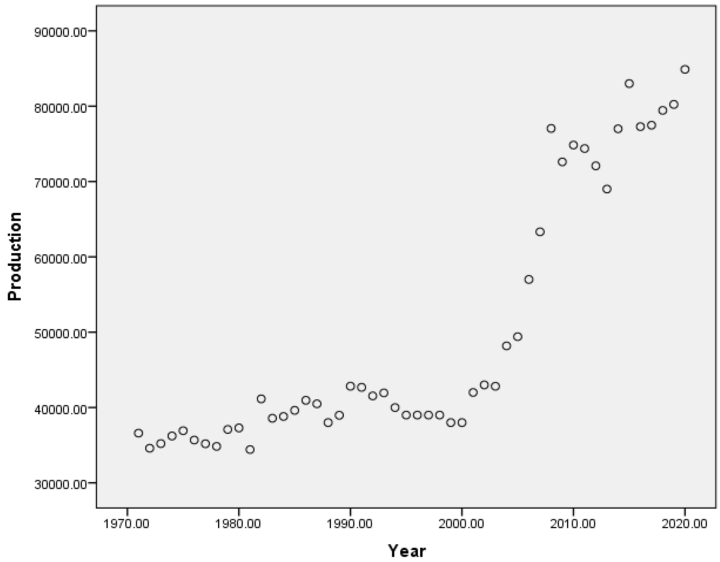

Figure 01. Scatter diagram of ginger production and time

According to the dataset, the maximum value for ginger production in Bangladesh from 1971 to 2020 is 84887.0 tons (Table 01). In addition, the mean value is 49933.42 tons, with a minimum value of 34419.0 tons.

Table 01. Different descriptive statistics of ginger production

	Minimum value	Mean	Standard deviation	Maximum value
Ginger Production	34419.0	49933.42	17039.78	84887.0

Table 02 shows that for all trend models, F statistic is significant at 1% level of significance. The R^2 and adjusted R^2 values are minimum for the inverse model comparing other models. The R^2 and adjusted R^2 values are maximum for compound and growth models among these eight models. Based on maximum R^2 and maximum adjusted R^2 values, compound and growth trend models are more suitable comparing with logarithmic, inverse, quadratic, cubic, power and S-curve models for the ginger production data in Bangladesh from the year 1971 to 2020.

Table 02. Estimated values for different trend models

Model/ Statistics	$\widehat{\beta_0}$	$\widehat{\beta_1}$	$\widehat{\beta_2}$	$\widehat{\beta_3}$	R^2	Adj R^2	F
Logarithmic	-15259032.70	2014702.47***			0.746	0.741	141.03***
Inverse	2061611.89	4014094440.39***			0.744	0.739	139.40***
Quadratic	-960443.76	-119.86***	0.254***		0.750	0.745	144.33***
Cubic	-624660.59	-59.51***	-119.04***	8.488E-005***	0.753	0.747	146.01***
Compound	2.689E-012	1.019***			0.782	0.778	172.59
Power	1.000E-013	37.40***			0.780	0.776	170.65***
S	48.121	-74533.11***			0.779	0.774	168.73***
Growth	-26.68	0.019***			0.782	0.778	172.59***

*** denotes for significant value at 1% level of significance.

Table 03 was used to assess the dependability of the fitted model. To determine the accuracy of the estimated model for the dataset, we find that MAPE is 12.14% for both the compound and growth models. Among these MAPE values, the MAPE for compound and growth models is the lowest. The fitted inverse model accounts for the highest MAPE value of 15.52%. We also looked at the MAD value for the entire fitted model. In this case, the MAD value is lower for the estimated compound and growth models, while the value is the same. The MAD value 6057.54 is accounted for by the fitted compound and growth model. The fitted inverse model has the highest MAD value of 7224.92. We finally get the compound and growth model that is more suitable for ginger data based on the MAPE and MAD values of the fitted model. So the estimated compound and growth models are $\hat{y}$ = (2.689E-012)*1.019^{t_i} and $\hat{y} = e^{-26.68+0.019t_i}$ respectively. According to this result, in Bangladesh, the compound growth rate of ginger production is 1.019 per year.

Table 03. Accuracy of fitted models

	Logarithmic	Inverse	Quadratic	Cubic	Compound	Power	S	Growth
MAPE	15.45	15.52	15.32	15.24	12.14	12.21	12.27	12.14
MAD	7190.18	7224.92	7120.34	7085.25	6057.54	6093.87	6130.13	6057.54

Karmokar and Imon (2008) showed that the compound trend model is suitable for the rice crop in Bangladesh and Singh et al. (2014) also presented some trend models for rice crops. For some major crops in Bangladesh, Akhter et al. (2016) presented growth and trend analysis. Das et al. (2022) presented six trend models and properly checked the performance of the trend models for tea production in Bangladesh. On economic performance of ginger production, Islam et al. (2012) focused on benefit cost ratio (BCR) for two ginger growing districts Nilphamari and Khagrachari, Bangladesh, in the time period of 2009-10. The BCR for ginger production in that time period was found 2.17. In Bangladesh, little research was conducted on ginger production and its trend model analysis. In this study, eight trend models are checked according to their performance for ginger production in Bangladesh.

IV. Conclusion

The demand for spices is increasing to meet the needs of various food items and for the health benefits they provide. As a result, a thorough examination of ginger production is critical. In this regard, we used ginger production data from FAOSTAT with the corresponding time in this study. The lower the MAPE and MAD values, the more reliable the fitted compound and growth model. These models have the same MAPE and MAD values, which are 12.14% and 6057.54, respectively. In addition, when compared to other fitted models, the fitted compound and growth model had the highest R^2 and adjusted R^2 values. The R^2 and adjusted R^2 values for both fitted models are 0.782 and 0.778, respectively. After comparing eight trend models, we discovered that the compound and growth trend models provide a better fitted model than the other six trend models. Despite the fact that the compound growth rate of ginger production is 1.019 per year, the land area is shrinking. As a result, this growth rate will not be stable in the coming days. As a result, researchers and policymakers must focus on developing new methods of producing ginger to meet the increasing demand for it.

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