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Does the Pattern of Wholesale Price Index of India Changes Every Year in the Last Ten Years – What Curves Tells Us

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ABSTRACT

This paper aims to analyze the year wise pattern of the Wholesale Price Index of India for the last 10 (*ten*) years and have employed the curve fitting techniques for doing the analysis. We have taken the *Wholesale Price Index of all the Commodities* of India as dependent variable and *Time* as independent variable and have found the best fit curve for every year staring from 2004 to 2014. Three different families of fits have been employed for this study namely Polynomial, Exponential and Gaussian. It has been observed that in the first 6 (*six*) years *i.e.* from 2005 to 2010, Polynomial type of fit is found to be the best fit for 2005 (*Cubic*), 2008 (*Cubic*) and 2010 (*Linear*); Exponential type of fit is best fit for 2009 (*Exponential1*) and Gaussian type of fit is best for the years 2006 and 2007 (*both Gaussian2*). In the last 4 (*four*) years *i.e.* from 2011 to 2014, Gaussian type of fit is found to be the best fit (*2011 – Gaussian1 and 2012, 2013 & 2014 – all Gaussian2*) and thereby exhibiting a particular pattern for the last 4 (*four*) years under study.

***Keywords*—**Curve fitting, Exponential curve, Gaussian curve, Polynomial curve, Wholesale Price Index.

I. INTRODUCTION

There is a huge change of India's status in the world due to its robust and growing economy. In 2014 according to a World Bank report, India became the third largest world economy in terms of purchasing power parity (PPP) [1][2][3]. According to a report by PWC, by 2050 India has the potential to become the second largest world economy (in terms of PPP) [4]. To achieve this we need to go forward and the roads are not full of roses. We are going to face a massive challenge in many fields *e.g.* rural development, urban sustainability etc [5]. Another problem faced by the Indian economy is inflation [6] which hinders the growth of the country.

Economist and Analyst analyses economic data to understand the trend/pattern of the economy, build models which help them to forecast future outcomes and/or simulate future events. They use different economic indicators for their work.

Economic indicator is a piece of macroeconomic scale economic data that judges the overall health of the economy [7]. Economic indicators provide measurements for evaluating the health of the economy, the latest business cycles *etc* [8]. If interpreted correctly these indicators become very useful to keep an eye on the economy. The Wholesale Price Index (*WPI*) represents the price of goods at a wholesale stage [9] and in India it is used as an important measure of inflation [10][11].

In this study we have analyzed the "Wholesale Price Index for all the Commodities" of India. We have analyzed the historical economic data to find out the answer of the following question – whether the trend or the pattern of the Wholesale Price Index of India exhibits same type of trend/pattern every year in the last 10 (*ten*) years. Finding answer of this question has eventually crystallized the formation of the primary objective of our study.

For the purpose of the study the researchers have collected the "*Wholesale Price Index*" data of India from "*Open Government Data (OGD) Platform India*" [12].

II. OBJECTIVES OF THE STUDY

The primary objective of our study is to find out whether the "*Wholesale Price Index for all the commodities*" of India had followed the same trend/pattern every year or it had exhibited different types of trend/pattern every year in the last 10 (*ten*) years *i.e.* from 2005 to 2014 by employing curve fitting techniques.

III. RESEARCH METHODOLOGY

To achieve the primary objective of the study the researchers need to identify the pattern of the dataset. For doing the analysis at first we have collected 120 (*one hundred and twenty*) months' data *i.e.* from January, 2005 to December, 2014 and grouped it year wise. As a result we have 10 (*ten*) sets of data *i.e.* from 2005 to 2014.

In this study the researchers have chosen '*Time*' as the independent variable and '*Wholesale Price Index for all the commodities*' as the dependent variable. The proposed generic model is given below:

Wholesale Price Index for all the commodities ~ f(Time)

The data points *i.e.* '*Wholesale Price Index of all the commodities*' and '*Time*' have been fitted with 7 (*seven*) different type of fits (*e.g.* Linear, Quadratic and Cubic from Polynomial; Exponential1 and Exponntial2 from Exponential; Gaussian1 and Gaussian2 from Gaussian) and the goodness of fit statistics *e.g.* R^2, Adjusted R^2, Sum of squares due to error (*SSE*), Root mean squared error (*RMSE*) and Degrees of freedom (*DFE*) of these models are measured. A model with low SSE (*value close to 0*), low RMSE (*value close to 0*), high R^2 (*value close to 1*) and high Adjusted R^2 (*value close to 1*) indicates a better fit [13]. The more degrees of freedom indicate the entire population has been sampled accurately [14].

The general equations [15] of the above models are given below:

Linear: $y = a*x + b$
Quadratic: $y = a*x\text{^}2 + b*x + c$
Cubic: $y = a*x\text{^}3 + b*x\text{^}2 + c*x + d$
Exponential1: $y = a_0*\exp(b_0*x)$
Exponential2: $y = a_0*\exp(b_0*x) + a_1*\exp(b_1*x)$
Gaussian1: $y = a_0*\exp(-((x-b_0)/c_0)\text{^}2)$
Gaussian2: $y = a_0*\exp(-((x-b_0)/c_0)\text{^}2) + a_1*\exp(-((x-b_1)/c_1)\text{^}2)$

For the purpose of the study we have used the following model names (*TABLE1*):

TABLE1
MODEL NAME

Model	Model Name
Linear	L
Quadratic	Q
Cubic	C
Exponential1	E1
Exponential2	E2
Gaussian1	G1
Gaussian2	G2

The researchers have used Residual *versus* Predictor plot [16], Residual plot [17], Residual lag plot [17][18], Histogram of the residuals [19] and Q-Q plot of the residuals [20] for judging the quality of the regression.

The researchers have used '*Linear least square*' [21] method and kept the '*Robust*' [22] off for the Polynomial type of fit while performing the curve fitting to fit the data points. For Exponential and Gaussian type of fit '*Non linear least square*' [23] method have been used by keeping the '*Robust*' off. We have used '*Trust Region*' algorithm [24] for '*Non linear least square*' method of curve fitting. The entire analysis was performed at 95% confidence level.

The curve which has (i) very high R^2, (ii) very high Adjusted R^2, (iii) very low SSE, (iv) very low RMSE and also has shown (v) sufficiency of the functional part of the model (from *Residual versus Predictor plot*), (vi) constant variance of residuals (from *Residual plot*), (vii) independence of error term (from *Residual lag plot*) & (viii) approximately normal distribution of the residuals (from *Histogram of the residuals* and *Q-Q plot of the residuals*) is chosen as the best fit curve by the researchers [19]. In the event when more than 1 (*one*) models are having very close goodness of statistics and the residual analysis findings for all of them are found to be ok (*i.e.* sufficiency of the functional part of the model is there, constant variance of residuals, independence of error terms are there and the residuals are approximately normally distributed) then the model which has more degrees of freedom that model is selected as the best fit model.

In this study, we have denoted the above mentioned findings of the residual analysis as:
(i) Sufficiency of the functional part of the model: "*RA1*"
(ii) Constant variance of residuals: "*RA2*"
(iii) Independence of error terms: "*RA3*"
(iv) Approximate normal distribution of residuals: "*RA4*"

For curve fitting and data analysis we have used MATLAB 7.7.0, SPSS 17.0 and MS Excel.

IV. DATA ANALYSIS & FINDINGS

The year wise goodness of fit statistics of all the models is tabulated below (*TABLE2*):

TABLE2
GOODNESS OF FIT STATISTICS OF THE MODELS

Year	Model Name	R^2	Adjusted R^2	SSE	RMSE	DFE
2005	L	0.9350	0.9285	1.9712	0.4440	10
	Q	0.9469	0.9351	1.6108	0.4231	9
	C *	0.9712	0.9604	0.8737	0.3305	8
	E1	0.9336	0.9270	2.0147	0.4489	10
	E2 *	0.9763	0.9674	0.7199	0.3000	8
	G1	0.9474	0.9357	1.5974	0.4213	9
	G2 *	0.9767	0.9573	0.7060	0.3430	6
2006	L	0.9223	0.9145	7.0090	0.8372	10
	Q	0.9626	0.9542	3.3760	0.6125	9

	C *	0.9901	0.9864	0.8913	0.3338	8
	E1	0.9181	0.9099	7.3882	0.8595	10
	E2	0.9819	0.9752	1.6287	0.4512	8
	G1	0.9640	0.9560	3.2451	0.6005	9
	G2 *	0.9966	0.9938	0.3058	0.2258	6
2007	L	0.9275	0.9202	2.0308	0.4506	10
	Q *	0.9646	0.9567	0.9921	0.3320	9
	C *	0.9657	0.9528	0.9608	0.3466	8
	E1	0.9254	0.9179	2.0904	0.4572	10
	E2	0.9641	0.9506	1.0059	0.3546	8
	G1 *	0.9647	0.9569	0.9875	0.3312	9
	G2 *	0.9725	0.9496	0.7707	0.3584	6
2008	L	0.5859	0.5445	70.7076	2.6591	10
	Q	0.9548	0.9447	7.7246	0.9264	9
	C *	0.9873	0.9826	2.1634	0.5200	8
	E1	0.5764	0.5341	72.3181	2.6892	10
	E2 *	0.9854	0.9799	2.4905	0.5580	8
	G1	0.9591	0.9500	6.9780	0.8805	9
	G2 *	0.9876	0.9773	2.1117	0.5933	6
2009	L	0.9577	0.9534	5.9244	0.7697	10
	Q	0.9737	0.9678	3.6880	0.6401	9
	C	0.9881	0.9836	1.6710	0.4570	8
	E1	0.9604	0.9564	5.5436	0.7446	10
	E2 *	0.9946	0.9925	0.7608	0.3084	8
	G1	0.9604	0.9516	5.5454	0.7850	9
	G2 *	0.9956	0.9920	0.6123	0.3194	6
2010	L *	0.9741	0.9716	3.2987	0.5743	10
	Q	0.9741	0.9684	3.2975	0.6053	9
	C *	0.9797	0.9721	2.5841	0.5683	8
	E1	0.9740	0.9714	3.3181	0.5760	10
	E2	0.9747	0.9652	3.2304	0.6355	8
	G1	0.9741	0.9684	3.3009	0.6056	9
	G2 *	0.9807	0.9646	2.4599	0.6403	6
2011	L	0.9622	0.9584	4.9181	0.7013	10
	Q *	0.9813	0.9772	2.4323	0.5199	9
	C *	0.9833	0.9770	2.1777	0.5217	8
	E1	0.9596	0.9556	5.2575	0.7251	10
	E2	0.9809	0.9737	2.4857	0.5574	8
	G1 *	0.9815	0.9774	2.4034	0.5168	9
	G2 *	0.9839	0.9706	2.0886	0.5900	6
2012	L	0.9395	0.9335	9.2611	0.9623	10
	Q	0.9812	0.9770	2.8780	0.5655	9
	C	0.9854	0.9799	2.2358	0.5286	8
	E1	0.9358	0.9294	9.8354	0.9917	10
	E2 *	0.9857	0.9803	2.1941	0.5237	8
	G1	0.9817	0.9776	2.8068	0.5585	9
	G2 *	0.9905	0.9827	1.4480	0.4913	6
2013	L	0.8767	0.8644	29.0889	1.7055	10
	Q	0.8778	0.8506	28.8352	1.7899	9
	C	0.9746	0.9651	5.9819	0.8647	8
	E1	0.8772	0.8650	28.9695	1.7020	10
	E2	0.8972	0.8587	24.2555	1.7412	8
	G1	0.8772	0.8499	28.9708	1.7942	9
	G2 *	0.9915	0.9845	2.0013	0.5775	6
2014	L	0.1923	0.1115	50.1121	2.2386	10
	Q	0.7630	0.7104	14.7004	1.2780	9
	C	0.9482	0.9288	3.2113	0.6336	8
	E1	0.1907	0.1097	50.2110	2.2408	10
	E2	0.9032	0.8668	6.0084	0.8666	8
	G1	0.7665	0.7147	14.4843	1.2686	9
	G2 *	0.9691	0.9434	1.9149	0.5649	6

* Candidate model for best fit

By candidate model we mean that the model may be a best fit model for the respective year.

The summary of residual analysis findings for the candidate models are given in the following table (*TABLE3*).

TABLE3
FINDINGS OF THE RESIDUAL ANALYSES OF THE CANDIDATE MODELS

Year	Model Name	RA1	RA2	RA3	RA4
2005	G2	Yes	No	No	Yes
	E2	No	No	No	Yes
	C #	Yes	Yes	Yes	Yes
2006	G2 #	Yes	Yes	Yes	Yes
	C	Yes	No	Yes	Yes
2007	G2 #	Yes	Yes	Yes	Yes
	C	No	No	Yes	Yes
	G1	No	No	Yes	Yes
	Q	No	No	Yes	Yes
2008	C #	Yes	Yes	Yes	Yes
	E2	Yes	Yes	Yes	Yes
	G2	Yes	Yes	Yes	Yes
2009	E2 #	Yes	Yes	Yes	Yes
	G2	Yes	No	Yes	Yes
2010	L #	Yes	Yes	Yes	Yes
	C	Yes	Yes	Yes	Yes
	G2	Yes	Yes	Yes	Yes
2011	Q	Yes	Yes	Yes	Yes
	C	Yes	No	Yes	Yes
	G1 #	Yes	Yes	Yes	Yes
	G2	Yes	No	Yes	Yes
2012	E2	No	Yes	Yes	Yes
	G2 #	Yes	Yes	Yes	Yes
2013	G2 #	Yes	Yes	Yes	Yes
2014	G2 #	Yes	Yes	Yes	Yes

Best fit model

Findings: From TABLE1 and TABLE2 we have observed that for 2005 and 2008 Cubic model is the best fit. For the year 2009 the best fit model is Exponential1 and for 2010 Linear model is the best. Gaussian1 model is found to be the best fit for 2011. We have also observe that for 2006, 2007, 2012, 2013 and 2014 the best fit model is Gaussian2 model.

The plots of the best fit models are given below (Figure 1 to Figure 10).

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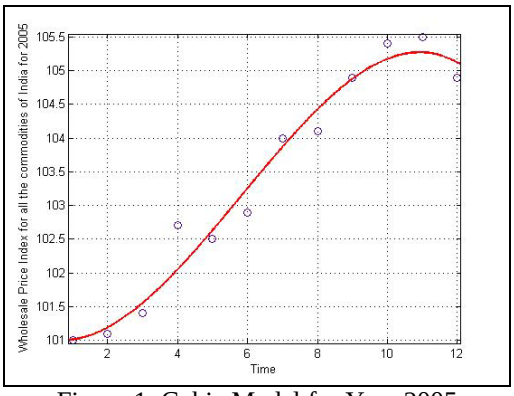

Figure 1: Cubic Model for Year 2005

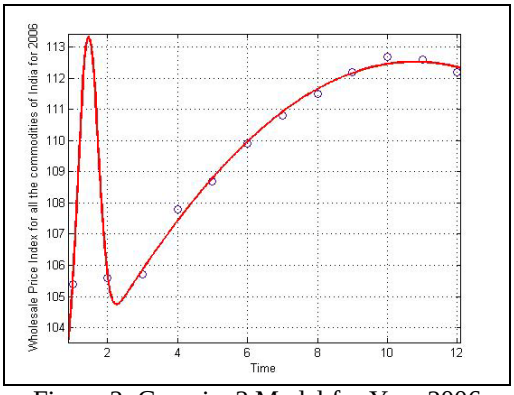

Figure 2: Gaussian2 Model for Year 2006

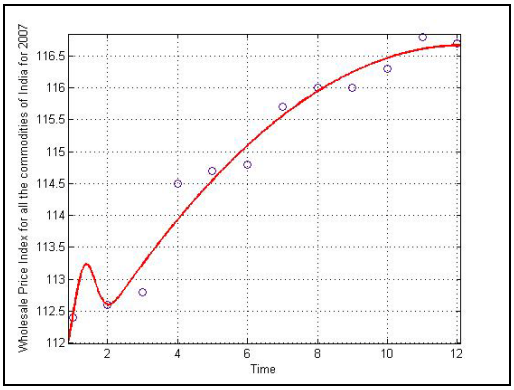

Figure 3: Gaussian2 Model for Year 2007

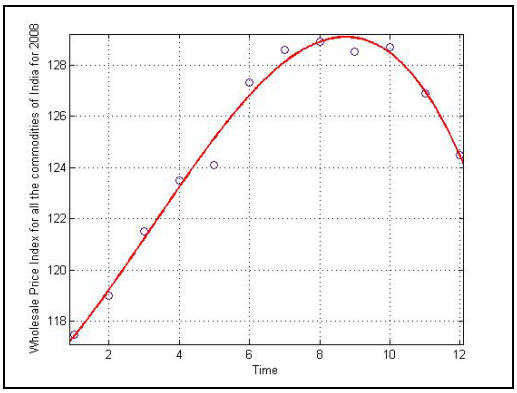

Figure 4: Cubic Model for Year 2008

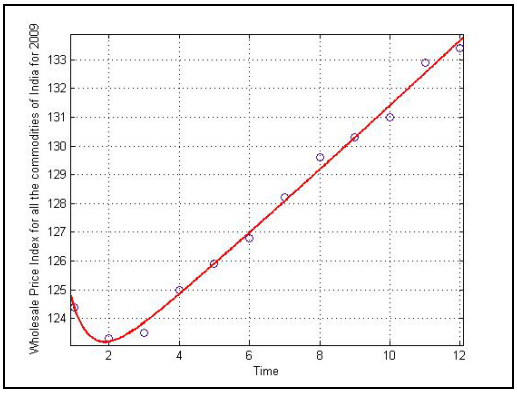

Figure 5: Exponential1 Model for Year 2009

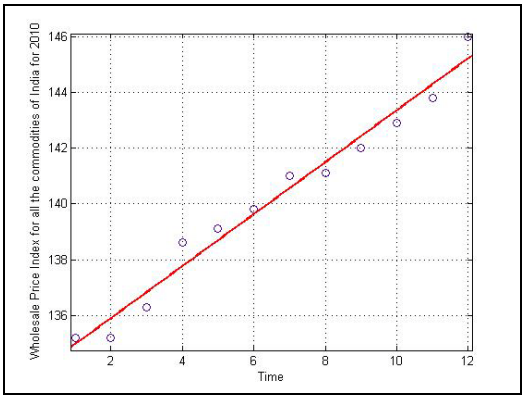

Figure 6: Linear Model for Year 2010

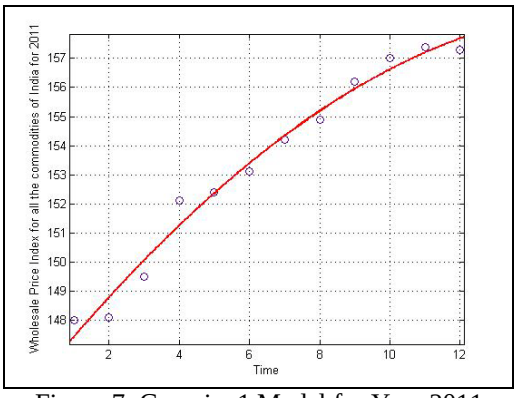

Figure 7: Gaussian1 Model for Year 2011

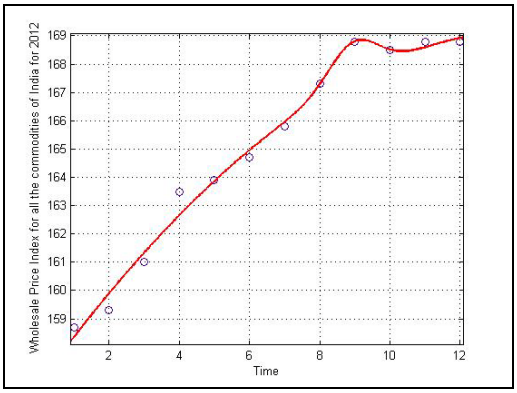

Figure 8: Gaussian2 Model for Year 2012

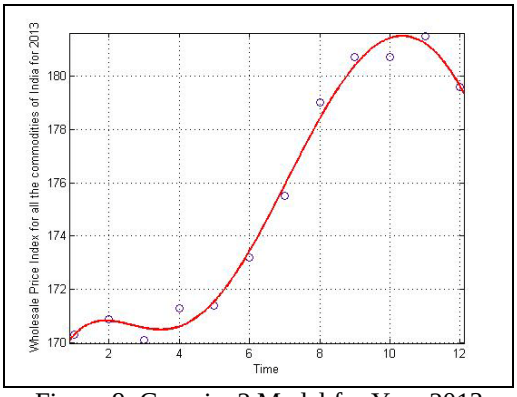

Figure 9: Gaussian2 Model for Year 2013

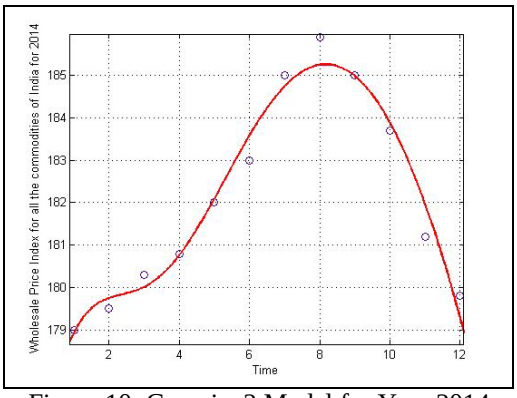

Figure 10: Gaussian2 Model for Year 2014

V. CONCLUSION

In this present study we have analyzed the historical data of "*Wholesale Price Index of all the Commodities*" of India for last 10 (*ten*) years by employing curve fitting techniques. We have used 7 (*seven*) types of fit for analyzing the data and have found the best fit curve for each year (*2005 – 2014*). We have observed that in 2005, 2008 and 2010 Polynomial type of fit and in 2009 Exponential type of fit are the best fits whereas in 2006, 2007, 2011, 2012, 2013 and 2014 Gaussian type of fit is the best. Therefore we can conclude that the "*Wholesale Price Index for all the commodities*" of India did not follow the same trend or pattern every year from 2005 to 2014. At the same time, it is also evident that from 2011 onwards every year the *Wholesale Price Index of all the Commodities* of India is following Gaussian pattern and thus if we consider only the last 4 (*four*) years *i.e.* from 2011 to 2014, then we can conclude that the indicator is indeed following a particular pattern.

This study provides us an early idea about year wise pattern of "*Wholesale Price index of all the Commodities*" of India for the last 10 (*ten*) years. The present study has employed only 3 (*three*) family of fits *i.e.* Polynomial (Linear, Quadratic & Cubic), Exponential and Gaussian. The researchers have not explored the other family of fits. This will certainly be our future endeavor to analyze this dataset with other types of fit and at the same time exploring the Gaussian type of fit in depth for a more detailed study.

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