Lack of Coordination in Supply Chain (Bullwhip effect) and how to crack it?

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Abstract:

The objective of this paper is to understand, broad view of "Lack of Coordination of Supply Chain (Bullwhip effect) and identifying the real culprit, the forecaster. If we go through the published articles and scholarly written research paper, it clearly reveals that the forecasting error is the root cause of the Bullwhip effect. The researchers aim to study various types of forecasting techniques covered under both subjective and quantitative methods, and intend to propose a best method to forecast with minimum error.
Design/Methodology/Approach: Review Paper

Keywords: Time Series, Moving Average (MA), Carrelogram, Partial Autocorrelation.

The underlying concept behind supply chain management is simple: customers order products from you; you keep track of what you're selling, and you order enough raw materials from your suppliers to meet your customers' demand (Michael, 2006). So why is it that, the most of the Economist & acclaimed supply chain professionals claimed that, "Managing a supply chain is becoming a bit like rocket science?"

The problem turns out to be one of coordination. Suppliers, manufacturers, sales people, logistics officer, customers have their own, often incomplete, understanding of what real demand is. Each group has control over only a part of the supply chain, but each group can influence the entire chain by ordering too much or too little. Further, each group is influenced by decisions that others are making.

This lack of coordination coupled with the ability to influence while being influenced by others leads to what Stanford's Hau Lee refers to as the Bullwhip Effect. Decisions made by groups along the supply actually worsen shortages and overstocks.

The bullwhip effect is illustrated by a story Prof. Lee tells about how Volvo found itself with extra inventories of green cars. To get them off the dealers' lots, Volvo's sales department offered special deals, so demand for green cars increased. Production, unaware of the promotion, saw the increase in sales and ramped up production of green cars.

Cisco faced a similar problem that resulted in a $2.2 billion inventory write-down. Only a few months before the write-down, Cisco wasn't able to get its products to customers quickly enough. Quoting a supplier to Cisco interviewed in CIO Magazine, "People see a shortage and intuitively they forecast higher. Salespeople don't want to be caught without supply, so they make sure they have supply by forecasting more sales than they expect. Procurement needs 100 of a part, but they know if they ask for 100, they'll get 80. So they ask for 120 to get 100."

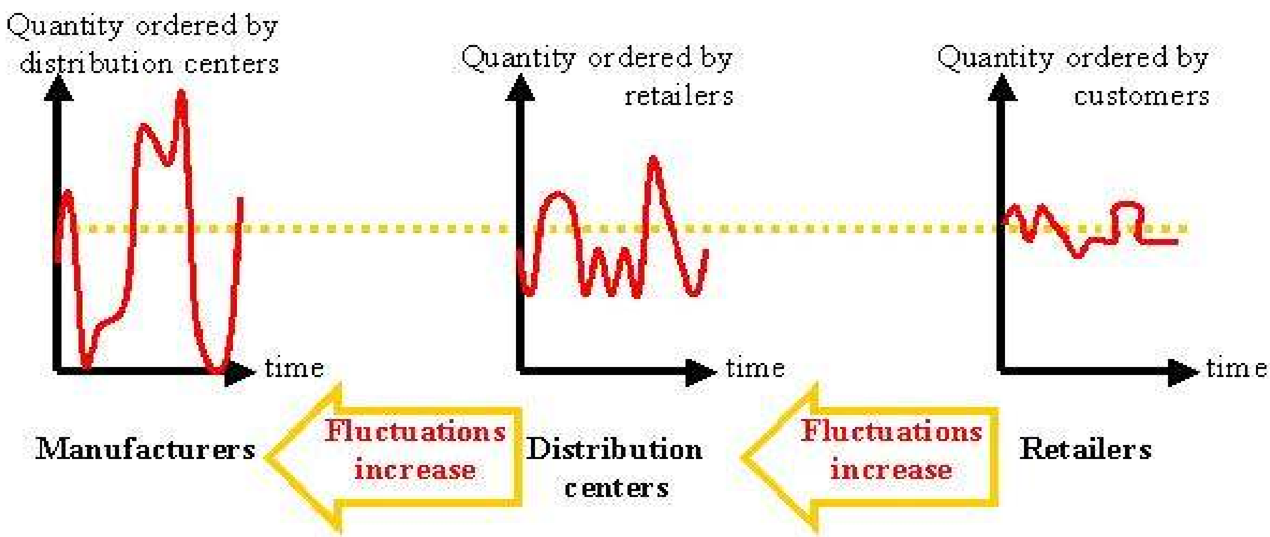
Lafarge India faced similar situation that due to lack of coordination between sales and logistics department the inventory at one of the major warehouse(dump) in Kolkata exceeded maximum permissible level resulted in huge damage of cement bags due to poor sales in that month due to festive season. The loss was irreparable because this lack of coordination was even reflected in loss of sales volume. (Source: CMA, meeting)

Ultratech (formerly Grasim) had faced similar situation as that of Lafarge India which resulted in huge inventory stock in the warehouse due to poor sales resulted in huge loss due to cement bag damage.(Source: CMA,meeting)

What is Bullwhip effect?

Figure 1

Source: http://www.damas.ift.ulaval.ca/~moyaux/travailE.html.



The Bullwhip Effect is a deformation in information when it goes upstream in the supply chain. More precisely, *the demand of the customer is put out of shape each time it goes from a company to another*. Assuming the demand of the customer is quasi-constant, this *deformation appears through the amplification of the first mini-fluctuations*. For example, with three companies having neither other clients nor suppliers, we have:

"The Bullwhip Effect (or Whiplash Effect) is an observed phenomenon in forecast- driven distribution channels. The concept has its roots in J Forrester's Industrial Dynamics (1961)", source: Because customer demand is highly unstable http://en.wikipedia.org/wiki/Bullwhip_effect, thus business must forecast such that resources can be met. Forecasts are purely based on statistics, and they are rarely perfectly accurate. Because forecast errors are a given, firms often carry an inventory buffer called "safety stock". Moving up the supply chain from end-consumer to raw materials supplier, each supply chain participant has greater observed variation in demand and thus greater need for safety stock. In periods of rising demand, down-stream participants will increase their orders. In periods of falling demand, orders will fall or stop in order to reduce inventory. The effect is that variations are amplified as one move upstream in the supply chain (further from the customer).

Forecasting as a planning tool:

Managerial decision-making is often gets complicated due to uncertainty in variables that constitute decision making process. How much to order or how much to manufacture based on sales forecast which will decide the firm strategy of procurement or production or logistics capability in terms of rake indent or entering into contract with third party logistics provider who will offer logistics services in the form of fleet carrier or warehousing space .In some cases on the basis of long term forecasting, recruitment strategy are formulated to meet future manpower requirements. But who knows about future, if something suddenly happens to USA or in Gulf then entire procurement strategy or recruitment strategy will get jeopardized, however researchers would like to limit the discussion within achievable range, because except almighty supreme authority, human race has no control over unforeseen uncertainties. In all above cases, we see that forecasting plays a vital role. Specially; one can identify the following key functions of forecasting:

(1) An estimation tool.
(2) A way of addressing the complex and uncertain environmental surrounding business decision making.
(3) A tool for predicting events related to operations planning& control.
(4) A vital for process planning.

Forecasting can be further classified into three major categories are:

(1) Short-Term
(2) Medium-Term
(3) Long-Term

Short-Term forecasting is employed on the basis of new information obtained. In case of India, which is one of the fastest world growing economy where retail sector, manufacturing sector, Logistics sector is growing at very fast rate hence under this dynamic situation forecasting of production plan or logistics plan based on short term sales projection based on past few months sales trend.

Medium-Term forecasting is employed on the basis of past few year trends, an estimate of future production plan or Logistics plan are prepared to meet the next 12-18 months demand.
Long –Term forecast based on the report of reputed agency or survey conducted at national level, highlighting future projection of demand spell the requirement of additional plant capacity, new future location, identification of future suppliers and source or recruitment of permanent workforce to meet growth and expansion of firm or Industry a long term forecast is made to ensure that opportunity is not lost due to lack of proactiveness or due to over estimation may leads to dire consequences in the form of idle investment, huge undesirable workforce, huge inventory pile up may result in huge economic loss.

Design of Forecasting Systems:

Designing and using forecasting system in an organisation involves three important stages:
(1)Identify time frame i.e. short term, midterm or long term.
(2)Develop and validate the forecasting model.
(3)Incorporate managerial inputs using their expertise.
Once the designer has met the above criteria, a dependable system can developed.

Methodology used:
(1)Identification of source of data:
Based on past year sales or available data through reliable secondary sources/primary source through questionnaire gives a concrete platform for building forecasting system. Thus the following sources are mentioned as useful from developing forecasting model are:

1. Sales force estimates.
2. Point of sales (POS) Data Systems.
3. Forecasts from Supply Chain Partners.
4. Trade/Industry Journals.
5. Surveys.
6. B2B Portals/market Places.
7. Managers Experience.

Models for Forecasting:
Forecasting models can be broadly classified under three categories:
(1)Extrapolative methods make use of past data and essentially prepare the future estimate by some method of extrapolating the past data.
(2)Causal models analyses the data from a point of cause-effect relationship.
(3)Another set of models consisting of subjective data on the basis of qualitative data. In some case it could be the set of qualitative and quantitative data.

Extrapolative Methods for Forecasting using Time series:
Time series is simply a collection of data at fixed time intervals over several years. Since extrapolative technique employs estimate of future requirement on the basis of past data.
The following extrapolative models, that is
Employed to forecast future result is:

1. Simple moving averages.
2. Weighted moving averages.

(3) Exponential smoothening method.

Simple moving averages:
The simplest model for forecasting, is simple moving averages (MA).The model simply consider only number of periods to be considered.
F_t= (D_{t-1}+D_{t-2}+D_{t-3})/3…..eqn.1 in case of 3period moving averages and F_t= (D_{t-1}+D_{t-2})/2 in case of 2 period moving averages. Here Ft represents forecasted value of next period where as D_{t-1}, D_{t-2},…. represents demand of existing and past periods.
To illustrate the basic application of this model:

Months	Sales('000) Mt(metric tons)	Forecast 2 period.	Forecast 3 period
Jan	60		
Feb	75		
March	85	67.5	
April	75	80	70
May	72	80	78.33
June	65	73.5	77.33
July	64	68.5	70.67
August		64.5	67

Table1.Source: Sales report of a ACC sales unit –Kolkata.
The August forecast will be computed using Simple Moving Average (SMA) based on two period and three period moving average.
However if consider weighted moving average the weights that to be assigned depends upon the past trend analysis and concerned manager wit. Here
F_t=w_1D_{t-1}+w_2D_{t-2}+…………….. +W_nD_{t-n}, …… eqn.2.
where w_1+w_2+w_3+………W_n=1.
In case of exponential smoothing technique the F_{t+1}=$F_{t+\alpha}$ (D_t -F_t)……..eqn.3
Where F_{t+1}=The exponentially smoothened forecast for period t+1, similarly Ft=exponentially smoothened forecast for period t and D_t=Actual demand during period t. α=The smoothening coefficient.
The value of α determines the effectiveness of the result, hence lower value of α shows that forecast is not responsive to the demand.

Literature Review:

In this researchers will, review techniques that are useful for analyzing time series data, that is, sequences of measurements that follow non-random orders. Unlike the analyses of random samples of observations that are discussed in the context of most other statistics, the analysis of time series is based on the assumption that successive values in the data file represent consecutive measurements taken at equally spaced time intervals.

Detailed discussions of the methods described in this section can be found in Anderson (1976), Box and Jenkins (1976), Kendall (1984), Kendall and Ord (1990), Montgomery, Johnson, and Gardiner (1990), Pankratz (1983), Shumway (1988), Vandaele (1983), Walker (1991), and Wei (1989). There are two main goals of time series analysis: (a) identifying the nature of the phenomenon represented by the sequence of observations, and (b) forecasting (predicting future values of the time series variable). Both of these goals require that the pattern of observed time series data is identified and more or less formally described. Once the pattern is established, we can interpret and integrate it with other data (i.e., use it in our theory of the investigated phenomenon, e.g., seasonal commodity prices). Regardless of the depth of our understanding and the validity of our interpretation (theory) of the phenomenon, we can extrapolate the identified pattern to predict future events.

Trend Analysis :

There are no proven "automatic" techniques to identify trend components in the time series data; however, as long as the trend is monotonous (consistently increasing or decreasing) that part of data analysis is typically not very difficult. If the time series data contain considerable error, then the first step in the process of trend identification is smoothing.

Smoothing:

Smoothing always involves some form of local averaging of data such that the nonsystematic components of individual observations cancel each other out. The most common technique is *moving average* smoothing which replaces each element of the series by either the simple or weighted average of n surrounding elements, where n is the width of the smoothing "window" (see Box & Jenkins, 1976; Velleman & Hoaglin, 1981). Medians can be used instead of means. The main advantage of median as compared to moving average smoothing is that its results are less biased by outliers (within the smoothing window). Thus, if there are outliers in the data (e.g., due to measurement errors), median smoothing typically produces smoother or at least more "reliable" curves than moving average based on the same window width. The main disadvantage of median smoothing is that in the absence of clear outliers it may produce more "jagged" curves than moving average and it does not allow for weighting.

Fitting a function:

Many monotonous time series data can be adequately approximated by a linear function; if there is a clear monotonous nonlinear component, the data first need to be transformed to remove the nonlinearity. Usually a logarithmic, exponential, or (less often) polynomial function can be used.

Analysis of Seasonality:

Seasonal dependency (seasonality) is another general component of the time series pattern.

Autocorrelation correlogram:

Seasonal patterns of time series can be examined via correlograms.The correlogram (autocorrelogram) displays graphically and numerically the autocorrelation function (*ACF*), that is, serial correlation coefficients (and their standard errors) for consecutive lags in a specified range of lags (e.g., 1 through 30).

Partial autocorrelations:

Another useful method to examine serial dependencies is to examine the partial autocorrelation function (*PACF*) - an extension of autocorrelation, where the dependence on the intermediate elements (those *within* the lag) is removed. In other words the partial autocorrelation is similar to autocorrelation, except that when calculating it, the (auto) correlations with all the elements within the lag are partialled out (Box & Jenkins, 1976; see also McDowall, McCleary, Meidinger, & Hay, 1980). If a lag of 1 is specified (i.e., there are no intermediate elements within the lag), then the partial autocorrelation is equivalent to auto correlation. In a sense, the partial autocorrelation provides a "cleaner" picture of serial dependencies for individual lags (not confounded by other serial dependencies).

Qualitative Techniques:

(1)Grass Roots:

'Grass Roots' forecasting builds the forecast by adding successively from the bottom. The assumption underlying here is that the person closest to the customer or end user of the product knows its future needs best.

(2)Market Research:

Very often firms hire outside consultancy that specialise in market research to conduct this kind of forecasting.

(3)Panel Consensus:

The underlying idea behind 'Panel consensus' is 'two heads better than one'. Panel forecasts are developed through open meetings with free exchange of ideas from all levels of management and individuals.

(4)Historical Analogy.

(5) Delphi Method (Expert Opinion): The Delphi method is an exercise in group communication among a panel of geographically dispersed experts (Adler and Ziglio, 1996). The technique allows experts to deal systematically with a complex problem or task. The principle of the technique is fairly straightforward. It comprises a series of questionnaires sent either by mail or via computerized systems, to a pre-selected group of experts. These questionnaires are designed to elicit and develop individual responses to the problems posed and to enable the experts to refine their views as the group's work progresses in accordance with the assigned task. The main point behind the Delphi method is to overcome the disadvantages of conventional committee action. According to Fowles (1978) anonymity, controlled feedback, and statistical response characterize Delphi. The group interaction in Delphi is anonymous, in the sense that comments, forecasts, and the like are not identified as to their originator but are presented to the group in such a way as to suppress any identification.

In the original Delphi process, the key elements were (1) structuring of information flow, (2) feedback to the participants, and (3) anonymity for the participants. Clearly, these characteristics may offer distinct advantages over the conventional face-to-face conference as a communication tool. The interactions among panel members are controlled by a panel director or monitor who filters out material not related to the purpose of the group (Martino, 1978). The usual problems of group dynamics are thus completely bypassed. Fowles (1978) describes the following ten steps for the Delphi method:

1. Formation of a team to undertake and monitor a Delphi on a given subject.
2. Selection of one or more panels to participate in the exercise. Customarily, the panelists are experts in the area to be investigated.
3. Development of the first round Delphi questionnaire
4. Testing the questionnaire for proper wording (e.g., ambiguities, vagueness)
5. Transmission of the first questionnaires to the panelists
6. Analysis of the first round responses
7. Preparation of the second round questionnaires (and possible testing)
8. Transmission of the second round questionnaires to the panelists
9. Analysis of the second round responses (Steps 7 to 9 are reiterated as long as desired or necessary to achieve stability in the results.)
10. Preparation of a report by the analysis team to present the conclusions of the exercise

Conclusion:

Researchers come to conclusion though there are so many available computerized models that support in forecasting but here the research is limited to few but simple models, that basicly aims to minimize the error .When sufficient data is not available and nature of the forecast is short term then the qualitative technique such as market research or Delphi method are quite useful ,but the serious limitation of the technique is that it cannot be relied due to inherent defects such as the moderator or credibility of research consultancy which carry out the market survey.However a mixed approach

can be taken, that is mean value of simple moving average(SMA) and weighted moving average(WMA) can be taken as it is assumed by Krajewskiki,Ritzman,Malhotra:Operations Management,8th edition Pg.556".Thus forecasting accuracy not only prevents supply chain disorder due to which either stock piles up blocking capital or stock goes out resulting in loss in sales.

Limitations:

The research is based on secondary data and testing has not been done so far hence there is an immense opportunity to identify the magnitude of smoothening coefficients (α),that is to be assigned for different situation for different case so that accurate forecast can be made using this method.

Appendix:

Analysis of the Table 1,present a comparative study between 2 period moving average, weighted moving average and exponential smoothening method(α=0.3):

ACC Sales Report

Forecasting 2 period moving average

Input Data

Period	Actual Value
Period 1	60
Period 2	75
Period 3	85
Period 4	75
Period 5	72
Period 6	65
Period 7	64

Next period 64.500

Forecast Error Analysis

Forecast	Error	Absolute error	Squared error	Absolute % error
67.500	17.500	17.500	306.250	20.59%
80.000	-5.000	5.000	25.000	6.67%
80.000	-8.000	8.000	64.000	11.11%
73.500	-8.500	8.500	72.250	13.08%
68.500	-4.500	4.500	20.250	7.03%
Average		**8.700**	**97.550**	**11.69%**
		MAD	**MSE**	**MAPE**

Table2

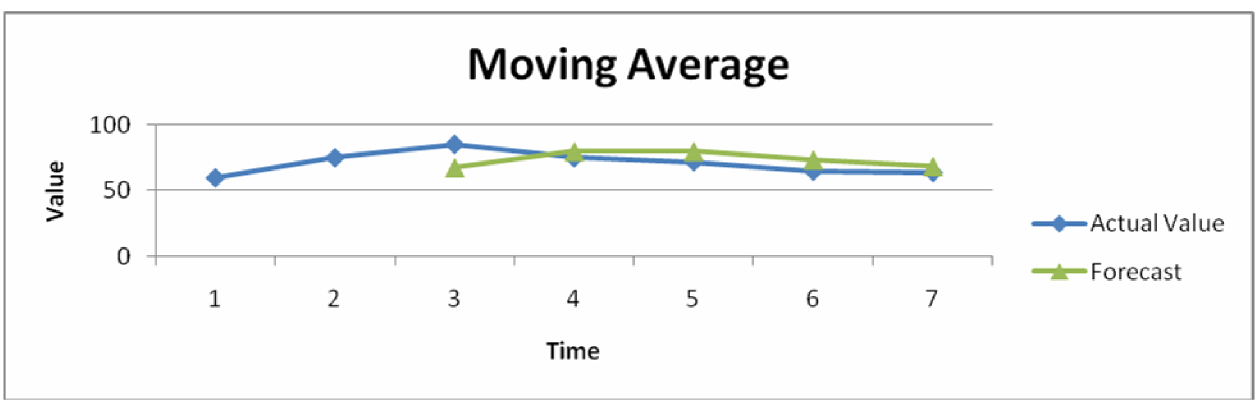


Fig.2 Graphical analysis of 2 Period moving average.

ACC Sales Report

Forecasting 3 period weighted moving average

Input Data

Period	Actual value	Weights
Period 1	60	0.2
Period 2	75	0.3
Period 3	85	0.5
Period 4	75	
Period 5	72	
Period 6	65	
Period 7	64	

Next period **65.900**

Forecast Error Analysis

Forecast	Error	Absolute error	Squared error	Absolute % error
77.000	-2.000	2.000	4.000	2.67%
78.000	-6.000	6.000	36.000	8.33%
75.500	-10.500	10.500	110.250	16.15%
69.100	-5.100	5.100	26.010	7.97%
Average		**5.900**	**44.065**	**8.78%**
		MAD	**MSE**	**MAPE**

Table3

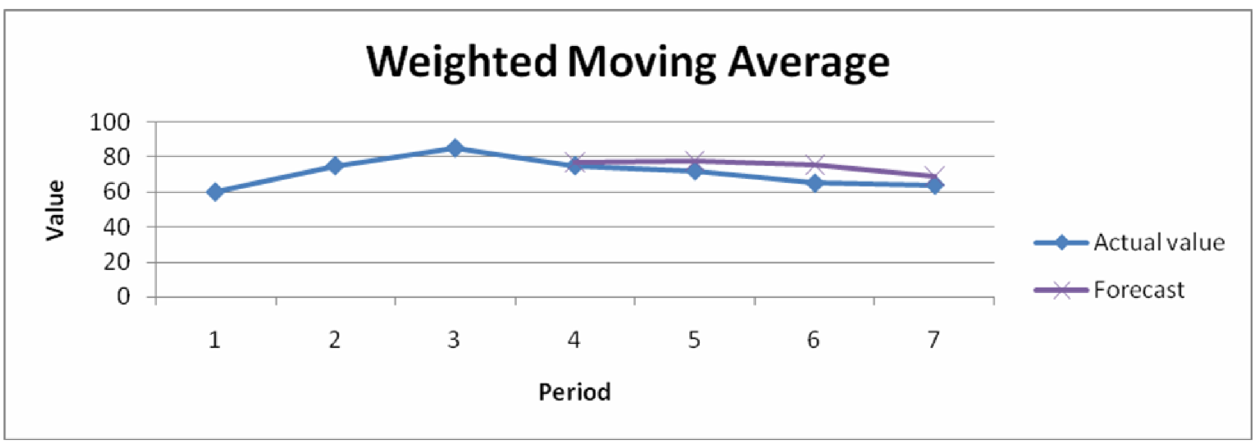


Fig.3 Graphical Analysis of 3 period moving average.

ACC Sales Report

Forecasting Exponential smoothing

Input Data

Period	Actual value
8 1	60
8 2	75
8 3	85
8 4	75
8 5	72
8 6	65
8 7	64

Alpha	0.3

Next period **68.115**

Forecast Error Analysis

Forecast	Error	Absolute error	Squared error	Absolute % error
60.000				
60.000	15.000	15.000	225.000	20.00%
64.500	20.500	20.500	420.250	24.12%
70.650	4.350	4.350	18.922	5.80%
71.955	0.045	0.045	0.002	0.06%
71.969	-6.969	6.969	48.560	10.72%
69.878	-5.878	5.878	34.550	9.18%
Average		**8.790**	**124.547**	**11.65%**
		MAD	**MSE**	**MAPE**

Table4.

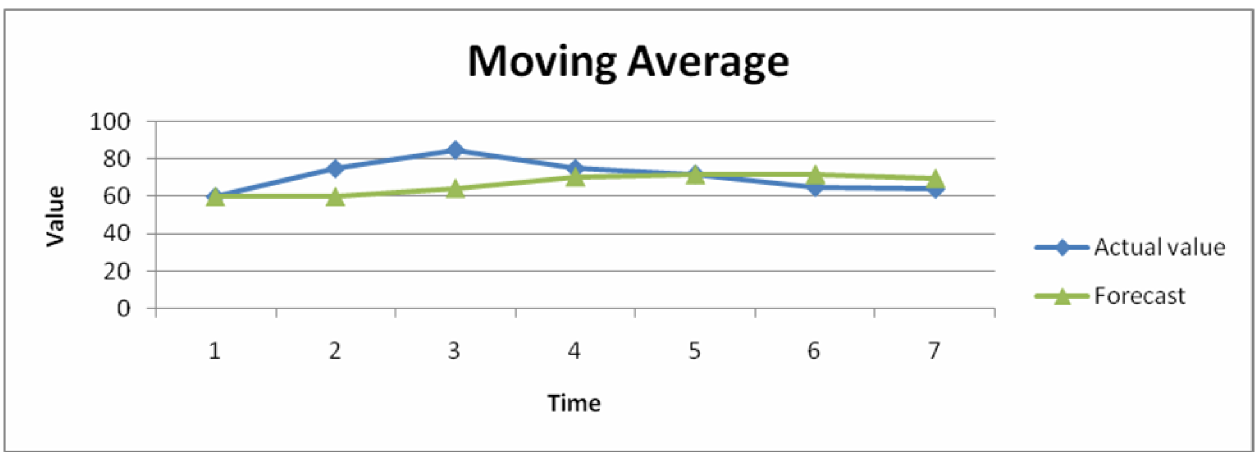


Fig.4 Exponential smoothening (α=0.3)

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