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Formulation of Approximate Generalized Field Data Based Model for the Prediction of Investment in Financial Market

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Abstract: *In the present research, the important factors responsible for the variations in the financial market have been found out with the help of a new technique which is known as a mathematical model. Basically any physical phenomenon can be represented by knowing its causes and effects for its occurrence. If one comes out with the quantitative relationship between these causes and effects, then it will be considered as a mathematical model. In fact to establish this relationship one has to understand the physics involved in the phenomenon. The upcoming articles focus on the formulation of the mathematical model followed by qualitative and the quantitative analyses. Here, qualitative analysis means interpretation of mathematical model and quantitative analysis covers (1) Sensitivity analysis (2) Optimization of model (3) Reliability of the model. etc.*
Keywords: *Financial market, Mathematical model, Optimization of model , Reliability of the model, Sensitivity analysis.*

I. Introduction To Problem, Scope & Methodology

In general the behaviour of the financial market is considered as a very complex phenomenon, because it is affected by various prominent variables. At present there is no such relationship in existence which can predict the behaviour of financial market in general. Hence it is inevitable to come out with a mathematical relationship for representing this complex phenomenon.The process of model formulation requires some prominent steps :-

1. Identification of variables
2. Established pi terms on the basis of judgement.
3. Test planning
4. Field data generation
5. Model formulation by identifying the constant and various indices of pi terms

II. Literature Review

Kanakaraj, A. [1] have examined the trend of stock prices and various macro economic variables between the time periods. Chowhan, P.K [2] have tried to fetch reasons for turbulence in stock market in the short run in India taking into account SENSEX as the main index. Kaur & Sahu [3] In their research attempted to explore the relation especially the causal relation between BSE SENSEX and some macro economic variables by using correlation, descriptive statistics, unit root stationery tests and Granger causality. Subash R [4] stated in his thesis, Extreme volatility has plagued financial markets worldwide since the 2008 Global Crisis. Investor sentiment has been one of the key determinants of market movements.

III. Identification Of Variables

The model formulation starts with the identification of variables for phenomenon. These variables can be categorized as (1) Independent variables or causes (2) Dependent variables or effects and (3) Extraneous variable. Basically, the independent variables are those, which vary without affecting other variables of the phenomenon. In experimentation the choice of variation remains with the researcher however in field data based model as such there is no control over independent variable of the researcher, as they vary depending on the situation of the field. Whilst, dependent variable are those, which only varies when the variation in the independent variables takes place. The extraneous variables are those, which vary randomly, and in uncontrolled manner, In view of the present phenomenon, following some prominent variables have been identified.

SR. NO.	Dependent/ Independent Variable	Name of Variable	Representation
1	Dependent variable	SENSEX as Financial Market	FM
2	Independent variable	Gross Domestic Product	GDP
3	Independent variable	Repo Rate	RR
4	Independent variable	Wholesale Price Index Inflation	WPI
5	Independent variable	Index of Industrial Production	IP
6	Independent variable	Forex Reserve	FR
7	Independent variable	Exchange Rates (Rs vs $)	ER
8	Independent variable	Money Supply M3	MS
9	Independent variable	Fiscal Deficit	FD
10	Independent variable	Foreign Institutional Investment	FII

"Table 1" List of Independent and Dependent Variables.

IV. Established Pi Terms On The Basis Of Judgement

The second step of this process is to reduce down these independent variables into group of pi terms. As all the independent variables are dimensionless hence the Pi terms can be established based on the judgement. However for the present case following are the Pi term which represents the present Phenomenon.

$$(FM) = K \times \left[\left(\frac{WPI * RR}{GDP}\right)\right]^{a}, \left[\left(\frac{MS * FD}{IP}\right)\right]^{b}, \left[\left(\frac{FII * FR}{ER}\right)\right]^{c} \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

V. Test Planning

The main goal of test planning is to minimize the error during field Survey or in experimentations and to maximize the use of produced data with control of outside influence. It covers following points,

1. Test envelope
2. Test points
3. Test sequence

However, in field survey the above mentioned points could be chosen by the researcher for a particular period of time. It means, the researcher only has a scope to choose the period for which he could have Test envelope, Test points, and Test sequence for pi terms, which occurs without any control. But for some variables he has a partial control where he could set the range of Test envelope, Test points, Test sequence.

VI. Test Envelope

It is well known that, one can find fair change in dependent variable by varying independent variables of the phenomenon. Test envelope is nothing but the range over which one can vary these independent variables during experimentation or in field survey. But as previously said in field survey has limited scope for choosing the Test Envelope. The following points emphasize on how one will decide the range (i.e. maximum and minimum values of independent variables)

1. The available funds and time, as time and cost are directly related to the range.
2. The range could be ascertained by deciding the most prominent independent variable which has the good impact on the dependent variable, by reviewing previous data and literature of the phenomenon under study. The present phenomenon is represented by one dependent Pi terms and three independent Pi terms. The first independent Pi term represents .Following is the test envelopes for the present phenomenon.

Terms	**π1**	**π2**	**Π3**
Maximum	14.73	676023.50	15750.77
Minimum	3.69	95960.36	60.57

Table 2: The Values of Different Range of Test Points for π1, π2, π3, for dependent pi term.

VII. Test points

During field survey then researcher gather the data for some discrete values of independent variables are known as Test points. The test points come under the regime of test envelope. However the selection of test points are affected by various factors like (a) requirement of accuracy, (b) possible variation in independent variables and (c) associated cost. The following table shows the different test points.

Test Points	π1	π2	Π3
	14.73	95960.36	166.933
	4.97	126467.4	166.501
	6.80	141125.6	60.565
	3.88	130816.8	2807.415
	5.20	137791.8	2810.141
	3.69	180451.9	3373.193
	3.76	190998.1	1555.873
	6.99	190267.7	15750.767
	7.61	568079.3	7427.447
	7.77	676023.5	12952.120

Table 3: The Values of Different Test Points for π1, π2, and π3.

VIII. Test Sequence

In general when researcher considers the test sequence for the experimentation then he could find two categories namely (a) Irreversible experiment and, (2) Reversible experiment. In reversible experiment he could obtain the desire test condition at any time whereas in irreversible experiment one cannot obtain the desired test condition at any time. It means that the sequence of experimentation should be in ascending order or descending order. But in case of field survey irreversible test sequence is applied because it is quiet difficult to arrive the previous condition at one particular time.

IX. Data Generation

For the present research the researcher has gathered the data for the variables mentioned in table 1 from the statistical data published on the website by Reserve Bank of India for public information.

X. Model Formulation By Identifying The Constant And Various Indices Of Pi Terms

The indices of different pi terms aimed at model can be identified by using multiple regression analysis. By considering three independent pi terms and one dependent pi term, Let model aimed at be of the form,

$(\pi) = K*((\pi_1)^a*(\pi_2)^b*(\pi_3))$.----------(2)

The regression equations become as under.

$\sum Y = n K1 + a\sum A + b\sum B + c\sum C + d\sum D + e\sum E + f\sum F$
$\sum YA = K1\sum A + a\sum A^2 + b\sum AB + c\sum AC + d\sum AD + e\sum AE + f\sum AF$
$\sum YB = K1\sum B + a\sum AB + b\sum B^2 + c\sum BC + d\sum BD + e\sum BE + f\sum BF$
$\sum YC = K1\sum C + a\sum AC + b\sum BC + c\sum C^2 + d\sum CD + e\sum CE + f\sum CF$ ----------(3)

In the former equations n is the number of sets of readings, A,B,C, depicts the independent pi terms π1,π2,and π3,whilst Y represents, dependent pi term. Afterwards, estimate the values of independent pi terms for corresponding dependent pi term, which helps to form the equations in matrix form.

The following matrix represents the equations, which is used for programming.

[y]=[X] x[a]

$$\begin{pmatrix} 38.69167936 \\ 29.90733793 \\ 205.1432224 \\ 125.8794881 \end{pmatrix} = \begin{pmatrix} 10, 7.760428897, 52.89068952, 32.02371291 \\ 7.\ \ 760428897, 6.337235525, 41.09213672, 24.5821913 \\ 52.89068952, 41.09213672, 280.4537038, 170.7617181 \\ 32.02371291, 24.5821913, 170.7617181, 108.9831056 \end{pmatrix} \begin{pmatrix} K \\ a \\ b \\ c \end{pmatrix}$$

By solving, the above matrix in MATLAB software, the values of different indices have been found out

K =	2.0012
a =	-0.1997
b =	0.2319
c =	0.2486

By substituting above values one can get following model,

$y = 100 \times \pi1^{-0.1997}\ \pi2^{0.2319}\ \pi3^{0.2486}$---------- (4)

XI. Interpretation Of Model

Interpretation of model is being presented in terms of several aspects viz (1) order of influence of various inputs (causes) on outputs (effects) (2) Interpretation of curve fitting constant K.

XII. Order Of Influence of Various Inputs And Their Relative Influence

Equation (5.4) is formed based on field data. It indicates that π_3 term, whichrelates to Foreign exchange, has highest influence as 0.2486 on effect i.e. SENSEX as Financial Market, whilst, the least influence is seen for π1as-0.1997, which relates to Economic growth. The π2 relates to Industrial contribution and its growth has moderate influence as 0.2319 on the effect.

Interpretation of Curve Fitting Constant (K)

The value of curve fitting constant in this model is 100. This collectively represents the combined effect of all extraneous variables. Further, as it is positive, this indicates that, there are good numbers of causes, which have influence on increasing effect.

XIII. The Quantitative Analysis Of Mathematical Model

The main emphasis of this section is to carry out quantitative analysis of mathematical model. This analysis comprises of (1) Sensitivity analysis (2) Optimization of model (3) Reliability of the model.

XIV. Sensitivity Analysis

The sensitivity analysis is performed to ascertain the sensitiveness of each independent pi term contained in the mathematical model. The procedure for sensitivity analysis is elaborated as under,

One can observe the adequate change in dependent pi terms by placing percentage change of independent pi terms. Therefore, in the present case, the change of + 10 % is introduced in individual independent pi terms independently (one at time). Thus, total rate of introduced change is 20%.

Thus by introducing 20% changes in each independent pi terms, the percentage change in dependent pi term is shown graphically in Figure 1. The sensitivity is evaluated and discussed below.

XV. Effect Of Introduced Change On The Dependent Pie Term

With reference to the model (Eq 4.), When, the total 20% of change is provided in the independent term π1, the change of **4.011 %** is observed in the value of dependent pi term (Y) (estimated from model). On the other hand the least change in the value of dependent pi term (Y) is **4.64 %** is observed.This change is due to pi term π3. In a similar way, the change of about **4.98 %,** is observed because of change in the values of π2 respectively. If one carefully note about the rate of change in dependent pi term with due effect of Independent Pi terms then it is observed that, the highest change in the dependent pi term is due to the independent term π3. Whist the pi term π1 is accountable for least change in the dependent pi term. Hence, π3 is the most sensitive pi term and π1 is the least sensitive pi term. The sequence of the various pi terms in descending order of sensitivity is π3, π2, π1

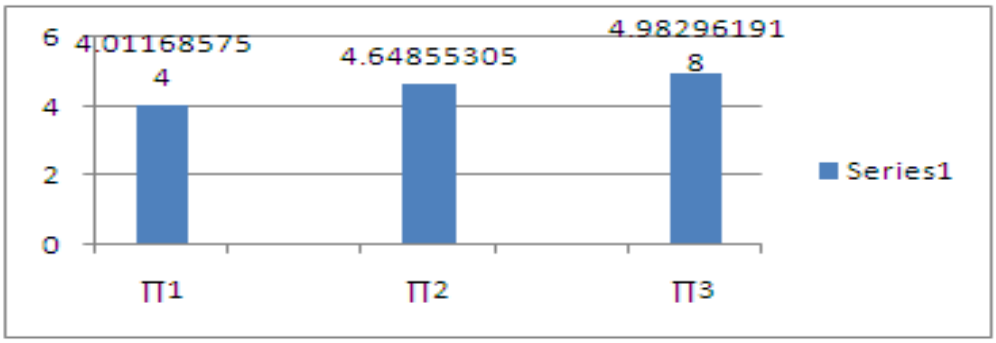

Figure 1. Sensitivity Graph of independent pi terms.

XVI. Optimization Of Model

The main aim of the present work is not merely to come out with a mathematical model but to provide the best set of independent variables. This in turn will help us to find out the maximum or minimum value of dependent pi term aiming with objective function. As far as the present case is concerned, the objective is to maximise the Sensitivity Index of Financial Market. The present model depicted in a nonlinear form and for the

optimization of this model, it is to be converted into linear form. It is carried out by taking log on both the sides. For the maximization of linear function one may use linear programming technique as detailed below.
For the dependent π term, we have

$(\pi) = K*((\pi1)\ a*(\pi2)\ b*(\pi3)\ c*$----------(5)

Taking Log on both the side of this equation,

$\text{Log}\ (Y) = \text{Log}\ K + a\ \text{Log}\ (\pi1) + b\ \text{Log}\ (\pi2) + c\ \text{Log}\ (\pi3)$ ----------(6)

Let, $\text{Log}\ (Y) = Z$; $\text{Log}\ K = K$; $\text{Log}\ (\pi1) = X1$; $\text{Log}\ (\pi2) = X2$; $\text{Log}\ (\pi3) = X3$;

Then the linear model in the form of first degree of polynomial can be written as,

$Z = k + a*X1 + b*X2 + c*X3$---------- (7)

In this case, the Sensitivity Index of Financial Market is the objective function for the optimization with specific target of maximization in view of linear programming problem. Secondly, it is required to apply the constraints to the problem .During gathering of data certain range of independent pi terms is achieved. In fact this range has a minimum and maximum value. Therefore, this range can be taken as constraints for this problem. Thus, there are two constraints for each independent variable.

Let, $\pi1$ max and $\pi1$ min, are the maximum and minimum value of independent pi term, Thus the first two constraints for the problem will be obtained by taking Log of these quantities and by substituting the value of multipliers of all other variables except the one under consideration equal to zero. Let the log limits be defined as C1 and C2 (i.e. C1= Log $\pi1$ max), (i.e. C2= Log $\pi1$ min).

Hence the equation of constraints becomes.

$1*X1 + 0*X2 + 0*X3 \leq C1$---------- (8)
$1*X1 + 0*X2 + 0*X3 \geq C2$---------- (9)

The other constraints are also found to be.

$0*X1 + 1*X2 + 0*X3 \leq C3$---------- (10)
$0*X1 + 1*X2 + 0*X3 \geq C4$----------(11)
$0*X1 + 0*X2 + 1*X3 \leq C5$----------(12)
$0*X1 + 0*X2 + 1*X3 \geq C6$----------(13)

By solving the above linear programming one can get minimum value of Z, and the best set of values of independent pi terms to acquire this minimum value. However, the values of dependent pi term and independent pi terms could be acquired by taking antilog of Z, X1, X2, and X3. The present linear programming problem is solved by MS Solver. This function is available with Microsoft Excel office. By solving, the above problem with MS solver, one would get, Z=3.36513362; X1=1.168122329;X2=4.982091875; X3=1.782222622;

Hence, $Z_{max}=(Y)_{max}$=antilog(3.36513362)=2317.39, and corresponding values of independent pi terms are obtained by taking the antilog of X1,X2,and X3, These values are 14.72, 95940.06, 60.56 etc.

Reliability Of Model

The reliability term is appertaining to the chance of failure. Indeed reliability is an indicator to show the performance of model. For the present case the reliability of model is evaluated as under,

With reference to model, the known values of independent pi terms have been submitted in the model and thus obtained the required dependent variable; generally it is called as calculated values of dependent variables. Now, one could find the error by subtracting the calculated values from observed values of dependent variable. Once the error is estimated, then reliability can be estimated by calculating the mean error.

This can be done by using following formula,
Reliability= 1- Mean error---------- (14)

Where, Mean error= ΣXIFI/ ΣFI

Where, ΣXIFI= Summation of the product for percentage of error and frequency of error occurrence and ΣFI= Summation of frequency of error occurrence. Hence for the present model reliability is obtained as 78%.

XVII. Conclusion

In the present research work it involves a rigorous study of selected macroeconomic variables based on mathematical modeling. As mentioned earlier that this approach applied in the field of management in order to find a concrete identification of groups of variables affecting the SENSEX as Financial Market. Following are the primary outcomes of this research work:

- It was found that the group of macroeconomic variable related to the foreign exchange i.e. independent **Pi 3** Term is the most prominent factor affecting the SENSEX as financial market. The Pi 3 term has been formed with the following Three Macroeconomic Variables: FII, Exchange rate Rs Vs $, Forex Reserve.

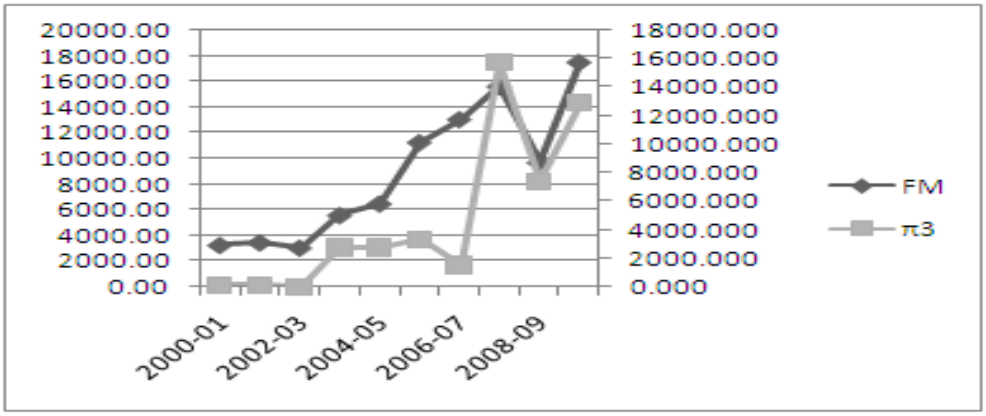

Figure 2. Pi 3 Term Plot.

- Next prominent group macroeconomic variable related to the Industrial Contribution and its Growth i.e. independent **Pi 2** Term and it has a Moderate influence on SENSEX as financial market. The Pi 2 term has been formed with the following Three Macroeconomic Variables: M3 Money Supply, Index of Industrial Production and Fiscal Deficit.
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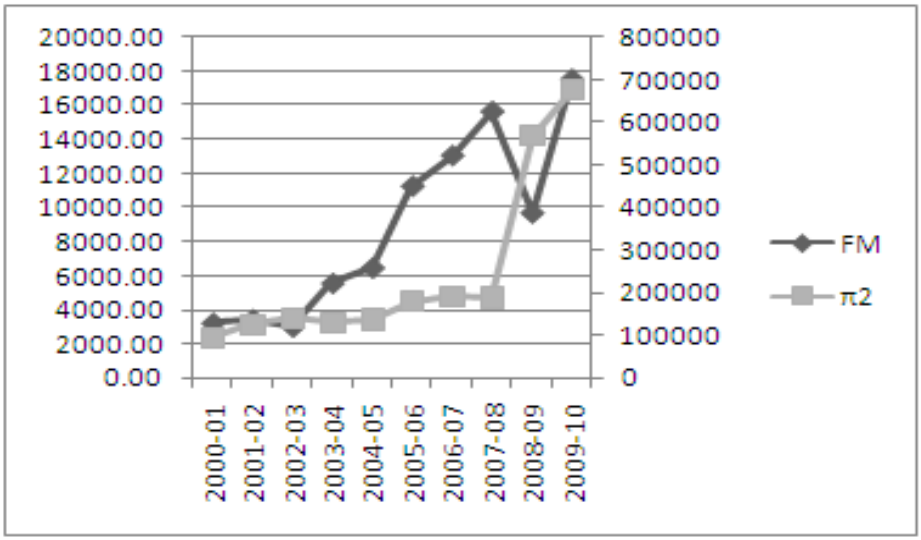

Figure 3. Pi 2 Term Plot.

- The least prominent group macroeconomic variable related to the Economic Growth i.e. independent **Pi 1** Term and it has a least impact on SENSEX as financial market. The Pi 1 term has been formed with the following Three Macroeconomic Variables: GDP, WPI Inflation and Repo Rate.

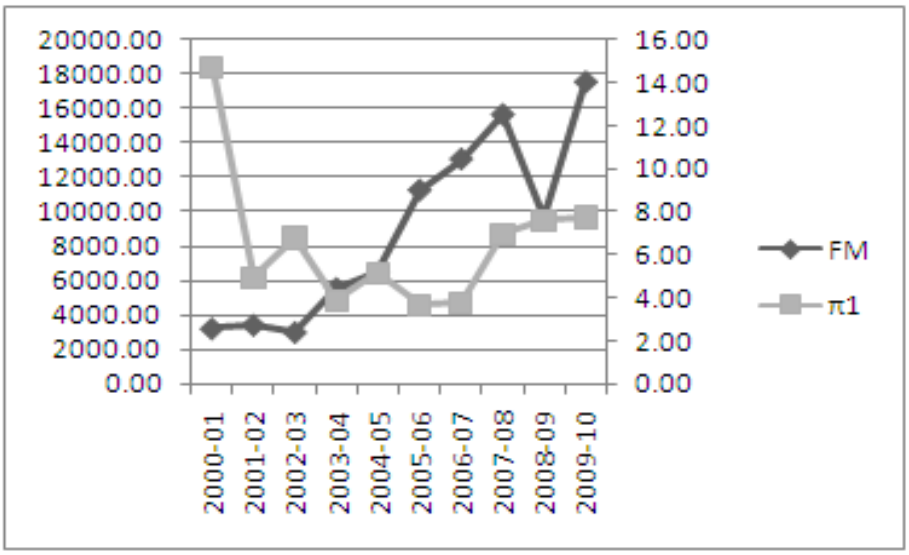

Figure 4. Pi 1 Term Plot.

- Based on the above discussions it can be clearly observed that the independent Pi term of foreign exchange **Pi 3** has the most dominant factors affecting the economy of the country, influencing the SENSEX as Financial Market. This term is evident because if one can state that the value of Rupee is less in comparison to other currencies like Dollar and the major investor in our country are the players in these currencies. It is clear from the **Pi 3** Term that a proper control over these factors will be of massive support to the growth of the economy and financial markets.
- Further the moderate Pi term **Pi 2** which is taken in relation to Industrial Production and its Growth should be used as strength in order to decrease the influence of **Pi 3** Term in regards to Indian Economy and Financial Market. It is clear from this statement that India must work on innovations and come up with manufacturing sectors to increase the industrial production and financial gains for the country. By working on the variables of **Pi 2** Term, the problems related to the individual variables of the terms can be managed.
- When one will work on Independent Term **Pi 2**, as stated above one can take proper control over **Pi 3** Term which will with effect improve the **Pi 1** Term because improvement in **Pi 3** and **Pi 2** directly affects **Pi 1**.
- The direction of macroeconomic variables and the nature of the SENSEX are predictable and reproducible and may be empirically observed. Changes in these macroeconomic variables have effects on the financial markets. The investments in financial markets can be managed strategically through having control over the Macroeconomic variables. After having control over the fluctuations in the financial markets the investors will gain confidence over their investments.

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