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Application of Multilayer Perceptron for Forecasting of Selected IIPs of India – An Empirical Analysis

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Abstract— The Index of Industrial Production (IIP) is an important indicator and a univariate time series data in nature. In the present study, the authors endeavored to develop forecasting models for twenty three (23) selected IIPs of India. The models were developed using Multilayer Perceptron. The study focused at (i) development of forecasting models, (ii) visualization of them, and (iii) analyzing the accuracies of the developed models. The study showed a mixed result with approximately twenty two percent (22%) i.e. five (5) out of twenty three (23) of the IIPs under study gave very good forecasting accuracy in terms of Mean Absolute Percentage Error (MAPE less than five), approximately twenty six percent (26%) i.e. six (6) out of twenty three (23) of the IIPs under study gave good forecasting accuracy (MAPE greater than or equal to five and MAPE less than ten) and approximately thirteen percent (13%) i.e. three (3) out of twenty three (23) of the IIPs under study gave moderate forecasting accuracy (MAPE greater than or equal to ten & MAPE less than twelve).

Keywords— Multilayer Perceptron, Index of Industrial Production, Mean Absolute Percentage Error, Forecasting, Time Series

I. Introduction

The Index of Industrial Production (IIP) of India is an important macroeconomic indicator. The IIPs of India under study are univariate time series data, collected over a span of time. The neural networks are used in diverse fields [1][2][3][4] including time series analysis [5]. This empirical analysis focuses at identifying the feasibility of efficient forecasting of some selected IIPs using “Multilayer Perceptron”, an Artificial Neural Network (ANN).

The present study tried to find the answer of the following research question:
“*Is it possible to develop forecasting model of the IIPs of India using Multilayer Perceptron?*”

In this paper the authors discussed very briefly about Index of Industrial Production, neural networks and stated the research question in the Introduction section (Section I), gave literature review in the Related Work section (Section II), expressed clearly the objectives in the Objectives of the Study section (Section III), briefly mentioned the methodology of the research in the Methodology section (Section IV), elaborated the results of the research with suitable diagrams and table in the Data Analysis & Findings section (Section V) and lastly in the Conclusion section (Section VI) appraised about the final findings of this empirical analysis.

II. Related Work

Neural network models were used by many researchers for forecasting time series data [6][7][8][9][10]. The use of neural networks for economic forecasting were explored by many [11][12][13][14][15]. Moody, Levin & Rehfuss (1993) had developed forecasting models for the monthly IIP of the US using neural network [16]. Heravi, Osborn, & Birchenhall (2004) compared the forecasting abilities of linear and neural net models for different categories of real industrial production in the UK, Germany and France [17]. Singh, Devi & Deb Roy (2016) had analyzed the IIP of India using ARIMA [18]. Potdar & Kinnerkar (2017) had developed neural network model for forecasting IIP of India where GDP, WPI, CPI and Index of eight core industries considered as inputs [19].

III. Objectives of The Study

- To develop forecasting models of the twenty three (23) selected IIPs of India using “Multilayer Perceptron” (MLP)
- To visualize the developed models
- To analyze the accuracies of the developed models

IV. Methodology

The data (*i.e.* the IIPs of India) under study was collected from “Open Government Data (OGD) Platform India [20]. The data ranged from April, 2012 to March, 2017 *i.e.* sixty (60) months. The data under study was monthly in nature.

The IIPs of twenty three (23) different items of India [20] was analyzed in this current work which is listed below along with their coded names.
Manufacture of –

(i) “food products” coded as V1,
(ii) “beverages” coded as V2,
(iii) “tobacco products” coded as V3,
(iv) “textiles” coded as V4,
(v) “wearing apparel” coded as V5,
(vi) “leather and related products” coded as V6,
(vii) “wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials” coded as V7,
(viii) “paper and paper products” coded as V8,
(ix) “coke and refined petroleum products” coded as V10,
(x) “chemicals and chemical products” coded as V11,
(xi) “pharmaceuticals, medicinal chemical and botanical products” coded as V12,
(xii) “rubber and plastics products” coded as V13,
(xiii) “other non-metallic mineral products” coded as V14,
(xiv) “basic metals” coded as V15,
(xv) “fabricated metal products, except machinery and equipment” coded as V16,
(xvi) “computer, electronic and optical products” coded as V17,
(xvii) “electrical equipment” coded as V18,
(xviii) “machinery and equipment n.e.c.” coded as V19,
(xix) “motor vehicles, trailers and semi-trailers” coded as V20,
(xx) “other transport equipment” coded as V21,
(xxi) “furniture” coded as V22.

The other two IIPs are (xxii) “Printing and reproduction of recorded media” coded as V9 and (xxiii) “Other manufacturing” coded as V23.

The data was divided into two parts – training set (forty eight months) and test set (twelve months).

In this paper, we used multilayer perceptron, an artificial neural network with a single hidden layer to develop forecasting models of the IIPs. We used “mlp” function from “nnfor” package of “R” [21] for development of the models.

The accuracy measures used in this study were as follows:

- Root Mean Square Error (RMSE)
- Mean Absolute Percentage Error (MAPE)

V. DATA ANALYSIS AND FINDINGS

The visualizations and summaries of the best fitted MLP models of these twenty three (23) IIPs are depicted below for our clear understanding of the situation.

The MLP model for IIP of “V1” is given below:

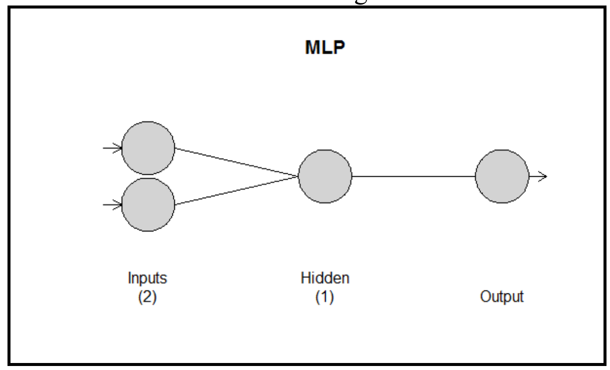

Figure 1: MLP model of “V1”

The model has two inputs (Lag 1 and 4) and one hidden node.

The MLP model for IIP of “V2” is given below:

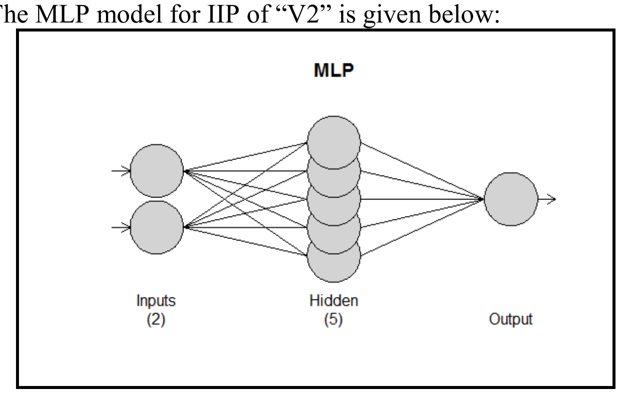

Figure 2: MLP model of “V2”

The model has two inputs (Lag 1 and 3) and five hidden nodes.

The MLP model for IIP of “V3” is given below:

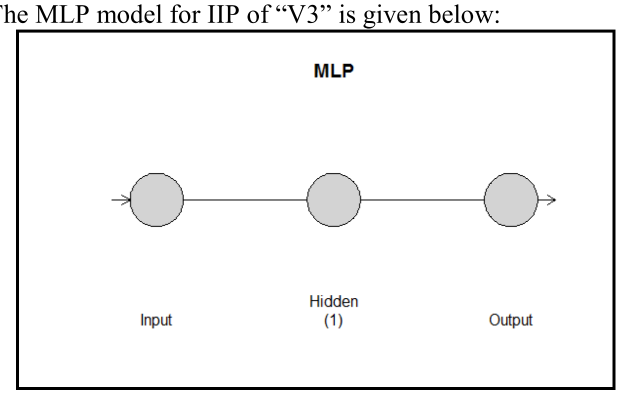

Figure 3: MLP model of “V3”

The model has one input (Lag 1) and one hidden node.

The MLP model for IIP of “V4” is given below:

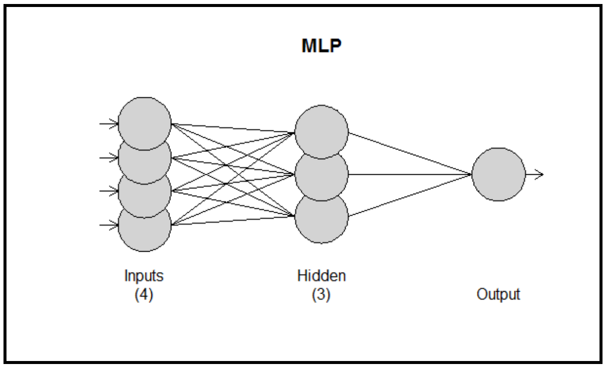

Figure 4: MLP model of “V4”

The model has four inputs (Lag 1, 2, 3 and 4) and three hidden node.

The MLP model for IIP of “V5” is given below:

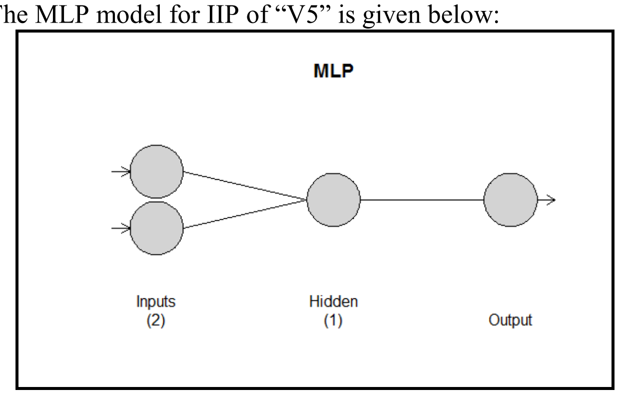

Figure 5: MLP model of “V5”

The model has two inputs (Lag 1 and 2) and one hidden node.

The MLP model for IIP of “V6” is given below:

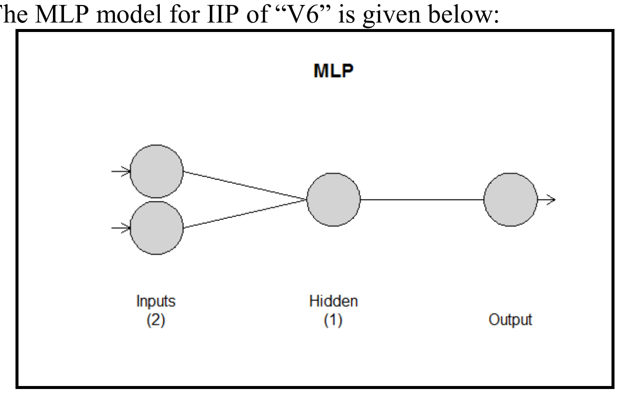

Figure 6: MLP model of “V6”

The model has two inputs (Lag 1 and 4) and one hidden node.

The MLP model for IIP of “V7” is given below:

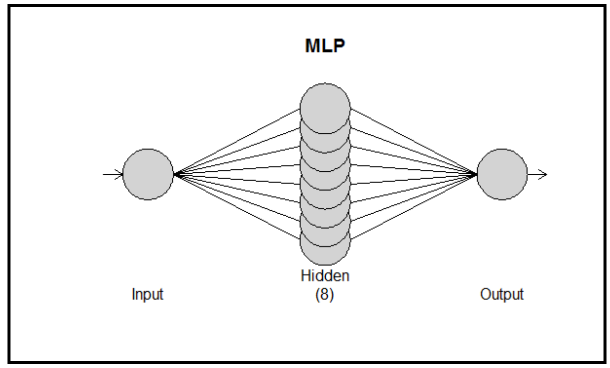

Figure 7: MLP model of “V7”

The model has two inputs (Lag 4) and eight hidden nodes.

The MLP model for IIP of “V8” is given below:

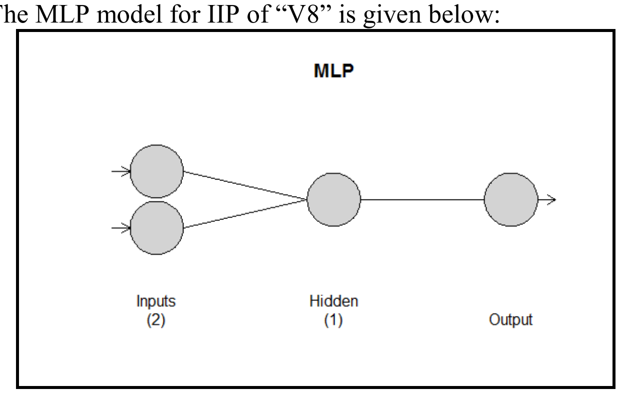

Figure 8: MLP model of “V8”

The model has two inputs (Lag 2 and 3) and one hidden node.

The MLP model for IIP of “V9” is given below:

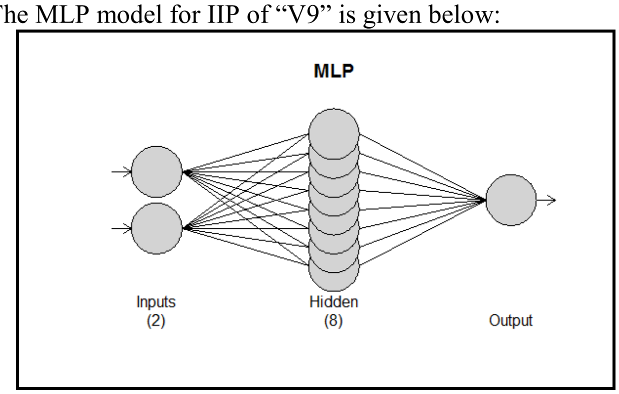

Figure 9: MLP model of “V9”

The model has two inputs (Lag 1 and 2) and eight hidden nodes.

The MLP model for IIP of “V10” is given below:

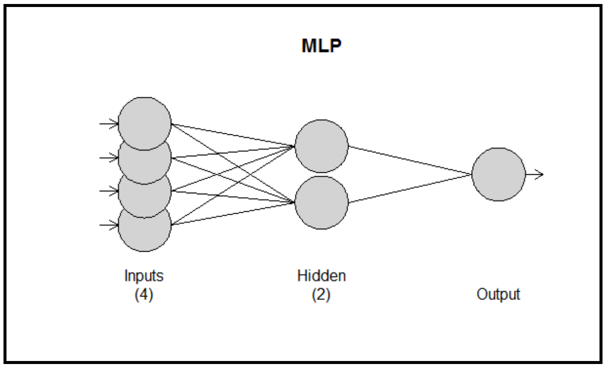

Figure 10: MLP model of "V10"

The model has two inputs (Lag 1, 2, 3 and 4) and two hidden nodes.

The MLP model for IIP of "V11" is given below:

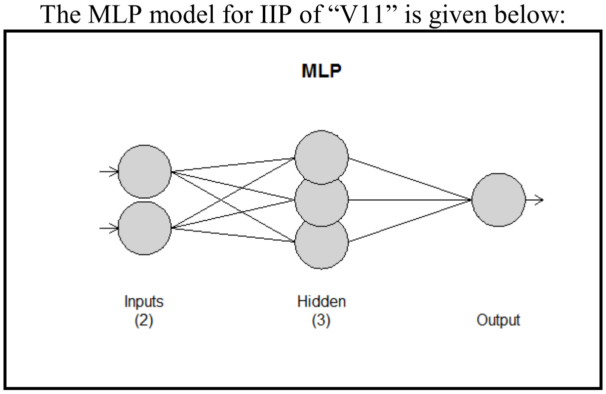

Figure 11: MLP model of "V11"

The model has two inputs (Lag 1 and 2) and three hidden nodes.

The MLP model for IIP of "V12" is given below:

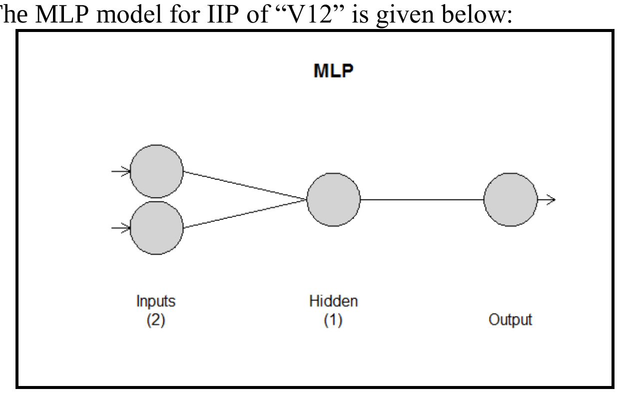

Figure 12: MLP model of "V12"

The model has two inputs (Lag 1 and 2) and one hidden node.

The MLP model for IIP of "V13" is given below:

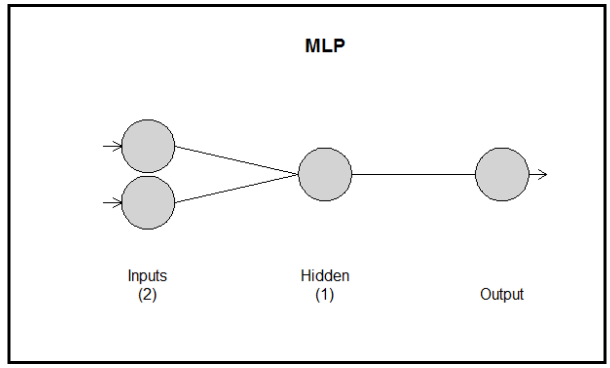

Figure 13: MLP model of "V13"

The model has two inputs (Lag 1 and 2) and one hidden node.

The MLP model for IIP of "V14" is given below:

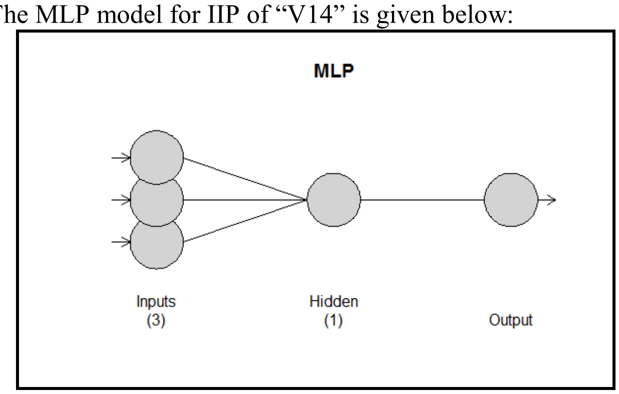

Figure 14: MLP model of "V14"

The model has three inputs (Lag 1, 2 and 4) and one hidden node.

The MLP model for IIP of "V15" is given below:

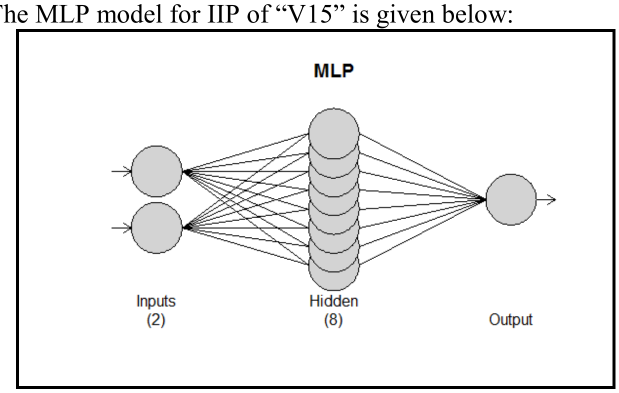

Figure 15: MLP model of "V15"

The model has two inputs (Lag 1 and 2) and eight hidden nodes.

The MLP model for IIP of "V16" is given below:

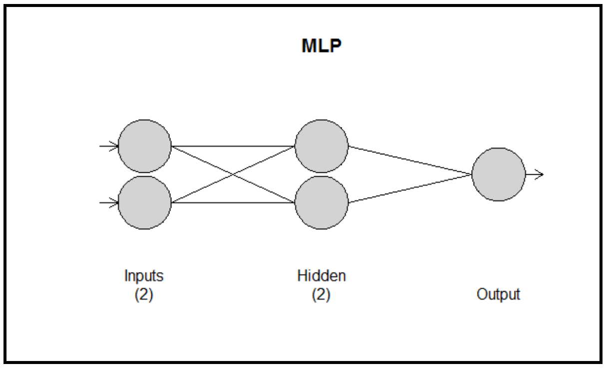

Figure 16: MLP model of "V16"

The model has two inputs (Lag 1 and 2) and two hidden nodes.

The MLP model for IIP of "V17" is given below:

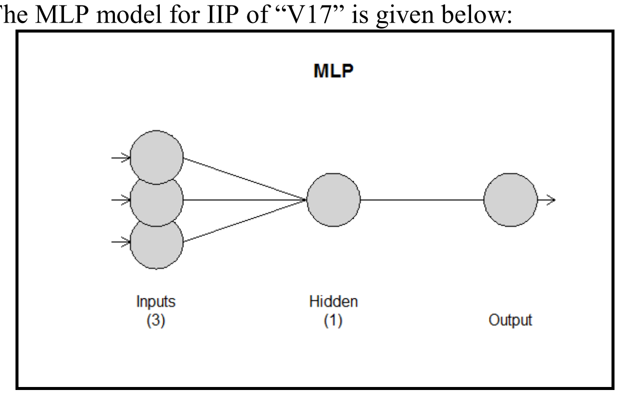

Figure 17: MLP model of "V17"

The model has three inputs (Lag 1, 2 and 4) and one hidden node.

The MLP model for IIP of "V18" is given below:

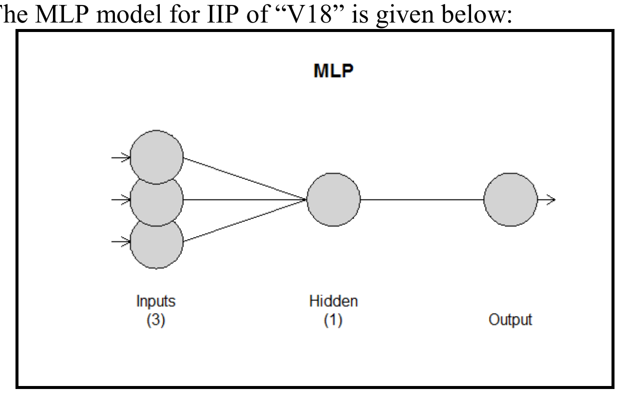

Figure 18: MLP model of "V18"

The model has two inputs (Lag 1, 2 and 4) and one hidden node.

The MLP model for IIP of "V19" is given below:

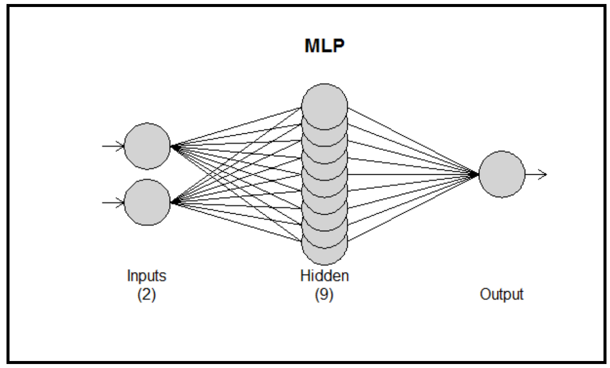

Figure 19: MLP model of "V19"

The model has two inputs (Lag 2 and 4) and nine hidden nodes.

The MLP model for IIP of "V20" is given below:

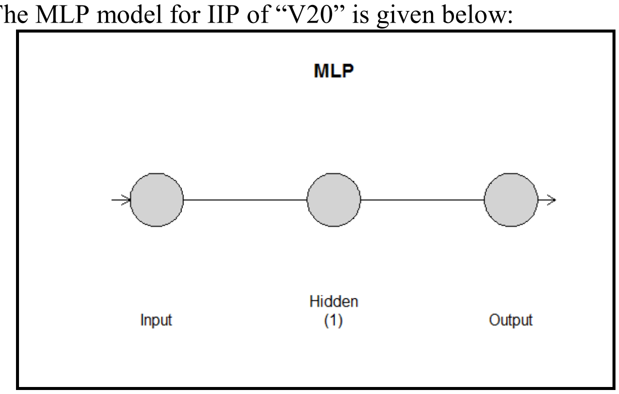

Figure 20: MLP model of "V20"

The model has one input (Lag 1) and one hidden node.

The MLP model for IIP of "V21" is given below:

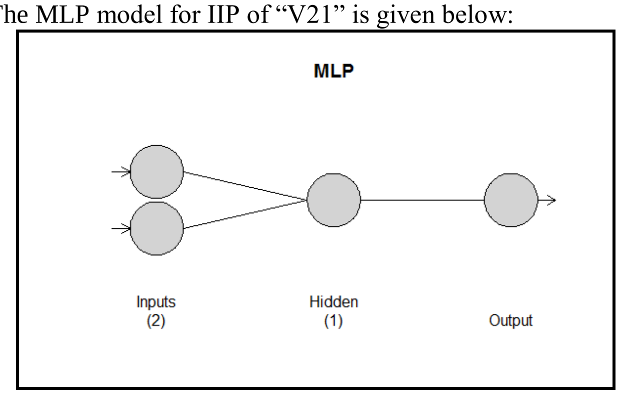

Figure 21: MLP model of "V21"

The model has two inputs (Lag 1 and 3) and one hidden node.

The MLP model for IIP of "V22" is given below:

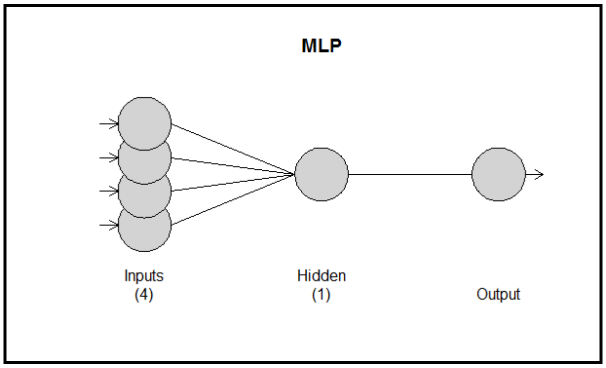

Figure 22: MLP model of "V22"

The model has two inputs (Lag 1, 2, 3 and 4) and one hidden node.

The MLP model for IIP of "V23" is given below:

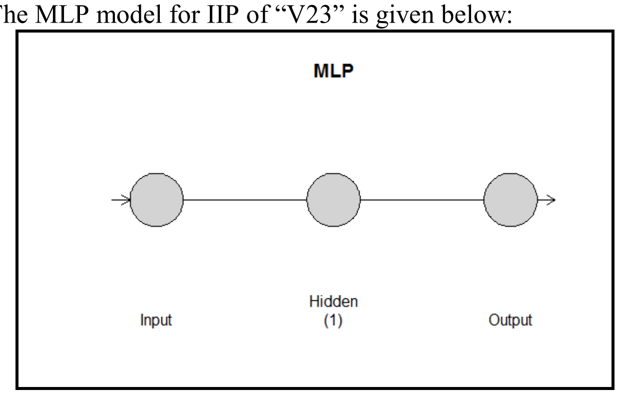

Figure 23: MLP model of "V23"

The model has one input (Lag 1) and one hidden node.

The accuracy measures of the best fitted MLP models developed for the twenty three (23) IIPs under study are tabulated below (Table 1):

Table 1: Accuracy measures of the developed models

Sl. No.	IIP (Coded Names)	RMSE (Training set)	12 months ahead forecasting	
			RMSE	MAPE
1*	V1	8.37	6.45	4.83
2	V2	6.76	19.22	15.25
3	V3	11.4	29.81	17.29
4*	V4	2.2	5.33	3.65
5	V5	14.5	39.96	19.9
6*	V6	7.18	11.04	7.96
7*	V7	5.25	7.27	6.21
8*	V8	4.37	5.74	4.07
9*	V9	3.23	7.15	5.76
10*	V10	3.64	6.05	3.89
11*	V11	4.09	3.2	2.47
12	V12	8.32	40.83	25.8
13*	V13	5.77	10.77	7.04
14*	V14	5.61	7.46	6.1
15*	V15	4.35	7.28	5.22
16	V16	8.08	33.4	22.61
17	V17	10.56	31.03	15.85
18	V18	13.73	32	15.22
19#	V19	6.58	13.9	11.06
20#	V20	5.59	13.12	11.76
21#	V21	6.49	18.36	10.66
22	V22	12.6	10.32	4.91
23	V23	14.83	18.87	12.87

* Models with good accuracy

\# Models with moderate accuracy

VI. Conclusion and Future Scope

The paper exhibits that out of twenty three (23) IIPs, eleven (11) *i.e.* approximately forty eight percent (48%) of the indexes could be effectively modelled for performing twelve (12) months ahead forecasting with good accuracy level (MAPE < 10) using multilayer perceptron. At the same time we observe that only three (3) *i.e.* approximately thirteen percent (13%) of the IIPs could be modelled with moderate accuracy (MAPE >= 10 & MAPE < 12) for forecasting of the same time period *i.e.* twelve (12) months ahead using the said technique. Therefore, we observe that approximately sixty one percent (61%) *i.e.* fourteen (14) out of twenty three (23) IIPs under study, could be modelled with good (48% approx) and moderate (13% approx) accuracies using multilayer perceptron but at the same time nine (9) *i.e.* approximately thirty nine percent (39%) of the IIPs under study could not be modelled effectively using the technique. In this study, we used a single hidden layer, keeping a generous scope of exploring other types of ANNs with more combinations for more efficient modelling of the IIPs of India in future. The study gave us a reasonable answer to our research question and we may come to an affirmative answer to the research question.

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Authors Profile

Dipankar Das is presently working as an Assistant Professor in the department of BCA, The Heritage Academy, Kolkata, India. His area of research interests includes Business Informatics, Data Analytics, Curve Fitting, Computational Intelligence *etc*. He has more than twenty one years of experience. He had published twenty five research papers in different International/ National journals and conferences.

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Samarth Mehta is presently pursuing BCA from The Heritage Academy, Kolkata, India. He is currently in 3rd year and has special interests in diverse fields of Data Science and Business Analytics. He takes pleasure in mining information from datasets by using different types of data analytics techniques.

