



FORECASTING MODEL OF EXPORT OF INDIAN ‘TEXTILE UPPER FOOTWEAR’ COMMODITIES USING DEEP LEARNING NEURAL NETWORK

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ABSTRACT

In the wake of ecological degradation, the current global state of affairs is inclined towards sustainable manufacturing. Pertaining to sustainable industrialization, the footwear industry is not an exception. A typical shoe manufacturing process involves environment-threatening and brutal leather extraction activities from animals. On the other hand, textile materials as one of the compositions of footwear manufacturing, mitigates the tannery process and sets out as an eco-friendly process. There upon, the economies that are the prime players in terms of footwear production should take the reins to foster sustainable footwear manufacturing. India being one of them holds the position of one of the top exporters of footwear globally and has the USA as its one of the top export destinations. This study revolves around the effect of export parameters on ‘textile in footwear’ commodities from India to the USA. This paper validates the use of Artificial Neural Network modeling with its different structures to predict export

predictions. The results showed that the Deep learning Neural Network outperformed the conventional method of Polynomial curve fitting.

Keywords: Footwear Industry, Eco-friendly shoes, Footwear exports, Deep learning Neural approach.

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1. Introduction

Towards Sustainability – One of the most prevailing terms in the last decades, is sustainability and every country is focused on sustainably manufacturing commodities. Of all the 17 SDGs prescribed in the commitments held in the General Assembly on 25th September 2015, SDG 9 is the goal highly associated with this study. SDG 9 throws light on 3Is i.e. Infrastructure, Industrialization, and Innovation. The goal is to build a persistent and sustainable infrastructure for the development of the economy along with human well-being and impartial accessibility. Comprehensive and sustainable industrialization by 2030 aims to raise the industry’s share of employment and GDP and upgrade research and development to encourage innovation (UN, 2015). An economy should envy others with a better approach to manufacturing commodities with sustainable intentions.

Footwear and Footwear Industry—According to Weib (1999), leather, textiles, rubber, foam, and plastics are the basic materials used in a typical shoe, with distinctive attributes of each and 40 different materials.

(Shahin, Theodoros, & Gareth, 2007) acknowledged the discards to the extent of their biodegradable nature and stated that footwear, furniture, and textiles are around 50% biodegradable which means they are still depleting the environment and must be reused or recycled. This would advance this sector's sustainability by mitigating the wastes that hamper and pollute the ecosystem. (Dominik & Christoph, 2019) analyzed the consumer behavior of purchasing eco-friendly shoes as more companies in the market are moving towards the production of eco-friendly shoes due to their degradable impacts on the environment in terms of manufacturing and disposal processes. Social Responsibility engaging ethical behaviors

along with one's intrinsic values with personal interests put forward the action to consumers' buying decision-making.

Footwear export from India—The top three countries of footwear exports from India are the USA, UK and UAE. The USA is considered the most favored nation, and India has the most frequent and significantly valued footwear-exporting economy (Exportimportdata, 2024). Although there are numerous export drivers for commodities in an economy, this study has selected a few export parameters for 'textile in footwear' after piloting relevant reviews.

2. Literature Reviews

2.1 Category 1 – Footwear Industry

(Gauri & A., 2010) noted that footwear is a garment worn on the feet, which serves as an economical and efficient way of production. The estimated revenue of the global footwear market in the year 2023 was approximately 400 billion US dollars (Statista, 2024). In terms of footwear consumption, the population is the prime mover. China, India, and the United States of America hold the top three consumers of footwear globally with a market share of 17.1%, 12.4%, and 9.4% respectively (World Footwear by Portuguese Shoes, 2024). The footwear industry comprises shoes, sneakers, luxury footwear, athletic and sports shoes, and other related goods. Footwear is a leather, textile, synthetic, and a range of materials commodity made-up. (Isistleather, 2024) reports that the leather footwear market is huge globally, estimated at 170 billion dollars, and is expected to increase by 2% to 3% annually. Astonishingly, the shoe industry is the largest leather user, with a heaping production of 14 billion pairs of leather shoes annually. In this figure, Asia solely produces over 10 billion compared to the other continents.

2.2 Category 2 – **Textile in Footwear – this category looks into the significance of textiles in footwear production**

Addressing some innovative visions in terms of designing shoes, its production substantially complies with textiles. Textiles that are beyond conventional textiles are high-performance textiles that have improved qualities and in the past few decades, these have been involved as the components in the uppers of shoe manufacturing to enhance performance with high technical characteristics in terms of strength and elasticity. For instance, Nike HyperAdapt 1.0 launched in the year 2016 which had an innovative feature of Electric Adaptable Reaction Lacing (EARL), the production of these innovative shoes involves 'smart textiles' as its composition. Smart textiles are the products that are obtained by using smart materials in the

production of textiles. LeBron collections (LeBron 15, LeBron 16 models) use ‘Knitposit’, knitted fabrics made from textile materials, as their raw materials. They are used as textile surfaces in the shoes. Adidas uses Primeknit, a knitted fabric as the upper material of the shoes (Gulas & Imre, 2020).

Material selection is the most important factor in design, appearance, and comfort (Patrycja, Zbigniew, Magdalena, & Bogusław, 2022).

The only part of the body that does not prolong the persistent temperature is the foot and keeps on changing along with the pre-and post-movements (Angel, Ana, Andrew, & Kota, 2021) and the thermal insulation of the footwear is always taken into account when it comes to functionality and suitability (Adam & Adam, 2019).

Regarding this, the multilayered construction of textiles gives protective clothing in terms of thermal comfort and guard (Małgorzata & Sylwia, 2014). The textile lining as for the selection of the materials for footwear manufacturing has better insulation properties than the other materials (Wioleta, Małgorzata, Zbigniew, Jolanta, & Justyna, 2018). On the other hand, (Rachel, Mike, Erin, & David, 2011) states that shoe uppers are vital for heat transfer as they are the only component that sheaths the foot surface.

2.3 Category 3 – Selection of the export drivers

(Niloufer, 2024) and (Yin-Wong & Rajeswari, 2013) had relevance to the monthly standard deviation to capture the exchange rate volatility to cope with the exchange rate risks and uncertainties. (Obsa, 2023) found that the effect of the real exchange rate on export earnings is vital for the economy. (Niloufer, 2024) and (K. Nirmal, G., & Adinan, 2024) selected real GDP and Corruption Perception Index respectively as the export drivers in the trade flows from India. Adding to the selection of parameters for export (Kazunobu, Jota, & Nori, 2020) found that a significant reduction in import tariff increases the exports.

2.4 Category -4 ANN modeling

Artificial Neural Network has a structure that enormously mimics the anatomy of neural networks in the human body (Jie & Zhiyuan, 2020). The effect of these network structures on the precision of the ANN model of how accurately the model can predict the expected value by training and testing data through comparing the indices was done by (Gayathiri & Manimaran, 2023). (Hon-Yi, et al., 2012) compared the conventional Logistic Regression model and the Artificial Neural Network (ANN) model and found that the ANN model was more accurate with minimal errors than the former in predictions.

2.5 Objectives of the Study

1. To identify the variables that can affect textile footwear export.
2. To study the effect of different variables on exports based on the identified trend using their correlation model.
3. To develop the ANN model with different structures to study the effect on exports based on the identified trend and forecasting based on these variables.
4. To compare the conventional prediction using polynomial curve fitting and ANN forecast of exports based on the identified trend.

3. DATA ANALYSIS AND INTERPRETATION

3.1 Objective No.1 – To identify the variables that can affect the export of textile footwear.

– During the Reviewing the Literature and consult with experts the following variables identified that serve as the export drivers of textile footwear. These variables are classified in two categories – a. dependent Variable and independent variables.

3.2 Dependent Variable

Export Values- The export values are the values of the 'textile in footwear' commodities denoting the footwear with textile materials as its composition. In the Harmonized coding system, the commodity Footwear comes under Chapter 64. This study has covered the sub-section of footwear to 8-digit level specification. The following are the identified "textile in footwear" commodities in the study-

HS 6401

HS 64011010

HS 64019210

HS 64019910

HS 6402

HS 64021210

HS 64021910

HS 64022010

HS 64029110

HS 64029910

HS 6403

HS 64031920

HS 64039110
HS 64039120
HS 64039910
HS 64039920
HS 6404
HS 64041110
HS 64041910
HS 6405
HS 64052000
HS 6406
HS 64061010
HS 64062000
HS 64069040
HS 64069050

These commodities are identified bearing the notes that stated, the term ‘rubber’ or ‘plastics’ includes woven fabrics or other textile products as their external layers being visible to the naked eye.

3.3 Independent Variables

- i) Real GDP – According to Wikipedia, Real GDP is the macroeconomic parameter that estimates the total value of all goods and services produced in an economy in a year after adjusting the price changes i.e. inflation and deflation. It is different from nominal GDP as unlike Real GDP it does not reflect the true growth in the economy. For instance, if the GDP in the next year is increased by 10%, and if this increment is due to the general increase in the price level of all commodities i.e. inflation. So, the nominal GDP is not the true growth indicator, thus the real GDP is taken into account to measure the effective and real GDP growth that adjusts the inflation rate and capture the actual growth of the economy.
- ii) Exchange Rate Volatility – The rate at which one currency is valued relative to the other currency is known as the exchange rate. The exchange rate does not consider the risks and uncertainties involved in international trade. Thus, to capture the frequency of fluctuations and measure the unpredictability of the exchange rate, the standard deviation of each year of INR and US\$ has been applied.

- iii) Tariff Rate – According to Wikipedia, tariffs are the taxes imposed by the government on the import or export of goods. In relevance to this study, the import duty imposed by the government of the USA on the commodities identified according to the HS coding has been considered.
- iv) Corruption Perception Index – After the assessment done by the 12 different institutions such as the World Economic Forum, World Bank, etc. with 13 different surveys to capture the corruption practices of 180 countries, the Corruption Perception Index is given by ranking the countries and giving scores out of 100 by their perceived level of public sector corruption. (François, 2023)

Table – 1 List of Dependent variables	
Dependent Variable	Data Source
Export Values (in US \$)	International Trade Centre, Trade Map www.traemap.org
Independent Variables	
Real GDP of the USA (in US \$)	World Bank www.data.worldbank.org
Real GDP of India (in US \$)	World Bank www.data.worldbank.org
Exchange Rate (in US \$)	https://in.investing.com/ Reserve Bank of India https://www.rbi.org.in/scripts/referenceratearchive.aspx
Tariff Rates (in %)	WTO www.stats.wto.org
Corruption Perception Index (Score)	Transparency International www.transparency.org

3.4 Objective 2 – To study the effect of different variables on exports based on the identified trend using their correlation model.

The correlation analysis in EXCEL has determined the strength of the association and direction of the relationship between the export values of ‘textile in footwear’ commodities and their drivers as shown in Table 2.

GDPU	GDPI	TaR (%)	ExV	CIU	CII
0.687851	0.629248	-0.56355	0.19631	-0.46751	0.03425

The Table - 3 below depicts the strength and direction of the independent variables concerning the export values for the duration of 2014 to 2023 considering the calendar year data i.e. from January 01, 2014, to December 31st 2023.

Independent Variables	Strength of Association and Direction of Relationship
1. Real GDP of USA	Strongest- Positive
2. Real GDP of India	Positive
3. Exchange Rate Volatility	Positive
4. Corruption Perception Index of India	Positive and the Lowest
5. Tariff Rates	Highest- Negative
6. Corruption Perception Index of USA	Low - Negative

4. Interpretation

Real GDP- As the Real GDP of the United States of America increased, the export values of footwear with textile materials increased, showing the strongest positive relationship between these two variables. Same with the real GDP growth of India. However, the real GDP

growth of the USA significantly affected the increase in product exports than the real GDP growth of India.

Exchange Rate Volatility- The high exchange rate volatility increased the value of the product exports.

Tariff Rates – The relation between import duty and the export values from India to the USA have shown a negative correlation which means the lower the import duty in the USA on these products, the higher the export of footwear with textile materials from India.

Corruption Perception Index (Score)— As corruption in the USA decreased, export values from India to the USA increased, as shown by the results.

Surprisingly, on the other hand, corruption in India has increased export values to the USA, which shows that the unhealthy Business Environment in India and the competitive status might have increased bribes for export to other nations.

4.1 Objective No.3 – To develop Deep learning NN model with different structures to study the effect on exports based on the identified trend and forecasting based on these variables.

In the process of development of the deep learning NN (DLNN) model is trained which had 3 layers i.e. the input layer, hidden layers, and a single output layer.

The input layer is a distribution layer and contains 6 nodes to distribute 6- independent variables which are the export drivers of the textile footwear. While the output layer constitutes only a single node as the export value of textile footwear. The DLNN model included 6 inputs (i.e. Real GDP of the USA, the Real GDP of India, Exchange rate volatility, Tariff rates, the Corruption Perception Index of the USA, and the Corruption Perception Index of India). Between them are the hidden layers in which the different neurons had been assigned. The DLNN model is trained, the errors is minimized between the projected results and the actual output.

At first, only one hidden layer was considered using hit and trial on a random basis, which showed results as in the graph below, where the actual and the forecasted results are depicted together in Fig. 1.

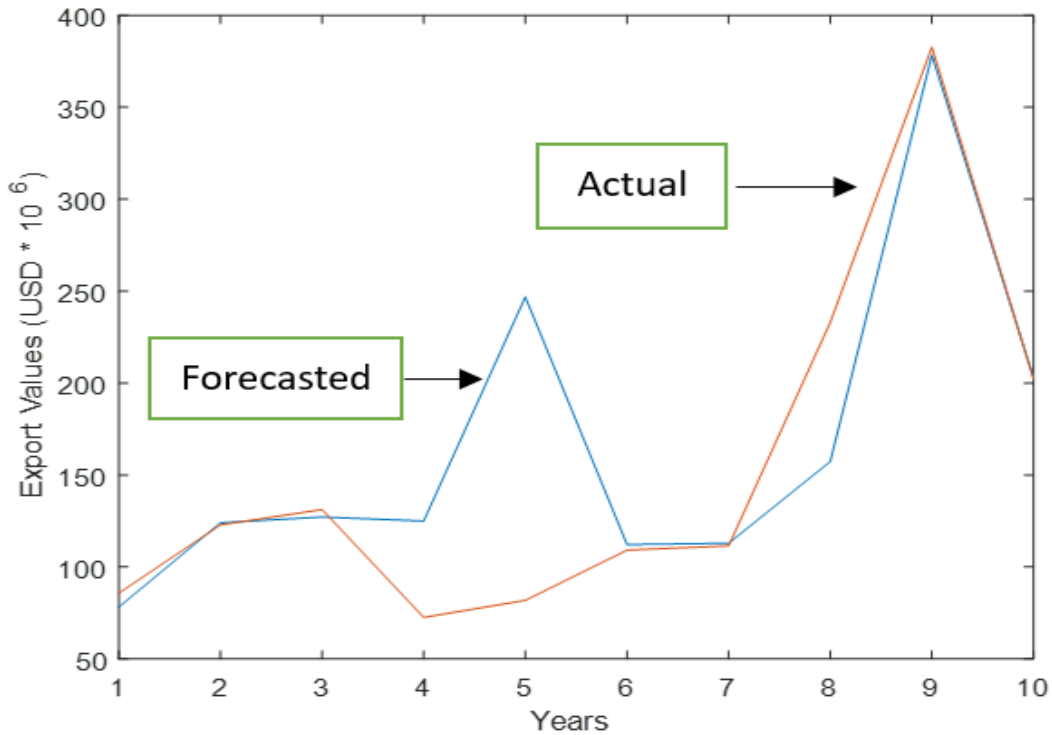


Fig. 1 Results of DLNN Forecasting and Actual results

The Actual trend depicted in the graph is the past export values of the period of study which is from 2014 to 2023, The forecasted trend shows the accuracy of the ANN model when a single hidden layer consisted of 8 neurons, after being learned and trained. The schematic diagram representation is shown in Fig. 2

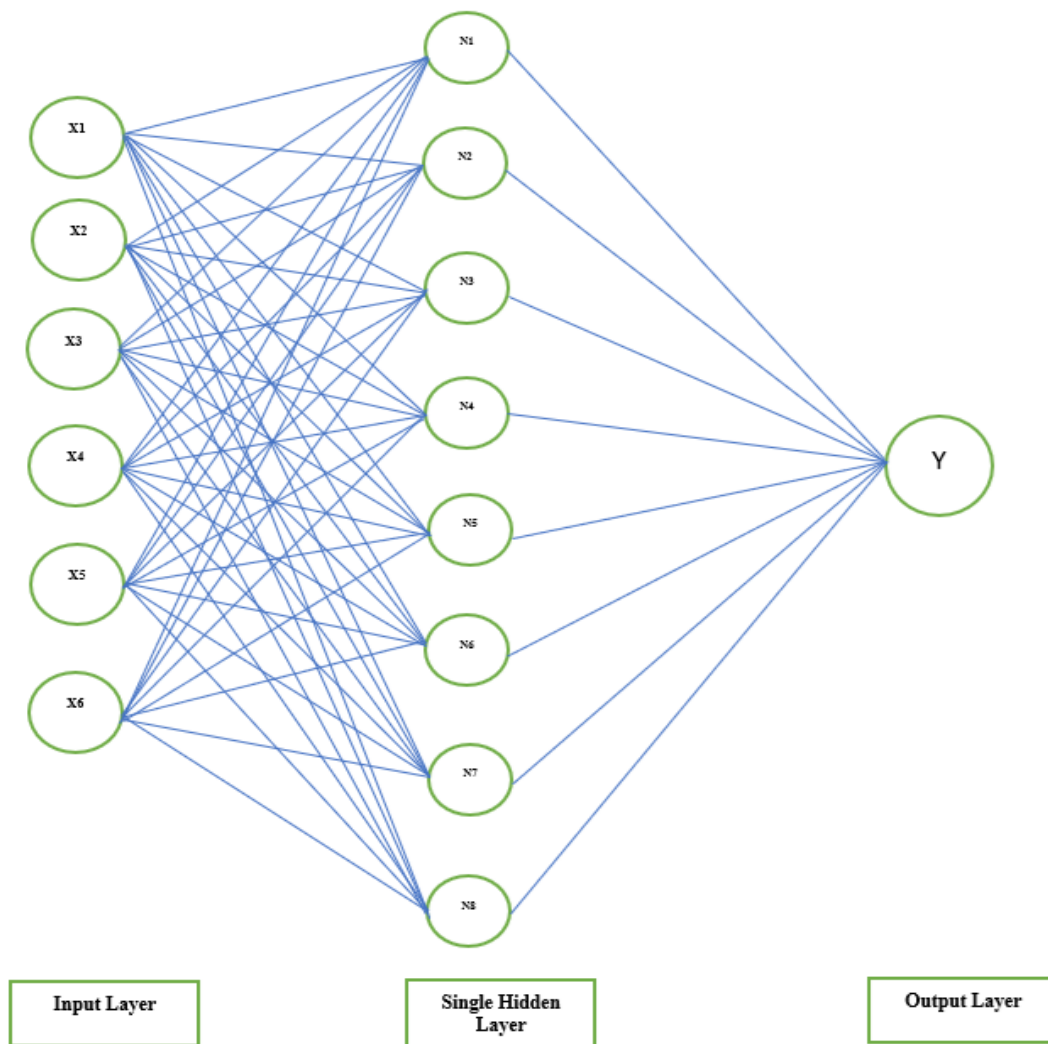


Fig.: 2- Schematic representation of DLNN.

The Input or Distribution layer has 6 neurons interconnected with 8 neurons in the hidden layer trained on a 'hit and trial' basis to give a single output in the Processing layer. The total number of weights calculated is $(6*8) + (8*1) = 48+8 = 56$. The graph above showed a significant gap between the actual and the forecasted trends, so to minimize the errors the data was trained again, and another DLNN structure was experimented on hit and trial basis.

Another DLNN structure was developed by training the data on a random basis in which two hidden layers were considered divides as [5,3]. The results are shown in Fig. 3.

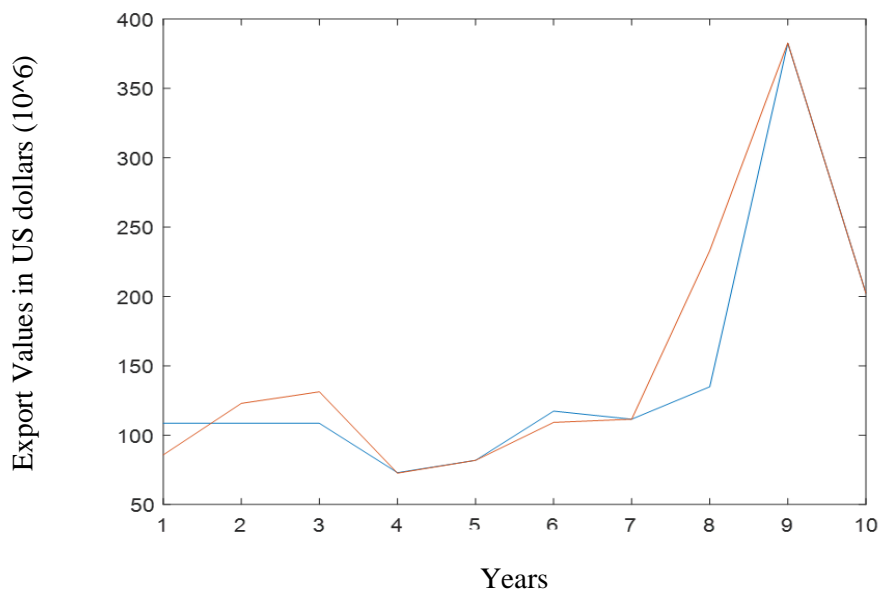


Fig. 3 Results of DLNN forecasting with two hidden layer of neurons 5 and 3 respectively.

The data trained with 2 hidden layers [5,3] showed considerable results to validate the study model's reliance on the DLNN forecasts. The errors between the actual trend and the data trained in these iterations resulted in better performance than the trial before. This means that the predictions that the DLNN has made are reliable for forecasting the exports of 'textile in footwear' based on these models. The schematic diagram representation of [5,3] DLNN model is shown in Fig. 4.

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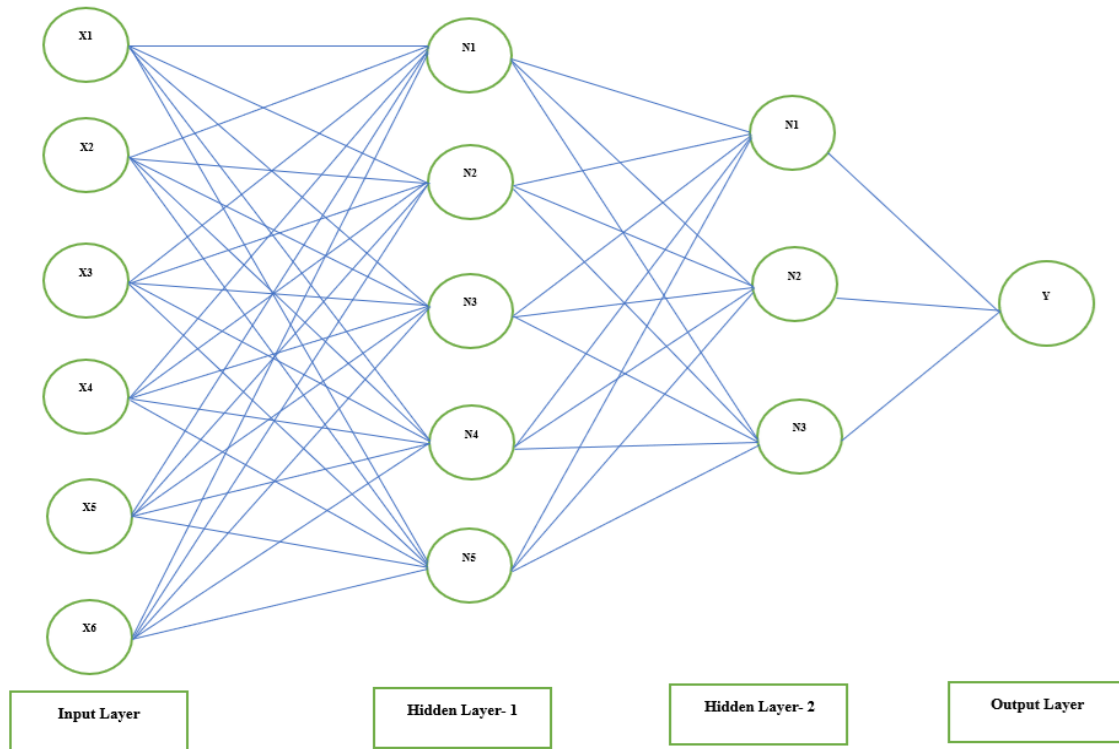


Fig. 4 – Schematic representation of DLNN structure with two hidden layers with 5 and 3 neurons respectively.

The total number of weights is calculated as –

$$(6*5) + (5*3) + (3*1) = 30 + 15 + 3 = 48$$

4.2 Objective 4 - To compare the conventional prediction using polynomial curve fitting and ANN forecast of exports based on the identified trend.

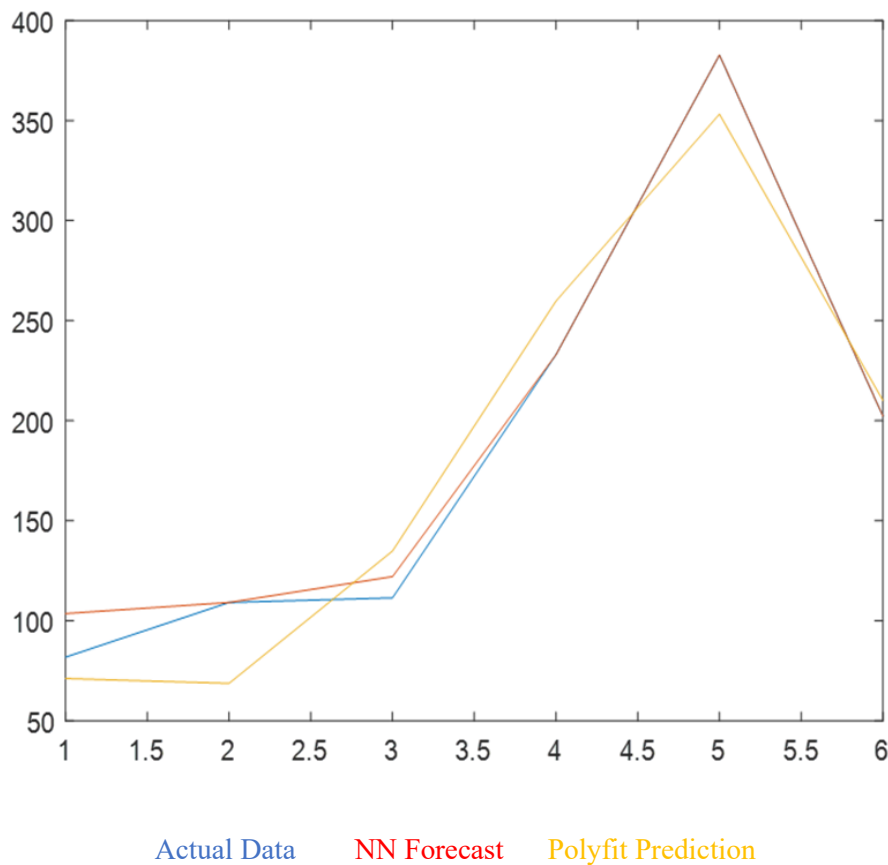


Fig. 5 Comparison of DLNN and polyfit prediction

It is found that the DLNN forecast has outperformed the predictions of conventional Polynomial curve fitting. The DLNN forecast curve has significantly coincided after a certain time. The conventional Polyfit method shows only curve fitting without learning and training data, whereas the DLNN forecast showed a remarkable accuracy of the forecast, thus validating our study model.

5. Findings

This study upshots the relevant export parameters of the ‘textile in footwear’ commodities and exposes the views of the correlation model. Out of all the six independent variables as the drivers of exports, the increased corruption practices in India deliberately augmented the export of textile footwear. Despite the increase in exports, it does not show the development of India.

Employing the heart of DLNN structures, this study ascertained the validation of the study model to use DLNN in export forecasting. Lastly, the comparison of conventional Polynomial curve fitting and DLNN forecasts cognized the accuracy of the DLNN forecasts modeling instead of traditional methods for predictions.

6. Conclusion

In the matter of international trade, exports, and imports form the fundamental part of a country's economy and facilitate universal efficiency. Regarding the export of any commodity, manufactured in a country are some relevant factors that drive the trade internationally. With the emergence of sustainability, any economy is emulous towards sustainable manufacturing and sustainable consumption of products. Likewise, the footwear industry needs a stimulation towards sustainable shoe manufacture, the countries that have global recognition in terms of footwear manufacturing should retain or improve their positions in terms of exporting to other economies that have significant demand for consumption.

India is one of the prime players in footwear production, now should look forward to moving ahead competitively in terms of sustainable footwear exports globally. The proposed flowchart paves the way toward sustainable manufacturing in the footwear industry-

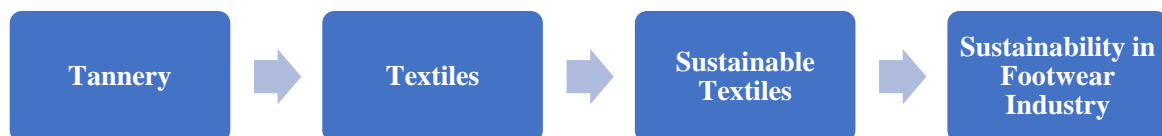


Fig. 6 Paradigm shift in Footwear Industry from non-sustainable to sustainable industry

Thus, in order to attain sustainability in the footwear industry, the first stage is to shift from the slaughtering and tannery process to the use of textiles. The move from textiles to the use of sustainable textile materials, by all means, will effectuate sustainability in the footwear industry.

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