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ORIGINAL RESEARCH

Grey Markov Models for Predicting the Social Sustainability Performances of Firms

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Abstract
Considering the three dimensions of sustainability, viz. economic, environmental, and social, the social dimensions of sustainability are getting lesser attention by firms and the same can be evinced from the sustainability ratings of firms, particularly in developing economies. Social sustainability is measured over several dimensions, where Thomson Reuters uses an integrated framework using four major indicators: the *shareholders score*, the *community score*, the *product responsibility score*, and the *human rights score* to measure and evaluate the social sustainability performances of firms. These four indicators are measured based on a number of company level indicators, as observed from the reported information of firms. We consider for this study, the Environmental, Social, and Governance (ESG) ratings of 10 Indian firms that are constantly evaluated for their social sustainability performances, for the past nine years in the reports of Thomson Reuters. We have formulated a periodic prediction model for the social sustainability performances of firms based on a basic grey prediction model (GM (1, 1)) and a moving probability Markov based error prediction model. It is observed from the results of the case evaluation that Indian firms have to mend or amend their strategies to improving their focus on social sustainability. Although, some of the firms show trivial increasing performance trends for these indicators, many of them follow declining trends. Focusing on the theory of Utilitarianism, we conclude that any improvements in socially responsible activities of firms can result in social good; along with the gain of sustainable competitive advantages for them.

Keywords ESG scores · Prediction models · Grey theory · Markov chains · Social sustainability

1 Introduction

Sustainability and performances evaluations remain as attractive research keywords for supply chain practitioners of the decade. Sustainability and the triple bottom line approaches are incorporated into the supply chains of almost all global firms, considering

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competitive advantages and owing to increasing pressure from stakeholders (Jadhav et al., 2019). Economic, environmental and social dimensions of sustainability are widely discussed across the literature on sustainability and sustainable supply chains (Bappy et al., 2019; Govindan et al., 2020). As we see, sustainability ratings provided by different rating agencies can offer an indication of the performance of firms on various dimensions of sustainability. Although sustainability and the related issues are discussed in literature and practice of supply chains, social dimensions of sustainability are getting lesser attention; particularly, as we discern through the sustainability ratings of firms in developing economies (Drempetic et al., 2019). Environmental, Social and Governance (ESG) scores of global firms released by Thomson Reuters can offer a comprehensive outlook of the sustainability performance of global firms. These ESG scores are measured over 10 major indicators and 400 plus sub-indicators leading to the overall sustainability of firms (Thomson Reuters, 2019). Among which, the social sustainability is measured over four major indicators: the *shareholders score*, the *community score*, the *product responsibility score*, and the *human rights score*.

One pillar model of sustainability defies the fact that the three dimensions of sustainability are given equal weighting, while consideration for implementation into practice (Boyer et al., 2016). Apart from that, this model gives added priorities to the ecological dimension of sustainability and observes that sustainable development need to conserve eco systems and those resources needed for better economic and social life (Rajesh, 2023a, b). In the one pillar model, aspects such as economic and social become pertinent considering the fact that the ecological advancements and developments desires to be economically viable and socially attuned, too (Gast et al., 2017). Later on, social sustainability has gained prominence with a chief aim to curb the level of poverty in various developing economies. The three pillar model of sustainability, which was developed later, agrees to the fact that human wants shall not be adequately fulfilled by merely giving an ecologically stable and healthy environment, but the socio-cultural needs are also to be considered with priority (Clune & Zehnder, 2018; Rafiaani et al., 2020). Although there are several existing disputes regarding the assumption of equal weightings for the pillars of sustainability, ecological objectives are the one slightest disputed and the economic goals follows it. But, there are several disagreements in defining the major social purposes considering sustainable development (Yadava & Sinha, 2016). Social sustainability is defined in various ways considering social standards, democratic rights, and institutional sustainability. Sustainability approaches seek for the marginal social necessities for development on a long run, i.e. it pursues to recognize the challenges for the operation of the society for a long term (Fischer et al., 2020).

The social dimension of sustainability is assessed in literature using several indicators, where there are a set of three major pointers to evaluate this dimension (Ahmadi et al., 2017). First of which, deals with the gratification of the basic needs and is related to the quality of life. The major sub-indicators of this can include distribution of income, individual income, poverty, unemployment, education and training, conditions of housing, health conditions, and security. Apart from that, it also includes personal gratification with housing, income, work, health, and the environment. The additional sets of core indicators are related to the privilege of social justice in sustainability discourse, in addition to social coherence. The notion of social justice specifies the justice concerning the dissemination of economic goods or it can be defined as providing equal opportunities, considering quality of life and partaking in society. Hence, we observe that the second group of indicators can cover issues related to gender equity and equal opportunities for education. And the third set of major pointers can relate to aspects of social coherence and the same can evaluate social network integration, measures of solidarity, and measures of tolerant attitudes. Social dimension of sustainability is boosted by the introduction of the concepts of Corporate Social Responsibility (CSR). Exact and commonly accepted demarcations for social sustainability and corporate social responsibility are not available in the extant literature on supply chains. Still, there are strong linkages, as seen in literature linking the concepts of sustainability and CSR (Liang & Renneboog, 2017). Many of the available definitions of CSR relates to the ethical behaviors towards environment, society and economy. It is recommended from literature that a firm that considers the aspects of social sustainability need to consider its' implementation over the entire supply chain (Singh et al., 2023).

We consider the four measures of social sustainability given by Thomson Reuters and formulate a prediction model for the future sustainability performances of firms based on grey prediction models and moving probability state Markov models. As we focus our research in the Indian context, we consider the social sustainability performances of select Indian firms that perform consistently well in the Thomson Reuters' ESG ratings. Thus, the study considers 10 Indian firms for predicting their future performances in social sustainability. This paper is further arranged as follows. Section 2 details the theoretical background of the study and elaborates the constructs for measuring the social sustainability of firms. Section 3 specifics the methodology for prediction using the combined model of grey theory and moving probability Markov models.Sect. 4 elaborates the case study considering the data of 10 Indian firms, which is followed by the analysis of the results and related discussions in Sect. 5. Section 6 incorporates the conclusions, limitations, and future directions of work that is followed by the implications of the research towards the theory, practice, and policy of social sustainability of firms, which are presented in Sect. 7.

2 Background of the Study

We review some of the recent developments in the literature concerned to social sustainability and glimpses of these works are presented here. Govindan et al. (2021) presented a state of the art literature on social sustainability tensions in supply chains and outlined some of the important factors and barriers contributing to the same. Considering frameworks, Sajjad and Shahbaz (2020) presented a conceptual framework incorporating mindfulness and social sustainability, and outlined the role of mindfulness practices to achieving social sustainability for workplaces. Seeing the financial benefits of social sustainability, Schönborn et al., (2019) observed the role of social sustainability in the financial success of firms and identified the dimensions of social sustainability in corporate culture that can act as predictors of financial success.Prior to this, Mani and Gunasekaran (2018) studied how pressures from sustainability culture, government, stakeholders, and customers can influence the adoption of social sustainability practices of firms, with particular focus on developing economies context.

Larimian and Sadeghi (2021) considered urban social sustainability by incorporating dimensions of social interaction, sense of place, social participation, safety, social equity and neighborhood satisfaction, and developed a comprehensive measurement scale to assess urban social sustainability. Considering studies on indicators, Popovic et al. (2018) identified several quantitative indicators of social sustainability in supply chains and classified them into categories of generic, echelon, and specific indicators. It is seen that most of the recent developments in the area of social sustainability are focused on conceptual development, creating frameworks, and analysing drivers and barriers. It is also seen that forecasting social sustainability performances, particularly using small datasets are not attempted in the literature and is the typical focus of this study.

An information integrated approach is needed for addressing the CSR and issues related to social sustainability of firms. And decision-makers call for exact tools that require complete picture of the dimensions of CSR and the potential impacts of its implementation. Social sustainability has been described using several indicators in businesses and is interpreted in a variety of means (Ajmal et al., 2018; Mani et al., 2016a, 2016b; Schönborn et al., 2019). Some of the representative indicators, while operationalizing social sustainability are taken from the extant literature. We observe that these indicators appear prominently in the publically reported information of firms, such as; annual reports, reports on sustainability, data on social responsibility, and citizenship initiatives.The indicators are discussed as follows.

2.1 Labor Equity

This measure is an indicator of the distribution of employee returns inside an organization (Eizenberg & Jabareen, 2017). It is required to benchmark this measure for all workforces of firms. It is measured as the average hourly labor cost to the hourly compensation package offered for the top paid employee by the firm. The more this fraction is, the more is the level of labor equity of the firm.

2.2 Healthcare

This matric measures the role of a firm or a corporation in providing better healthcare for its employees and their families (Maghsoudi et al., 2020). This is measured as the ratio of the healthcare expenses paid by company per employee to the per employee market capitalization. As there can be biases due to different industry types, market capitalization is considered as a better measure than revenue or profit per employee. Wellness expenses per employee or health maintenance can also be used as a measure of healthcare, although it is challenging to observe this data from the publically reported information.

2.3 Safety

Social sustainability measures, as observed from the reported information of firms can also consider the safety of workplace (Ballet et al., 2020). The hours lost due to accidents can be an indicator for the safety of workplace. Still, the ratio of mean days not injured to the total employee working days can be a better indicator of the level of safety of the firm.

2.4 Philanthropy

Most of the firms play vital financial roles in the public and in a society that do not add to its core business functions (Mani et al., 2016a, 2016b). Some of these are, funding various public welfare programs, providing fellowships, etc. A firm's philanthropic obligation can be evaluated as the ratio of contributions in charity to its market capitalization.

These four indicators, in general can be observed from the publically reported information of the firm, such as; corporate reports or sustainability reports. All of these indicators are positive indicators of social sustainability of the firm; as when these indicators increase, there is an improvement in the overall level of social sustainability performance of the firm. Although these four indicators need not include the entire spectrum of measures for social sustainability, they can cover many of the human and social needs and can act as an opening plug for evaluating the social sustainability of firms or corporations. Considering the ESG evaluations of Thomson Reuters, the four indicators that describe social sustainability are the *shareholders score*, the *community score*, the *product responsibility score*, and the *human rights score* (Thomson Reuters, 2019). These major indicators are measured using a number of minor indicators contributing to it and these indicators can include all the general traits of social sustainability discussed above, such as; labor equity, healthcare, safety, and philanthropy. The ESG indicators of social sustainability performances of firms taken into consideration for the study and the definitions for the same given by Thomson Reuters in their ESG ratings are elaborated as follows.

2.5 Workforce Score

The Workforce Score, as indicated by Thomson Reuters represents a measure of the effectiveness of a company in achieving and maintaining the levels of job satisfaction, a healthy and safe workplace through sustaining diversity, equity, and equal opportunities, and at the same time providing opportunities for progressing their workforce.

2.6 Human Rights Score

The Human Rights Score indicates the competences of the firm to follow the fundamental human rights. At the same time, it represents the proficiencies of the firm to monitor, evaluate, and improve the effectiveness of retaining the fundamental human rights concords.

2.7 Community Score

The Community Score provided in the ESG ratings of Thomson Reuters indicates the commitment of the firm in developing the communities, which are located in and around the whereabouts of the firm. This also includes the evaluation of the business ethics of the firm, considering their obligations towards public education and public health.

2.8 Product Responsibility Score

The Product Responsibility Score offered by Thomson Reuters can gauge the capacity of a company for producing goods and services within the quality standards. Also, this indicator measures several other practices for producing responsible products, such as; health and safety of customers, integrity, and privacy of data. Hence, these four measures are used for evaluation of performances in social sustainability of firms and the methodology for prediction is elaborated in the coming section.

3 Methodology

Industrial integrations enhance the need for standard prediction models for firm performances (Xu, 2020). And hence, social sustainability performances are also a matter of concern. We use a grey prediction model, GM (1, 1) and a moving probability state Markov model for prediction and error correction (Deng, 1982, 1989). Grey prediction models are advantageous; as it can successfully handle small data and limited information and are able produce promising results (Hu, 2020; Lin & Liu, 2004; Liu & Lin, 2006; Wu et al., 2020). The moving probability Markov models are used to predict the state that the future error can occur, so as to improve the exactitude of prediction results (Kumar & Jain, 2010). The combined methodology has the stated advantage that it can produce reasonably good prediction results out of the small or limited information available. The methodology for prediction is pictorially displayed in Fig. 1 and is detailed as follows.

3.1 The Grey Model of the First Order and with One Variable (GM (1, 1)) Model

Let us assume that the initial sequence of data representing the performance in social sustainability of the firm for the period $1 \leq i \leq n$, be.

$$Z^{(0)} = \left(z^{(0)}(i)\right)_{i=1}^{n}, \tag{1}$$

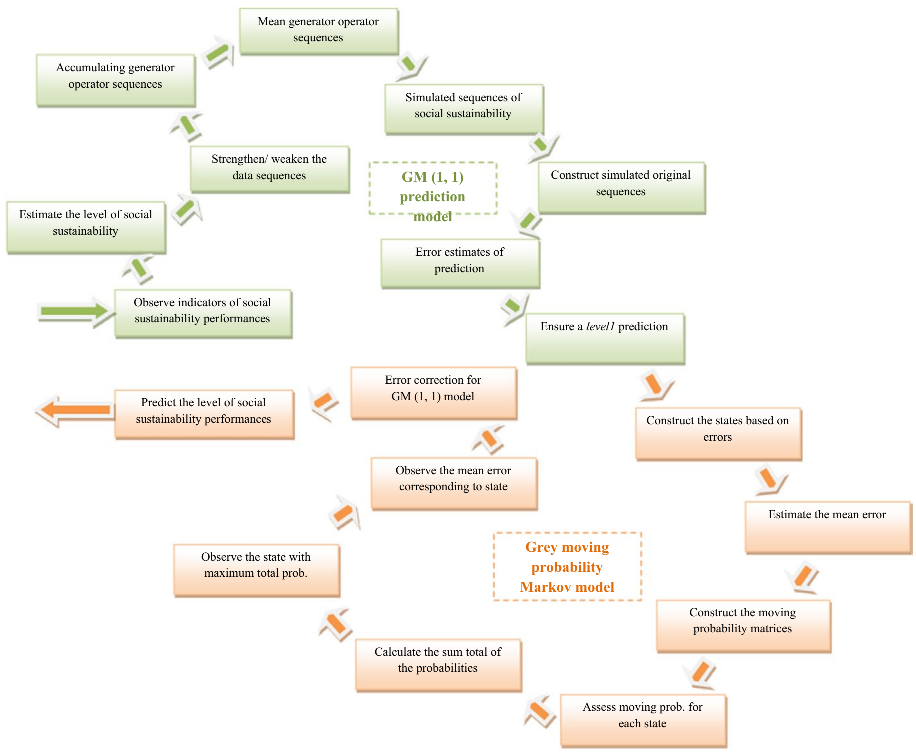

Fig. 1 Integrated model for prediction of social sustainability performances

Thus, $Z^{(0)}$ represents the periodical indicator of the social sustainability performance. Say for example; $z^{(0)}(2)$ indicates the zero order performance indicators of social sustainability for the second period taken into consideration.

Let us consider the following sequence of data;

$$Z = (z(1), z(2), z(3) \dots, z(n)). \tag{2}$$

Referring to the previous example, we can consider that z(2) indicates the periodical indicator for the second time period.

3.1.1 Data Transformation (Strengthening or Weakening Operators)

Due to the occurrence of some shock waves, the observed data may show too slow or too fast developmental tendencies and the same not represent the true developmental tendencies of the system (Liu & Lin, 2006). As such, the data cannot be used for statistical analysis, making predictions, or drawing conclusions out of it. Hence, strengthening or weakening of the data is needed and we employ either of these operators successively to remove the interference of shock waves. These operators can level the data for prediction and the accuracy of predictions can be enhanced.

Let us assume τ as a sequence operator, performed on the periodic data sequence, Z such that,

$$Z\tau = (z(1)\tau, z(2)\tau, z(3)\tau \dots, z(n)\tau). \tag{3}$$

Consider the sequence Z as a monotonically increasing sequence, then τ can represent *weakening* operator if,

$$z(k)\tau \geq z(k);\ k = 1, 2, 3 \dots, n. \tag{4}$$

Consider for an example, if $z(2)\tau \geq z(2)$ for the second period and the same hold true for all periods; then τ can be a *weakening* operator of the data. Similarly, τ can represent a *strengthening* operator of the monotonically increasing data sequence Z, if the following condition satisfies;

$$z(k)\tau \leq z(k);\ k = 1, 2, 3 \dots, n. \tag{5}$$

Consider for an example, if $z(2)\tau \leq z(2)$ for the second period and the same hold true for all periods; then τ can be a *strengthening* operator of the data. Considering the case of monotonically decreasing sequences, the reverse of Eqs. (4) and (5) holds true. For monotonically increasing sequences, the data will expand on application of a weakening operator and the data will shrink on application of a strengthening operator (Liu & Lin, 2006). Hence, for the response time sequences representing social sustainability, we use a weakening operator of second order to expand the data. The operator τ^2 is applied as follows;

$$Z^{(0)}\tau = \left(z^{(0)}(1)\tau, z^{(0)}(2)\tau, z^{(0)}(3)\tau \dots, z^{(0)}(n)\tau\right), \tag{6}$$

Where.

$$z^{(0)}(k)\tau = \frac{1}{n-k+1}\left(z^{(0)}(k) + z^{(0)}(k+1) + z^{(0)}(k+2) \dots, z^{(0)}(n)\right), \tag{7}$$

and

$$Z^{(0)}\tau^2 = \left(z^{(0)}(1)\tau^2, z^{(0)}(2)\tau^2, z^{(0)}(3)\tau^2 \ldots, z^{(0)}(n)\tau^2\right), \tag{8}$$

where

$$z^{(0)}(k)\tau^2 = \frac{1}{n-k+1}\left(z^{(0)}(k)\tau + z^{(0)}(k+1)\tau + z^{(0)}(k+2)\tau \ldots, z^{(0)}(n)\tau\right). \tag{9}$$

The sequence $\widetilde{Z}$ can be used to represent the sequence after second order weakening operation ($Z^{(0)}\tau^2$), i.e.,

$$Z^{(0)}\tau^2 = \widetilde{Z} = \left(\widetilde{z}^{(0)}(1), \widetilde{z}^{(0)}(2), \widetilde{z}^{(0)}(3) \ldots, \widetilde{z}^{(0)}(n)\right). \tag{10}$$

For example, we can say $\widetilde{z}^{(0)}(2)$ represents the value of indicator sequence for the second period, after applying the second order weakening operator.

3.1.2 Data Transformation (First Accumulating Generator Operator)

We obtain the first accumulating generator operators (1-AGO) of the sequence $\widetilde{Z}$ as follows;

$$\widetilde{Z}^{(1)} = \left(\widetilde{z}^{(1)}(1), \widetilde{z}^{(1)}(2), \widetilde{z}^{(1)}(3) \ldots, \widetilde{z}^{(1)}(n)\right), \tag{11}$$

where

$$\widetilde{z}^{(1)}(k) = \sum_{i=1}^{k} \widetilde{z}^{(0)}(i); k = 1, 2, 3 \ldots, n, \tag{12}$$

Thus, $\widetilde{z}^{(1)}(k)$ represents the cumulative sum up to k. For example, we can say that $\widetilde{z}^{(1)}(2)$ represents the value of indicator sequence for the second period, after application of the weakening operator of second order and the first accumulating generator operator, subsequently.

3.1.3 Data Transformation (Mean Generator Operator)

We obtain the mean generator sequences $\dot{Z}^{(1)}$ using the neighborhood values of $\widetilde{Z}^{(1)}$ and the same are displayed as follows;

$$\dot{Z}^{(1)} = \left(\dot{z}^{(1)}(1), \dot{z}^{(1)}(2), z^{(1)}(3) \ldots, \dot{z}^{(1)}(n)\right), \tag{13}$$

where

$$\dot{z}^{(1)}(1) = \left(\left(0.5 \times \widetilde{z}^{(1)}(k)\right) + \left(0.5 \times \widetilde{z}^{(1)}(k-1)\right)\right); k = 2, 3, 4 \ldots, n. \tag{14}$$

Consider as an example; $\dot{z}^{(1)}(2)$ represents the value in the periodical indicator sequence, after the weakening operator of second order, the accumulating generator operator, and the mean generator operator are applied.

3.1.4 Simulate the Performance Sequences

We use the GM (1, 1) prediction model and the sequences are simulated using the matrices γ and B as follows;

$$\gamma = \begin{bmatrix} \tilde{z}^{(0)}(2) \\ \tilde{z}^{(0)}(3) \\ z^{(0)}(4) \\ \vdots \\ \tilde{z}^{(0)}(n) \end{bmatrix}; B = \begin{bmatrix} -\dot{z}^{(1)}(2) & 1 \\ -\dot{z}^{(1)}(3) & 1 \\ -z^{(1)}(4) & 1 \\ \vdots & \vdots \\ -\dot{z}^{(1)}(n) & 1 \end{bmatrix}. \tag{15}$$

Here, we assume,

$$\frac{d\tilde{z}^{(1)}}{dt} + a\tilde{z}^{(1)} = b. \tag{16}$$

The prediction parameters a, b are observed using the method of least squares, represented as;

$$\hat{a} = [a, b]^T, \tag{17}$$

where $\hat{a}$ represents the column vector of prediction parameters obtained as follows;

$$\hat{a} = \left(\left[B^T B \right]^{-1} B^T \gamma \right). \tag{18}$$

The following expression results after expansion of the terms;

$$\hat{a} = \begin{bmatrix} \left(\frac{\left(\left(\frac{1}{n-1} \left(\sum_{k=2}^{n} \tilde{z}^{(0)}(k) \times \sum_{k=2}^{n} \dot{z}^{(1)}(k) \right) \right) - \left(\sum_{k=2}^{n} \left(\tilde{z}^{(0)}(k) \times \dot{z}^{(1)}(k) \right) \right) \right)}{\left(\sum_{k=2}^{n} \left[\dot{z}^{(1)}(k) \right]^2 - \frac{1}{n-1} \left[\sum_{k=2}^{n} \dot{z}^{(1)}(k) \right]^2 \right)} \right) \\ \left(\frac{1}{n-1} \left(\sum_{k=2}^{n} \tilde{z}^{(0)}(k) + a \sum_{k=2}^{n} \dot{z}^{(1)}(k) \right) \right) \end{bmatrix}. \tag{19}$$

The time response sequences are built based on *GM* (1, 1) model, after obtaining the parameters a, b and is shown as follows;

$$\hat{z}^{(1)}(k+1) = \left(\left[\tilde{z}^{(0)}(1) - \left(\frac{b}{a} \right) \right] e^{-ak} + \left(\frac{b}{a} \right) \right); k = 0, 1, 2, 3 \ldots, n-1, \tag{20}$$

and

$$\hat{z}^{(0)}(k+1) = \hat{z}^{(1)}(k+1) - \hat{z}^{(1)}(k). \tag{21}$$

Based on the Eqs. (20) and (21), we simulate the sequences of social sustainability performances, which are represented as follows;

$$\hat{Z} = \left(\hat{z}^{(0)}(k) \right)_{k=1}^{n}. \tag{22}$$

Say for example, we can say that $\hat{z}^{(0)}(2)$ indicates the simulated sequences for the second period.

3.1.5 Prediction Error Estimates

We calculate the error estimates to observe the accuracy of the prediction results. The prediction results, as obtained for the performances in social sustainability of 10 firms considered in the study were subject to satisfy a *level one* or *level two* predictions, based on five indicative error measures (Rajesh & Rajendran, 2019). The sequences of errors are observed as;

$$\varepsilon^{(0)} = \left(\varepsilon^{(0)}(k)\right)_{k=1}^{n}, \tag{23}$$

where

$$\varepsilon^{(0)}(k) = \left(\widetilde{z}^{(0)}(k) - \widehat{z}^{(0)}(k)\right), \tag{24}$$

and the relative errors of the sequences are as follows;

$$\Delta = \left(\delta_k\right)_{k=1}^{n}, \tag{25}$$

where

$$\delta_k = \frac{\left|\varepsilon^{(0)}(k)\right|}{\widetilde{z}^{(0)}(k)}, \tag{26}$$

with the mean relative errors of the sequences are indicated as follows;

$$\overline{\Delta} = \frac{1}{n}\left(\sum\nolimits_{i=1}^{n} \delta_i\right), \tag{27}$$

and the filtering errors of the sequences are shown as follows;

$$\varnothing = \delta_n. \tag{28}$$

We observe the error measures to lie in their permissible levels for a compatible *level one* or *level two* prediction results.

3.2 Grey Moving Probability Markov Model

Let us assume $\{Y_n : n \in T\}$ as a stochastic process; hence, for any integer $n \in T$ and for any states,$s_0, s_1, \ldots, s_n \in I$, then $\{Y_n : n \in T\}$ is referred to as a Markov chain, supposing that the following condition is satisfied;

$$P\left(Y_{n+1} = s_{n+1} \middle| Y_j = s_i; i, j = 0, 1, \ldots, n\right) = P\left(Y_{n+1} = s_{n+1} \middle| Y_n = s_n\right). \tag{29}$$

Equation (29) reveals that the future state at time $t = n + 1$ is merely dependent on the present state,$t = n$; and therefore, the future state is independent of all past states considering time $t \leq n - 1$. Let us consider the following equation;

$$P_{ij}(n) = P\left(Y_{n+1} = j \middle| Y_n = i\right), \tag{30}$$

which holds true for any random state $n \in T$ and $i, j \in I$, then $P_{ij}(n)$ can be referred to as the moving probability of the Markov chain (Kumar & Jain, 2010). Let's assume, if the moving probability of the Markov chain $P_{ij}(n)$ shows no relation to n, and then $\{Y_n : n \in T\}$ can be said as a homogenous Markov chain. We represent the moving probability matrix, considering a system state of a homogenous Markov chain as follows;

$$P = \left[p_{ij}\right] = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1n} & \cdots \\ p_{21} & p_{22} & \cdots & p_{2n} & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \end{bmatrix}. \tag{31}$$

We assume that the elements of the moving probability matrix are satisfying the following conditions; $p_{ij} \geq 0, i,j \in I$; and $\sum_{j\in I} p_{ij} = 1$, for all $i \in I$. This implies that the row sum of elements of P is always 1. Hence, the n^{th} step moving probability of the Markov chain is indicated as follows;

$$P_{ij}^{(n)} = P\left(Y_{m+n} = j \middle| Y_m = i\right), i,j \in I, n \geq 1 \tag{32}$$

Considering the same, $P^{(n)} = \left[p_{ij}^{(n)}\right]$ is referred to as the n^{th} step moving probability matrix, which fulfills the ensuing properties; $p_{ij}^{(n)} \geq 0, i,j \in I$; $\sum_{j\in I} p_{ij}^{(n)} = 1$, for all $i \in I$; and $P^{(n)} = P^n$.Let's reassume that the moving probability matrix of a Markov chain encompasses of grey values, and then the Markov chain can be referred to as a grey Markov chain (Wang & Meng, 2008). We can take on the initial state distribution of a finite grey Markov chain as,

$$P^T(0) = \left(p_1, p_2, \dots, p_n\right), \tag{33}$$

and let's also assume that the moving probability matrix of the same be represented as,

$$P(\otimes) = \left[P_{ij}(\otimes)\right], \tag{34}$$

And then, the distribution of the next state system can be represented as,

$$P^T(1) = P^T(0) \times P(\otimes). \tag{35}$$

Also, we can represent the second state system distribution as,

$$P^T(2) = P^T(0) \times P^2(\otimes). \tag{36}$$

If we continue like this up to the n^{th} state, we can characterize the system distribution as,

$$P^T(n) = P^T(0) \times P^n(\otimes). \tag{37}$$

Hence, we are able to predict the next state distribution or any future state distributions of the system by knowing the initial distribution and the moving probability matrix.

3.3 Grey State Markov Model

Let's assume $Z = (z(1), z(2), \dots, z(n))$ is representing the raw data series and $\widehat{Z} = (\widehat{z}(1), \widehat{z}(2), \dots, \widehat{z}(n))$ is indicating the simulated data series built using the GM (1, 1) model. Also, we assume that the sequence $\widehat{Z}$ is representing the trend prevalent in the original sequence Z. We divide it into n states in consideration that Z is an instable stochastic sequence and this satisfies the condition of a Markov chain.

$$\otimes_i = \left[\widetilde{\otimes}_{1i}, \widetilde{\otimes}_{2i}\right], \widetilde{\otimes}_i \in \otimes_i, \tag{38}$$

and

$$\widetilde{\otimes}_{1i} = \widehat{z}(k) + A_i; \widetilde{\otimes}_{2i} = \widehat{z}(k) + B_i, i = 1, 2, \dots, n. \tag{39}$$

We define the state moving probability for the sample data having size $M_{ij}(m)$, indicating the development of the system state from $\otimes_i$ to $\otimes_j$ through m steps. And we assume that the size of the sample data remaining at state $\otimes_i$ is M_i; hence the state moving probability is indicated as follows;

$$P_{ij}(m) = \frac{M_{ij}(m)}{M_i}, i = 1, 2, \dots, n \tag{40}$$

We often regard this as a one-step moving probability matrix indicated by P and we take on that the item to be forecasted is at the $\otimes_k$ state. We further check whether the k^{th} row of P is satisfying the following condition;

$$_j^{max} p_{kj} = p_{kl}. \tag{41}$$

If the condition is satisfied, the system can be assumed to develop from state $\otimes_k$ to $\otimes_l$. We further check whether two or more probability values in the k^{th} row of the matrix P are equal or nearly so. If the above condition satisfies, we can observe the n^{th} step moving probability matrices indicated as,$P^{(2)}$,$P^{(3)}$, and $P^{(n)}$. Markov chains and related models find several applications, as seen in literature (Ardia et al., 2018; Fei et al., 2017). We implement a case evaluation to exemplify the methodology elaborated for prediction and the details of the same are discussed in the next section.

4 Case Evaluation

We consider for this study, the integrated ESG ratings of 10 Indian firms that are consistently rated for their social sustainability indicators for the past nine years (Thomson Reuters, 2019). The reason for selecting 9 years as the time period of the study is that continuous ratings are available for the firms for the past nine years and also nine years data can be successfully incorporated in a small data prediction model like GM (1, 1), which is used in this study to provide accurate results. For the study, we separate the indicators of social sustainability from the ESG ratings and we consider the developmental tendencies of the 10 firms for a period of 9 years. We construct five different values for the social sustainability measures by assigning diverse importance weightings to the values of the 4 indicators used in the study: the *shareholders score*, the *community score*, the *product responsibility score*, and the *human rights score*. The weighting schemes vary from assigning equal weightings towards assigning highest priority weightings to each indicator, separately constituting five distinct values for the measure of social sustainability for a particular year. This is done to identify, if any potential biases are there in the calculation of social sustainability scores. The assumed weightings for the four factors (in the order) for the five different instances are as follows; ((0.25, 0.25, 0.25, and 0.25), (0.55, 0.15, 0.15, and 0.15), (0.15, 0.55, 0.15, and 0.15), (0.15, 0.15, 0.55, and 0.15), and (0.15, 0.15, 0.15, and 0.55). The firms considered for analysis of their social sustainability performances, the reference codes for them, their business sector classifications, and the Thomson Reuters economic sector classifications are shown in Table 1. The step-wise implementation of the methodology for prediction is elaborated below.

4.1 Step 1

The initial five sequences representing the social sustainability indicators of the firm code REDY.NS is shown in Table 2. Similarly, the social sustainability indicator

Table 1 Codes and classification of firms considered for analysis

Sl. no.	Ref. code	Company common name	Business sector	TRBC economic sector name	Country of headquarters	TRBC business sector name
1	REDY.NS	Dr. Reddy's Laboratories Ltd	Research and Development in the Physical, Engineering, and Life Sciences	Healthcare	India	Pharmaceuticals & Medical Research
2	GLSM.NS	GlaxoSmithKline Consumer Healthcare Ltd	Food Processing	Consumer Non-Cyclicals	India	Food & Beverages
3	BHEL.NS	Bharat Heavy Electricals Ltd	Air & Gas Compressor Mfg	Industrials	India	Industrial Goods
4	ITC.NS	ITC Ltd	Paperboard Mills	Consumer Non-Cyclicals	India	Food & Beverages
5	LART.NS	Larsen & Toubro Ltd	Engineering Services	Industrials	India	Industrial & Commercial Services
6	MAHM.NS	Mahindra and Mahindra Ltd	Sales Financing	Consumer Cyclicals	India	Automobiles & Auto Parts
7	TISC.NS	Tata Steel Ltd	Iron & Steel	Basic Materials	India	Mineral Resources
8	SAIL.NS	Steel Authority of India Ltd	Steel—NEC	Basic Materials	India	Mineral Resources
9	SUN.NS	Sun Pharmaceutical Industries Ltd	Medicinal & Botanical Mfg	Healthcare	India	Pharmaceuticals & Medical Research
10	MRTI.NS	Maruti Suzuki India Ltd	Automobiles—4 Wheelers	Consumer Cyclicals	India	Automobiles & Auto Parts

**TRBC* Thomson Reuters Business Classification, *Mfg*. manufacturing

Table 2 Initial sequences, first and second order weakening sequences of data (REDY.NS)

Year	Soc. Sus. 1	Soc. Sus. 2	Soc. Sus. 3	Soc. Sus. 4	Soc. Sus. 5
Initial periodical sequences					
2010	76.408	63.028	84.718	79.648	78.239
2011	77.373	65.918	85.411	77.563	80.601
2012	84.488	75.512	90.211	83.705	88.524
2013	81.618	70.853	88.5	80.735	86.382
2014	82.555	78.324	89.093	75.247	87.555
2015	86.869	87.475	91.111	82.626	86.263
2016	81.674	78.665	85.784	78.326	83.919
2017	82.364	79.961	85.543	79.031	84.922
2018	83.173	83.596	85.442	78.981	84.673
ZD					
2010	81.836	75.926	87.313	79.54	84.564
2011	82.514	77.538	87.637	79.527	85.355
2012	83.249	79.198	87.955	79.807	86.034
2013	83.042	79.812	87.579	79.158	85.619
2014	83.327	81.604	87.395	78.842	85.466
2015	83.52	82.424	86.97	79.741	84.944
2016	82.404	80.741	85.59	78.779	84.505
2017	82.769	81.779	85.493	79.006	84.798
2018	83.173	83.596	85.442	78.981	84.673
ZD^2					
2010	82.87	80.291	86.819	79.265	85.106
2011	83	80.837	86.758	79.23	85.174
2012	83.069	81.308	86.632	79.188	85.148
2013	83.039	81.659	86.412	79.085	85.001
2014	83.039	82.029	86.178	79.07	84.877
2015	82.967	82.135	85.874	79.127	84.73
2016	82.782	82.039	85.508	78.922	84.659
2017	82.971	82.688	85.468	78.994	84.736
2018	83.173	83.596	85.442	78.981	84.673

sequences for all other firms are constructed. The first and second order weakening operators are employed and the sequences corresponding to the same are constructed as per Eqs. (1)–(10). The sequences corresponding to the same for the firm code REDY.NS is shown in Table 2. Similarly, the weakening operator sequences for all other firms are calculated.

4.2 Step 2

The first aggregate generator operator sequences and the mean generator operator sequences are constructed as per Eqs. (11)–(14). These sequences for the firm code REDY.NS is as shown in Table 3. Similarly, for all other nine firms the sequences are constructed.

Table 3 First aggregate generator and mean generator sequences of data (REDY.NS)

Year	1 AGO					Year	Mean GS				
	Soc. Sus. 1	Soc. Sus. 2	Soc. Sus. 3	Soc. Sus. 4	Soc. Sus. 5		Soc. Sus. 1	Soc. Sus. 2	Soc. Sus. 3	Soc. Sus. 4	Soc. Sus. 5
2010	82.87	80.291	86.819	79.265	85.106	2010	–	–	–	–	–
2011	165.87	161.128	173.577	158.495	170.28	2011	124.37	120.71	130.198	118.88	127.693
2012	248.939	242.436	260.209	237.683	255.428	2012	207.405	201.782	216.893	198.089	212.854
2013	331.978	324.095	346.621	316.768	340.429	2013	290.459	283.266	303.415	277.226	297.929
2014	415.017	406.124	432.799	395.838	425.306	2014	373.498	365.11	389.71	356.303	382.868
2015	497.984	488.259	518.673	474.965	510.036	2015	456.501	447.192	475.736	435.402	467.671
2016	580.766	570.298	604.181	553.887	594.695	2016	539.375	529.279	561.427	514.426	552.366
2017	663.737	652.986	689.649	632.881	679.431	2017	622.252	611.642	646.915	593.384	637.063
2018	746.91	736.582	775.091	711.862	764.104	2018	705.324	694.784	732.37	672.372	721.768

4.3 Step 3

The matrices for estimating the prediction parameters are built as per Eqs. (15)–(19) for the five sequences, separately. These matrices for the firm code REDY.NS is as shown in Table 4. Similarly, the tabulations are made for other firms, as well.

4.4 Step 4

The simulated accumulating generator sequences and the actual simulated sequences are built, as per Eqs. (20)–(22). Predictions are made for the year 2019 and 2020, based on the data available till 2018. The simulated value of social sustainability performances for the year 2018, as well as the predicted value of social sustainability performances for year 2019 and 2020 for the firm code REDY.NS is shown in Table 5. Likewise for other firms, the sequences are built.

4.5 Step 5

The error measures are constructed for the GM (1, 1) model as per Eqs. (23)–(28). Based on the basic error measure, as shown in Eqs. (23) and (24), we construct different error states. Here, for the 10 firms, we carefully observe the errors and construct error intervals by considering 6 different error states. The error states for the firm code REDY.NS is indicated in Table 6. Similarly, the tabulations are made for other firms, as well. The range of error values is also shown in Table 6.

4.6 Step 6

The sum of moving probabilities for transition from one state to another is tabulated for all the five constructed sequences of social sustainability performances, based on the computed errors. These four sequences can represent the one step moving probability values, the two step moving probability values, the three step moving probability values, and the four step moving probability values. The basis for calculating the moving probabilities is as shown in Eqs. (29)–(41). These four sequences for the firm code REDY.NS is as presented in Table 7. Likewise for other firms, the sequences are constructed. Hence, the moving probabilities are calculated for 10 firms, 5 instances, and 6 states with 4 set of moving probabilities, i.e., we observe 200 ($10 \times 5 \times 4$) moving probability values. Say for instance, the one step moving probability represents the probability of moving from one state of error to another state, considering a one-step movement. Similarly, the two step moving probability indicates the probability of moving from one state of error to another state, considering a two-step movement. Likewise, the three step and four step moving probabilities are calculated.

4.7 Step 7

The sum total of the probabilities for 5 instances, and 6 states with 4 set of moving probabilities are calculated and the final values of the same for all the 10 firms taken into consideration are shown in Table 8. The moving probabilities considering the four

Table 4 Prediction matrices for GM (1, 1) as constructed (REDY.NS)

$B_1{}^TB_1$		$B_2{}^TB_2$		$B_3{}^TB_3$		$B_4{}^TB_4$		$B_5{}^TB_5$	
3.45749E−06	0.0014345	3.541E−06	0.00144	3.21799E−06	0.00139	3.80857E−06	0.001507	3.3068E−06	0.001405
0.001434506	0.7201735	0.001440197	0.710758	0.00139044	0.725785	0.001507279	0.721521	0.00140549	0.722371
$B_1{}^{T}\Upsilon_1$		$B_2{}^{T}\Upsilon_2$		$B_3{}^{T}\Upsilon_3$		$B_4{}^{T}\Upsilon_4$		$B_5{}^{T}\Upsilon_5$	
− 275,503.805	− 275,503.8	− 268,053.403	− 268,053	− 296,614.26	− 296,614	− 250,232.402	− 250,232	− 288,306.12	− 288,306
664.04	664.04	656.291	656.291	688.272	688.272	632.597	632.597	678.998	678.998
$(B_1{}^TB_1)^{-1}*(B_1{}^{T}\Upsilon_1)$		$(B_2{}^TB_2)^{-1}*(B2^{T}\Upsilon_2)$		$(B_3{}^TB_3)^{-1}*(B_3{}^{T}\Upsilon_3)$		$(B_4{}^TB_4)^{-1}*(B_4{}^{T}\Upsilon_4)$		$(B_5{}^TB_5)^{-1}*(B_5{}^{T}\Upsilon_5)$	
1.751E−05		− 0.00399		0.002498		0.000474		0.000946	
83.012263		80.41426		87.1135		79.26205		85.27676	

Table 5 Prediction error estimation for the GM (1, 1) model (REDY.NS)

Predicted errors							
Year	Soc. Sus. 1	Soc. Sus. 2	Soc. Sus. 3	Soc. Sus. 4	Soc. Sus. 5	1 AGO	
2010	0	0	0	0	0	2018	746.91
2011	– 0.01	−0.059	−0.03	0.024	0.018	2019	829.908
2012	0.06	0.089	0.06	0.02	0.073	2020	912.905
2013	0.032	0.116	0.057	−0.046	0.005	**Actual Predicted**	
2014	0.033	0.159	0.038	– 0.023	– 0.037	2019	82.998
2015	– 0.037	– 0.061	– 0.051	0.071	– 0.105	2020	82.997
2016	– 0.221	– 0.486	– 0.203	– 0.096	– 0.095		
2017	– 0.03	– 0.167	– 0.029	0.013	0.062		
2018	0.173	0.41	0.158	0.037	0.079		

Table 6 Error states of prediction (REDY.NS)

Error states of prediction						Error ranges		
Year	Soc. Sus. 1	Soc. Sus. 2	Soc. Sus. 3	Soc. Sus. 4	Soc. Sus. 5	States	Range	Mean error
2010	State 3	State 3	State 3	State 3	State 3	State 1	(– 3, – 1)	– 2
2011	State 3	State 3	State 3	State 4	State 4	State 2	(– 1, – 0.5)	– 0.75
2012	State 4	State 4	State 4	State 4	State 4	State 3	(– 0.5, 0)	– 0.25
2013	State 4	State 4	State 4	State 3	State 4	State 4	(0, 0.5)	0.25
2014	State 4	State 4	State 4	State 3	State 3	State 5	(0.5, 1)	0.75
2015	State 3	State 3	State 3	State 4	State 3	State 6	(1, 3)	2
2016	State 3	State 3	State 3	State 3	State 3			
2017	State 3	State 3	State 3	State 4	State 4			
2018	State 4	State 4	State 4	State 4	State 4			

set (one step, two step, three step, and four step) of values in contemplation and the sum total of the moving probabilities for the firm REDY.NS is pictorially displayed in Fig. 2. This is for clarity of understanding and for visualization purposes. Similarly, the moving probabilities and the cumulative moving probabilities can be represented for other firms, as well.

4.8 Step 8

The sum of total probabilities and the error states for the predicted year 2019 and 2020 are calculated and are shown in Table 9. The cumulative sum of state moving probabilities for all the 10 firms for the 6 states are graphically displayed in Fig. 3.

Table 7 Moving probabilities for the error states (REDY.NS)

Sum of moving probabilities

P_1	1	2	3	4	5	6	Sum	States	Prob
1	0	0	0	0	0	0	0	4	0
2	0	0	0	0	0	0	0	4	0
3	0	0	0.521739	0.478261	0	0	1	3	0.5
4	0	0	0.5	0.5	0	0	1	3	0.5
5	0	0	0	0	0	0	0	3	0
6	0	0	0	0	0	0	0	4	0
								Sum	1
P_2	1	2	3	4	5	6	Sum	States	Prob
1	0	0	0	0	0	0	0	4	0
2	0	0	0	0	0	0	0	4	0
3	0	0	0.347826	0.652174	0	0	1	3	0.5
4	0	0	0.681818	0.318182	0	0	1	3	0.5
5	0	0	0	0	0	0	0	3	0
6	0	0	0	0	0	0	0	4	0
								Sum	1
P_3	1	2	3	4	5	6	Sum	States	Prob
1	0	0	0	0	0	0	0	3	0
2	0	0	0	0	0	0	0	3	0
3	0	0	0.391304	0.608696	0	0	1	4	0.5
4	0	0	0.727273	0.272727	0	0	1	3	0.5
5	0	0	0	0	0	0	0	4	0
6	0	0	0	0	0	0	0	4	0
								Sum	1
P_4	1	2	3	4	5	6	Sum	States	Prob
1	0	0	0	0	0	0	0	4	0
2	0	0	0	0	0	0	0	3	0
3	0	0	0.478261	0.521739	0	0	1	3	0.5
4	0	0	0.5	0.5	0	0	1	3	0.5
5	0	0	0	0	0	0	0	4	0
6	0	0	0	0	0	0	0	4	0
								Sum	1

4.9 Step 9

The modified predicted sequences, based on the combined model of GM (1, 1) and the moving probability state Markov model based error correction model is as represented in Table 10.

Table 8 Sum total of the moving probabilities (All firms)

Sum of total probabilities						
REDY.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	0	0	0	0	0
State 2	0	0	0	0	0	0
State 3	0	0	1.73913	2.26087	0	0
State 4	0	0	2.409091	1.590909	0	0
State 5	0	0	0	0	0	0
State 6	0	0	0	0	0	0
GLSM.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	2	2	0	0	0
State 2	0	0.375	1.75	0.625	0.875	0.375
State 3	0	0.666667	1.5	0.944444	0.777778	0.111111
State 4	0	1.111111	1.888889	0.444444	0.555556	0
State 5	0.142857	0.714286	1.428571	1.142857	0.285714	0.285714
State 6	1	0.5	1	1	0	0.5
BHEL.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	0	0	0	0	0
State 2	0	0	2	2	0	0
State 3	0	0.041667	2.166667	1.625	0.166667	0
State 4	0	0.055556	2.388889	1.388889	0.166667	0
State 5	0	0.5	2	1.5	0	0
State 6	0	0	0	0	0	0
ITC.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	0	0	0	0	0
State 2	0	0	4	0	0	0
State 3	0	0.04	2	1.84	0.12	0
State 4	0	0.111111	2.388889	1.444444	0.055556	0
State 5	0	1	2	1	0	0
State 6	0	0	0	0	0	0
LART.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	0	0	0	0	0
State 2	0	0.666667	1.5	0.5	0.833333	0.5
State 3	0	0.5	1.863636	0.909091	0.681818	0.045455
State 4	0	0.6	2.6	0.6	0.2	0
State 5	0	0.5	1.666667	1.666667	0.166667	0
State 6	0	0	2	1	1	0
MAHM.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	0	0	0	0	0
State 2	0	1.428571	0.428571	1.714286	0.428571	0
State 3	0.411765	0.588235	1.235294	1.411765	0.352941	0
State 4	0	0.705882	2.176471	0.941176	0.176471	0

Table 8 (continued)

MAHM.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 5	0	1.5	1.5	0.75	0.25	0
State 6	0	0	0	0	0	0
TISC.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	0	0	0	0	0
State 2	0	0	0	0	0	0
State 3	0	0	1.818182	2.181818	0	0
State 4	0	0	2	2	0	0
State 5	0	0	0	0	0	0
State 6	0	0	0	0	0	0
SAIL.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	0	0	0	0	0
State 2	0	0.285714	1.142857	2	0.571429	0
State 3	0	0.888889	1.333333	1.388889	0.388889	0
State 4	0	0.5	2.125	1.125	0.25	0
State 5	0	0.5	1.5	2	0	0
State 6	0	0	0	0	0	0
SUN.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0	0	4	0	0	0
State 2	0	0.333333	2	1.333333	0.333333	0
State 3	0	0.266667	1.066667	2.266667	0.333333	0.066667
State 4	0.105263	0.842105	1.105263	1.578947	0.263158	0.105263
State 5	0.333333	0.666667	1.333333	1.333333	0	0.333333
State 6	1	0	3	0	0	0
MRTI.NS	State 1	State 2	State 3	State 4	State 5	State 6
State 1	0.444444	0.333333	1.333333	0.777778	0.444444	0.666667
State 2	0	0	0.5	0.5	1.5	1.5
State 3	0.923077	0.230769	0.846154	0.692308	0.769231	0.538462
State 4	0.333333	0.333333	1	0.5	1.166667	0.666667
State 5	1.25	0	1.375	0.5	0.5	0.375
State 6	1.142857	0	1.571429	0.285714	0.285714	0.714286

5 Results and Discussion

Integrated performance evaluation for social sustainability is receiving increased attention in recent times, as this can be reflected in the increase in number of research articles that discusses on the same (Dempsey et al., 2011; Vallance et al., 2011). Many research works can be seen discussing the theme of social sustainability with a conceptual basis (Hervani et al., 2017; Wang et al., 2018). Also, we can see that some of the works are based on empirical evidences, while others have discussed on the modeling aspects of social sustainability (Mani et al., 2020; Sroufe & Gopalakrishna-Remani, 2019). We formulate a

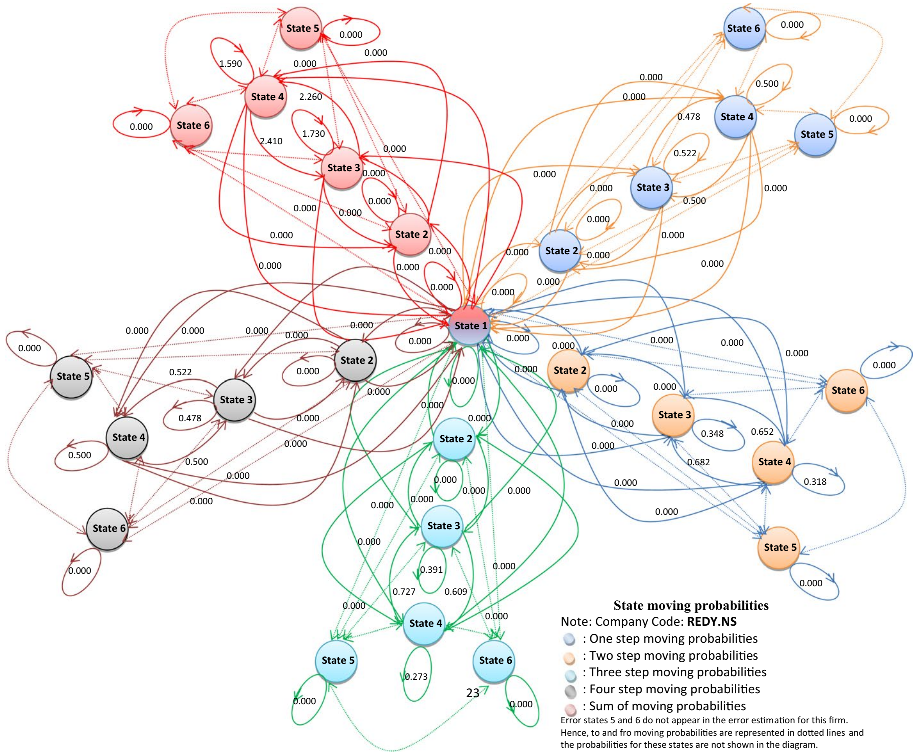

Fig. 2 State moving probabilities. Note: Company Code: REDY.NS

periodic performance prediction model for social sustainability that considers four measurement aspects of social sustainability. These four indicators include the *workforce score*, the *human rights score*, the *community score*, and the *product responsibility score*. We have formulated a periodic prediction model for the social sustainability performance indicators of firms, based on the basic grey prediction model (GM (1, 1)) and the moving probability Markov model based error state prediction model. The combined model is capable of handling small data and provides useful and reliable prediction results.

The case evaluation has been conducted for 10 Indian firms and the results of prediction are analyzed. We observe the following from the trends of prediction; four (GLSM.NS, SAIL.NS, SUN.NS, and MRTI.NS) of the considered firms show increasing trends for social sustainability performances for the year 2019, while six (REDY.NS, BHEL.NS, ITC.NS, LART.NS, MAHM.NS, and TISC.NS) among them show decreasing trends for social sustainability performances. This shows that major Indian firms need to consider revisiting their strategies to support more social sustainability initiatives. These declaiming trends for firms are alarming and social sustainability should be considered with high priorities to upsurge its performances through proactive measures. Considering the trends for the year 2020, we observe some similar patterns, but more firms are showing better performances on social sustainability, when compared to 2019.The Indian firms that are considered for analysis and prediction and are showing increasing trends for social sustainability performances for the year 2020 are GLSM.NS, BHEL.NS, TISC.NS, SAIL.NS, and SUN.

Table 9 Sum total of probabilities for the predicted year (All firms)

	Total probabilities for the predicted year			
	Sum of probabilities 2019	Sum probabilities 2020	Error state for 2019	Error state for 2020
REDY.NS			Total probability (2019)	Total probability (2020)
			2.074110672	2.049713712
State 1	0	0		
State 2	0	0		
State 3	2.074111	2.049714	State 3	State 3
State 4	1.925889	1.950286		
State 5	0	0		
State 6	0	0		
GLSM.NS			Total probability (2019)	Total probability (2020)
			1.448743386	1.504285819
State 1	0.047619	0.06994		
State 2	0.708333	0.610303		
State 3	1.448743	1.504286	State 3	State 3
State 4	0.88459	0.897613		
State 5	0.563823	0.654993		
State 6	0.346892	0.262865		
BHEL.NS			Total probability (2019)	Total probability (2020)
			2.092592593	2.225565844
State 1	0	0		
State 2	0.138889	0.062114		
State 3	2.092593	2.225566	State 3	State 3
State 4	1.615741	1.560185		
State 5	0.152778	0.152135		
State 6	0	0		
ITC.NS			Total probability (2019)	Total probability (2020)
			2.166666667	2.231130864
State 1	0	0		
State 2	0.254074	0.08051		
State 3	2.166667	2.231131	State 3	State 3
State 4	1.502222	1.599898		
State 5	0.077037	0.088461		
State 6	0	0		
LART.NS			Total probability (2019)	Total probability (2020)
			2.014646465	2.010417815
State 1	0	0		

Table 9 (continued)

LART.NS			Total probability (2019) 2.014646465	Total probability (2020) 2.010417815
State 2	0.483838	0.605133		
State 3	2.014646	2.010418	State 3	State 3
State 4	0.886364	0.816824		
State 5	0.544444	0.467586		
State 6	0.070707	0.100038		
MAHM.NS			Total probability (2019) 1.669467787	Total probability (2020) 1.254407645
State 1	0.137255	0.101932		
State 2	0.906863	1.01866		
State 3	1.669468	1.161353	State 3	
State 4	1.023109	1.254408		State 4
State 5	0.263305	0.326392		
State 6	0	0		
TISC.NS			Total probability (2019) 2.050395257	Total probability (2020) 2.079320226
State 1	0	0		
State 2	0	0		
State 3	2.050395	1.92068	State 3	
State 4	1.949605	2.07932		State 4
State 5	0	0		
State 6	0	0		
SAIL.NS			Total probability (2019) 1.696097884	Total probability (2020) 1.577267114
State 1	0	0		
State 2	0.510582	0.618982		
State 3	1.696098	1.44641	State 3	
State 4	1.54795	1.577267		State 4
State 5	0.24537	0.35734		
State 6	0	0		
SUN.NS			Total probability (2019) 1.588888889	Total probability (2020) 1.852387401
State 1	0.330409	0.083303		
State 2	0.535673	0.394382		
State 3	1.588889	1.254273	State 3	
State 4	1.342982	1.852387		State 4
State 5	0.128947	0.326099		

Table 9 (continued)

SUN.NS			Total probability (2019)	Total probability (2020)
			1.588888889	1.852387401
State 6	0.073099	0.089556		
MRTI.NS			Total probability (2019)	Total probability (2020)
			1.25709707	1.036249662
State 1	0.734178	0.674705		
State 2	0.205128	0.158569		
State 3	1.257097	1.03625	State 3	State 3
State 4	0.579645	0.595759		
State 5	0.647945	0.785271		
State 6	0.576007	0.749446		

NS; while the firms REDY.NS, ITC.NS, LART.NS, MAHM.NS, MRTI.NS show declining performances on social sustainability performances for the year 2020, as per the results observed from the proposed prediction model. We have done a validation of the results considering the best fit distribution for the data representing each of the 10 firms. This is done using the ©XLSTAT software and the best distribution considering the fit of data are observed. The distribution fit, the *p* values, and the parameters for the best fit distribution are calculated and are represented in Table 11.

In order to validate the findings of study and for the generalizability of the results, we analyse the data of 39 Indian firms listed in the Thompson Reuters ESG evaluation and are continuously rated for a period of 10 years from 2009 to 2018. We observe that some of the firms show too fast or too slow developmental tendencies considering a past data trend. Hence to avoid this trend, we restrict our analysis for a period from 2014 to 2018 and observe for predicting the social sustainability performances of these firms for 2019. We have assigned equal weighting (0.25) for the four indicators of social sustainability performance namely; *shareholders score*, *the community score*, *the product responsibility score*, *and the human rights score* for calculating the overall score for social sustainability performances. This is to reduce the bias and to obtain the social sustainability score with equal consideration to all of the four indicators. We observe from the results of implementation of the grey prediction model to the 39 firms that the social sustainability indicators of Indian firms need significant improvements. Among these firms, 16 out of the 39 show declining trends for social sustainability performances and 19 of them show slight improvements.

Only four firms (VDN.NS, GOCP.NS, DIVI.NS, and PIRA.NS) show significant improvements in the social sustainability performance scores for the predicted year 2019. The detailed results of prediction considering the 39 firms, their industrial sector classifications are shown in Table 13 and are attached in the "Appendix". Hence, the analysis substantiates the results of our study that the Indian firms need significant focus on their social sustainability and indicators and this also throw insights into the policy implications of the study. As we consider the data corresponding to a five year window and the Markov based error corrections were not applied, some small discrepancies in the prediction results has been observed for the prior firms. The firms REDY.NS, BHEL.NS, GLSM.NS, LART.

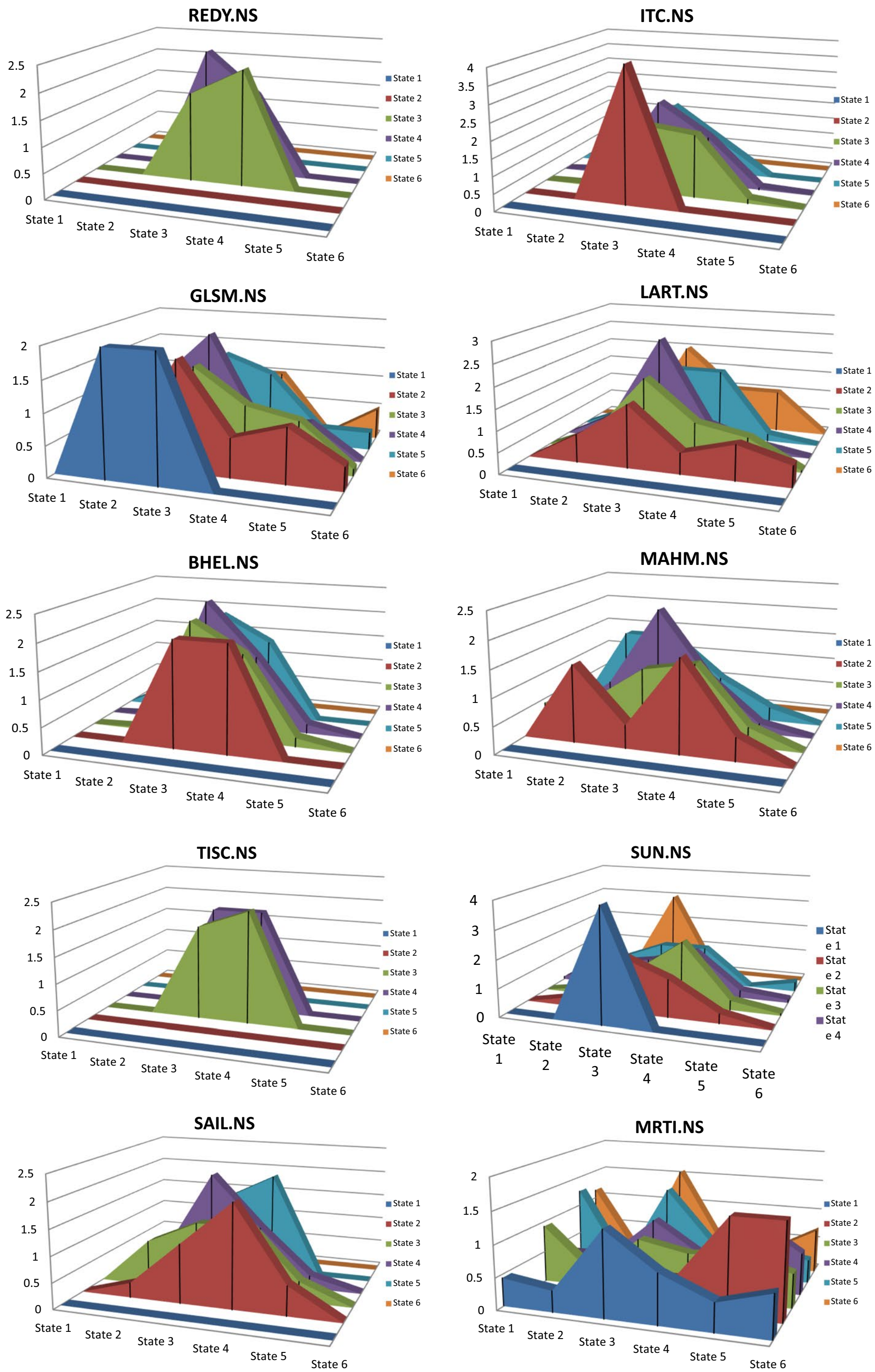

Fig. 3 Cumulative sum of state moving probabilities

Table 10 Error adjusted predicted values for social sustainability indicators for the case firms

Sl. no	Code	Error state 2019	Error state 2019	Error correction 2019	Error correction 2020	Actual prediction 2019	Actual prediction 2020	Adjusted prediction 2019	Adjusted prediction 2020
1	REDY.NS	State 3	State 3	− 0.25	− 0.25	82.998	82.997	82.748	82.747
2	GLSM.NS	State 3	State 3	− 0.25	− 0.25	56.748	57.448	56.498	57.198
3	BHEL.NS	State 3	State 3	− 0.25	− 0.25	49.38	49.842	49.13	49.592
4	ITC.NS	State 3	State 3	− 0.25	− 0.25	72.654	72.537	72.404	72.287
5	LART.NS	State 3	State 3	− 0.25	− 0.25	53.264	52.844	53.014	52.594
6	MAHM.NS	State 3	State 4	− 0.25	0.25	75.573	75.03	75.323	75.28
7	TISC.NS	State 3	State 4	− 0.25	0.25	94.302	94.427	94.052	94.677
8	SAIL.NS	State 3	State 4	− 0.25	0.25	76.499	76.3	76.249	76.55
9	SUN.NS	State 3	State 4	− 0.25	0.25	59.272	60.209	59.022	60.459
10	MRTI.NS	State 3	State 3	− 0.25	− 0.25	79.367	78.894	79.117	78.644

Table 11 Best fit distribution for the data of 10 Indian firms

Distribution	*p* value	Distribution	*p* value	Distribution	*p* value	Distribution	*p* value	Distribution	*p* value
Beta4	0.743	**Chi-square**	**0.903**	**Beta4**	**0.962**	Chi-square	0.135	**Chi-square**	**0.976**
Chi-square	0.155	Erlang	0.645	Chi-square	0.513	Erlang	0.892	Erlang	0.933
Erlang	0.572	Exponential	0.023	Erlang	0.327	Exponential	0.002	Exponential	0.007
Exponential	0.002	Fisher-Tippett (1)	0.000	Exponential	0.012	Fisher-Tippett (1)	0.000	Fisher-Tippett (1)	0.000
Fisher-Tippett (1)	0.000	Fisher-Tippett (2)	0.895	Fisher-Tippett (1)	0.000	Fisher-Tippett (2)	0.918	Fisher-Tippett (2)	0.943
Fisher-Tippett (2)	0.390	Gamma (1)	0.000	Fisher-Tippett (2)	0.423	Gamma (2)	0.875	Gamma (1)	0.000
Gamma (2)	0.618	Gamma (2)	0.789	Gamma (1)	0.000	**GEV**	**0.934**	Gamma (2)	0.801
GEV	0.744	GEV	0.059	Gamma (2)	0.402	Gumbel	0.000	GEV	0.707
Gumbel	0.000	Gumbel	0.000	GEV	0.087	Log-normal	0.815	Gumbel	0.000
Log-normal	0.653	Log-normal	0.804	Gumbel	0.000	Logistic	0.885	Log-normal	0.819
Logistic	**0.839**	Logistic	0.827	Log-normal	0.390	Normal	0.811	Logistic	0.786
Normal	0.678	Normal	0.760	Logistic	0.625	Normal (Standard)	0.000	Normal	0.759
Normal (Standard)	0.000	Normal (Standard)	0.000	Normal	0.432	Student	0.000	Normal (Standard)	0.000
Student	0.000	Student	0.000	Normal (Standard)	0.000	Weibull (2)	0.744	Student	0.000
Weibull (2)	0.816	Weibull (2)	0.718	Student	0.000	Weibull (3)	0.000	Weibull (2)	0.705
				Weibull (2)	0.557			Weibull (3)	0.000

Best Fit: Logistic distribution

Estimated parameters(Logistic):

Parameter	Value	Standard error
μ	82.595	0.969
s	1.356	0.448

Best Fit: Chi-square distribution

Estimated parameter(Chi-square):

Parameter	Value	Standard error
DF	46.241	0.524

Best Fit: Beta4 distribution

Estimated parameters (Beta4):

Parameter	Value	Standard error
alpha	2.069	0.868
beta	0.683	0.081
c	30.154	1.555
d	50.728	

Best Fit: GEV distribution

Estimated parameters(GEV):

Parameter	Value	Standard error
k	-0.014	0.333
beta	2.212	0.578
μ	72.890	0.568

Best Fit: Chi-square distribution

Estimated parameter(Chi-square):

Parameter	Value	Standard error
DF	62.982	0.517

Table 11 (continued)

Distribution	*p* value	Distribution	*p* value	Distribution	*p* value	Distribution	*p* value	Distribution	*p* value
Chi-square	0.214	**Beta4**	**0.954**	Chi-square	0.667	Chi-square	0.940	Beta4	0.525
Erlang	0.970	Chi-square	0.127	Erlang	0.761	Erlang	0.708	Chi-square	0.684
Exponential	0.003	Erlang	0.587	Exponential	0.005	Exponential	0.022	Erlang	0.848
Fisher-Tippett (1)	0.000	Exponential	0.003	Fisher-Tippett (1)	0.000	Fisher-Tippett (1)	0.000	Exponential	0.005
Fisher-Tippett (2)	0.917	Fisher-Tippett (1)	0.000	Fisher-Tippett (2)	0.612	Fisher-Tippett (2)	0.858	Fisher-Tippett (1)	0.000
Gamma (2)	**0.987**	Fisher-Tippett (2)	0.470	Gamma (1)	0.000	Gamma (1)	0.000	Fisher-Tippett (2)	0.862
GEV	0.080	Gamma (2)	0.660	Gamma (2)	0.772	**Gamma (2)**	**0.963**	Gamma (1)	0.000
Gumbel	0.000	GEV	0.126	GEV	0.087	GEV	0.079	Gamma (2)	0.795
Log-normal	0.963	Gumbel	0.000	Gumbel	0.000	Gumbel	0.000	GEV	0.030
Logistic	0.978	Log-normal	0.654	Log-normal	0.744	Log-normal	0.930	Gumbel	0.000
Normal	0.972	Logistic	0.894	**Logistic**	**0.910**	Logistic	0.954	Log-normal	0.800
Normal (Standard)	0.000	Normal	0.688	Normal	0.821	Normal	0.949	**Logistic**	**0.864**
Student	0.000	Normal (Standard)	0.000	Normal (Standard)	0.000	Normal (Standard)	0.000	Normal	0.787
Weibull (2)	0.968	Student	0.000	Student	0.000	Student	0.000	Normal (Standard)	0.000
Weibull (3)	0.000	Weibull (2)	0.927	Weibull (2)	0.875	Weibull (2)	0.944	Student	0.000
				Weibull (3)	0.000	Weibull (3)	0.001	Weibull (2)	0.763
Best Fit: Gamma (2) distribution		Best Fit: Beta4 distribution						Weibull (3)	0.000

Estimated parameters (Gamma (2)):

Parameter	Value	Standard error
k	385.90	194.299
beta	0.208	0.105

Estimated parameters (Beta4):

Parameter	Value	Standard error
alpha	3.499	1.043
beta	1.144	0.119
c	80.219	1.771
d	95.542	

Best Fit: Logistic distribution

Estimated parameters(Logistic):

Parameter	Value	Standard error
μ	75.262	
s	4.370	

Best Fit: Gamma (2) distribution

Estimated parameters(Gamma (2)):

Parameter	Value	Standard error
k	19.694	9.879
beta	2.272	1.154

Best Fit: Logistic distribution

Estimated parameters(Logistic):

Parameter	Value	Standard error
μ	78.937	0.972
s	5.119	0.972

NS, TISC.NS, and SUN.NS show slight improvements in their social sustainability performances, where the firms ITC.NS, MAHM.NS, MRTI.NS, and SAIL.NS show declining performances for their social sustainability performances.

6 Conclusions and Scope of Future Works

We have offered in this study, an integrated prediction model using grey theory and moving probability state Markov models for evaluating and predicting the performances in social sustainability of firms. We have used the data and information related to social sustainability performances of 10 Indian firms from 2010 to 2018 and the predictions for their social sustainability performances were made for the year 2019 and 2020.The evaluations were made based on 4 major indicators of social sustainability performances and social sustainability performance sequences are constructed for 5 instances, by changing the weighting scheme of these indicators. The first one, among the sequences was constructed assuming an equal weighting scheme for these indicators; whereas, four of the other sequences are constructed by assuming highest weightings to individual indicators, separately for each instance; while assuming equal weightings for the other indicators.

It is observed from the results of the combined prediction model that Indian firms have to mend or amend their strategies to focus more on their social sustainability performances. Although some of the firms show slight increasing performances for the indicators, most of them follow declining trends. Hence, this research can provide directions for firms towards setting a benchmark for their social sustainability performances and to improve the lagging indicators to achieving and sustaining this benchmark level. There are some confines of this study, as well. The performance indicators taken in this research are the indicators taken into consideration by Thomson Reuters for evaluating the social sustainability performances of firms. Several other rating agencies, such as; the Global Reporting Initiatives, IChemE, or the Wuppertal Sustainability Indicators, and Sustainalytics may provide different indicators to assess the social sustainability performances of firms.

Although a comparative study using the data from Sustainalytics is shown in the study, a detailed relative study considering other indicators into prediction model can provide more insights and can be considered as a direction of future work. Also, we have considered only 10 Indian firms that are consistently rated for their social sustainability for the past 10 years by Thomson Reuters. More firms can be included into study by reducing the time span for consideration. Even though, 29 more firms were later incorporated and considered for the generalizability of the results, additional data can be incorporated to further validate the results. This can provide more insights in the direction of a comparative study on social sustainability performances and can be regarded as another direction of prospect works. As we see that the research consider 10 Indian firms for analysis, followed by the addition of 29 firms, the results are not generic and can be assumed that similar results may be expected for other firms, as well. A detailed study in this direction can provide more discernment on it.

As discussed prior, we analyze the results of the study, considering the alternative data of ESG risk ratings of Sustainalytics, a different ESG score benefactor. The ESG risk ratings provided by Sustainalytics can capture the exposure to ESG risk of a firm, the industry

Table 12 Predicted social sustainability performances and risk orderings by Sustainalytics

Sl. no.	Code	Adjusted prediction 2019	Adjusted prediction 2020	Sustainalytics ratings 2020–2022	Risk category
1	REDY.NS	82.748	82.747	31.4	High
2	GLSM.NS	56.498	57.198	29.7	Medium
3	BHEL.NS	49.13	49.592	35.2	High
4	ITC.NS	72.404	72.287	27.5	Medium
5	LART.NS	53.014	52.594	34.4	High
6	MAHM.NS	75.323	75.28	19.3	Low
7	TISC.NS	94.052	94.677	35.9	High
8	SAIL.NS	76.249	76.55	40.9	Severe
9	SUN.NS	59.022	60.459	36.2	High
10	MRTI.NS	79.117	78.644	25.7	Medium

specific risks of a firm, and it also reports how firms manage these ESG risks. The risk ratings on ESG provided by Sustainalytics can provide an overall ESG risk score for investors to understand how much of the ESG risk of a company remain unmanaged. As being a negative indicator, we see that the more of the risk is unmanaged, and then higher is the ESG risk rating score. The score is calculated across 138 pre-defined sub-industry classifications and are based on 20 material ESG issues. Controversies are assessed and accommodated in the ESG, resulting in the decrease in the management score and a subsequent increase in the ESG risk score. The predicted social sustainability performances using the proposed model are compared with the ESG risk ratings and risk classifications of firms provided by Sustainalytics. This is shown in Table 12. We observe the measures of Spearman's rank correlation (− 0.042) with coefficient of determination (0.002) for the social sustainability predicted performance values and the ESG risk ratings of the company provided by Sustainalytics. A Pearson coefficient of correlation (− 0.125) was also calculated to verify the results, where the coefficient of determination (0.016) is also intended.

Even though a weak negative correlation is only observed, the negative correlation is indicating that the social sustainability indicators of ESG are performing well, then there is less probability that the firms are included under a high risk category by the ESG rating scheme. Although, the measures and indicators of ESG ratings by Thomson Reuters and the ESG risk ratings by Sustainalytics may vary, we can interpret our results in the light of the risk classifications provided by Sustainalytics. We observe that majority of the firms (6 out of 10) considered for the study are classified under the severe or high risk category by the ESG ratings of Sustainalytics. Also, we observe that considerable number of firms (3 out of 10) fall in the medium risk category. Not surprisingly, only one firm, MAHM.NS is classified in the low risk category based on the ESG risk ratings of Sustainalytics.This supports our findings that Indian firms need to improve their social sustainability performances, as well as the overall ESG performances. This can aid firms to gaining sustainable competitive advantages for future, as well as it can make the firm to be appealing to customers, stakeholders, and other shareholders.

7 Implications of the Study

This research offers several implications to the theory of social sustainability and practice of information and data predictions for social sustainability performances of firms. The main advantage is that practitioners can predict the position of their firm on social sustainability in future; so that they can take proper corrective actions for improvement of their performances. The theoretical, practical, and policy implications of the research are discussed below.

7.1 Implications to Theory

We center on the theory of Utilitarianism to elucidate the theoretical underpinnings of the study. Utilitarianism is an ethical theory focusing on normative ethics and the theory states that any action or activity can be considered morally right, if that action or activity produces the most good (Van Staveren, 2007; Warke, 2000). Extending the theory towards social sustainability, we can say that the actions or activities creating more social goodness in the society can be considered as socially sustainable. Since, social sustainability and its building constructs are highly correlated with the ethical dimensions of sustainability; we can infer that the actions taken by the firm can be considered right, if it creates and promotes happiness of society and the same can be considered wrong, vice-versa. Utilitarianism can be considered different, in comparison with other ethical theories, as it is silent on the motive of the action performer. According to Utilitarianism, it is possible for a firm to do a right action, even though the motive of the action may not be exactly right. Applying this towards the concept and practice of social sustainability, we can comment that the focus on social sustainability need to be improved for firms; no matter whether it is arising due to demands from customers or stakeholders for a sustainable product, or due to increasing pressures from competitors, while competitors are focusing more on socially responsible activities and gaining good market share. Thus, we can conclude that increasing socially responsible activities of the firm can cause more social good, along with the gain of several sustainable competitive advantages for firms.

7.2 Implications to Practice

The research offers several implications to information practitioners and managers. Managers are suggested to utilize the combined prediction model, as proposed in this study to evaluating and predicting the social sustainability performances of their firm. This allows them to apprehend the current status of the firm considering social sustainability and the development directions, where the firm needs to work on to achieving the targeted levels for social sustainability performances. Also, the prediction results can be helpful to understand the competitors' position in social sustainability, considering future trends; and managers can plan their actions accordingly in this direction. This also helps in benchmarking the performances of the firm in social sustainability; so as it can help them to achieve or maintain the desired level of performances. Also, the model is advantages for managers, as they can process any quantitative and qualitative information or data measured in any ordinal, interval, or ratio scales. Hence, the total social sustainability performances can be calculated based on the proposed methodology by including more parameters, clubbing both the qualitative and the quantitative information, to obtaining satisfactory results.

7.3 Implications to Policy

From a business perspective, social sustainability is considered as a least quantifiable part in the sustainability evaluations using a triple bottom-line approach. Although, measuring social sustainability is a difficult task, identification of the same is an easy job. The policies for social sustainability performance improvements for firms can focus on several thrust areas. Significant among them are the human rights, fair labour practices, living conditions, health, safety, wellness, equity, work-life balance, diversity, empowerment, engagement in communities, volunteerism, philanthropy, etc. Social impacts of businesses can include all entities affecting the company-stakeholder relations, including how well suppliers are being managed and paid? And how much a product can influence and affect the lives of people? Companies need to understand the risks of social sustainability, where poor social sustainability performances can lead to damaging product quality and brand image. At the same time, customers and stakeholders are more informed and engaged that they prefer those companies who are transparent in their social sustainability norms. Finally, social sustainability is achievable and attainable. For this, companies need to partner with Non-Government Organisations (NGOs) or any social sustainability organisations to become more transparent, more ethical in their operations and processes, and for understanding the human cost of businesses.

Appendix

See Table 13.

Table 13 Predicted social sustainability performances of Indian firms

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
1	Asian Paints Ltd	Paints	Basic Materials	India	Chemicals	ASPN.NS	2014	56.43116
						ASPN.NS	2015	43.79433
						ASPN.NS	2016	46.83735
						ASPN.NS	2017	42.64286
						ASPN.NS	2018	43.56509
2	Piramal Enterprises Ltd	Toilet Preparation Manufacturing	Healthcare	India	Pharmaceuticals & Medical Research	PIRA.NS	2014	28.98352
						PIRA.NS	2015	28.28283
						PIRA.NS	2016	41.10169
						PIRA.NS	2017	56.39535
						PIRA.NS	2018	62.88462
3	Dr.Reddy's Laboratories Ltd	Research and Development in the Physical, Engineering, and Life Sciences	Healthcare	India	Pharmaceuticals & Medical Research	REDY.NS	2014	82.55495
						REDY.NS	2015	86.86869
						REDY.NS	2016	81.67373
						REDY.NS	2017	82.36434
						REDY.NS	2018	83.17308
4	GlaxoSmithKline Consumer Healthcare Ltd	Food Processing	Consumer Non-Cyclicals	India	Food & Beverages	GLSM.NS	2014	37.04044
						GLSM.NS	2015	48.93617
						GLSM.NS	2016	54.98555
						GLSM.NS	2017	54.47861
						GLSM.NS	2018	55.43478

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
5	UPL Ltd	Pesticide and Other Agricultural Chemical Manufacturing	Basic Materials	India	Chemicals	UPLL.NS	2014	51.3587
						UPLL.NS	2015	43.97163
						UPLL.NS	2016	41.26506
						UPLL.NS	2017	43.35714
						UPLL.NS	2018	37.79586
6	Cipla Ltd	Pharmaceuticals	Healthcare	India	Pharmaceuticals & Medical Research	CIPL.NS	2014	26.92308
						CIPL.NS	2015	29.79798
						CIPL.NS	2016	46.39831
						CIPL.NS	2017	48.44961
						CIPL.NS	2018	29.80769
7	Siemens Ltd	Vehicular Lighting Equipment Mfg	Industrials	India	Industrial Conglomerates	SIEM.NS	2014	49.67949
						SIEM.NS	2015	53.52564
						SIEM.NS	2016	53.57143
						SIEM.NS	2017	49.39024
						SIEM.NS	2018	58.03571
8	JSW Steel Ltd	Iron & Steel	Basic Materials	India	Mineral Resources	JSTL.NS	2014	77.55872
						JSTL.NS	2015	76.83946
						JSTL.NS	2016	81.75566
						JSTL.NS	2017	70.45082
						JSTL.NS	2018	73.10231

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
9	Marico Ltd	Offices of Other Holding Companies	Consumer Non-Cyclicals	India	Personal & Household Products & Services	MRCO.NS	2014	30.04808
						MRCO.NS	2015	37.72727
						MRCO.NS	2016	39.43966
						MRCO.NS	2017	42.5
						MRCO.NS	2018	45.15625
10	Nestle India Ltd	Food Processing—NEC	Consumer Non-Cyclicals	India	Food & Beverages	NEST.NS	2014	95.05814
						NEST.NS	2015	90.71691
						NEST.NS	2016	92.64184
						NEST.NS	2017	91.90751
						NEST.NS	2018	90.30749
11	ACC Ltd	Brick, Stone, and Related Construction Material Wholesalers	Basic Materials	India	Mineral Resources	ACC.NS	2014	70.05814
						ACC.NS	2015	70.17045
						ACC.NS	2016	75.27778
						ACC.NS	2017	71.32353
						ACC.NS	2018	74.76415
12	Bharat Heavy Electricals Ltd	Air & Gas Compressor Mfg	Industrials	India	Industrial Goods	BHEL.NS	2014	34.03465
						BHEL.NS	2015	48.10049
						BHEL.NS	2016	42.02236
						BHEL.NS	2017	46.98427
						BHEL.NS	2018	49.18385

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
13	Hero MotoCorp Ltd	Automobiles	Consumer Cyclicals	India	Automobiles & Auto Parts	HROM.NS	2014	43.93564
						HROM.NS	2015	45.55288
						HROM.NS	2016	49.89316
						HROM.NS	2017	49.71374
						HROM.NS	2018	48.25581
14	United Spirits Ltd	Distillers & Vintners	Consumer Non-Cyclicals	India	Food & Beverages	UNSP.NS	2014	20.40816
						UNSP.NS	2015	23.07692
						UNSP.NS	2016	22.54902
						UNSP.NS	2017	32.87037
						UNSP.NS	2018	29.71698
15	Ambuja Cements Ltd	Brick, Stone, and Related Construction Material Merchant Wholesalers	Basic Materials	India	Mineral Resources	ABUJ.NS	2014	74.7093
						ABUJ.NS	2015	76.42045
						ABUJ.NS	2016	75.55556
						ABUJ.NS	2017	81.61765
						ABUJ.NS	2018	79.00943
16	Hindalco Industries Ltd	Metals—Non Ferrous	Basic Materials	India	Mineral Resources	HALC.NS	2014	60.87884
						HALC.NS	2015	49.24497
						HALC.NS	2016	59.36455
						HALC.NS	2017	53.19579
						HALC.NS	2018	64.59016

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
17	Hindustan Unilever Ltd	Soft Drink Mfg	Consumer Non-Cyclicals	India	Personal & Household Products & Services	HLL.NS	2014	64.42308
						HLL.NS	2015	70.45455
						HLL.NS	2016	81.03448
						HLL.NS	2017	90.17857
						HLL.NS	2018	94.84375
18	Aditya Birla Nuvo Ltd	NULL	Industrials	India	Industrial Conglomerates	ABRL.NS	2014	40
						ABRL.NS	2015	34.29487
						ABRL.NS	2016	38.46154
						ABRL.NS	2017	38.69048
						ABRL.NS	2018	35.97561
19	ITC Ltd	Paperboard Mills	Consumer Non-Cyclicals	India	Food & Beverages	ITC.NS	2014	74.08088
						ITC.NS	2015	71.2766
						ITC.NS	2016	77.96243
						ITC.NS	2017	72.45989
						ITC.NS	2018	72.69022
20	Larsen & Toubro Ltd	Engineering Services	Industrials	India	Industrial & Commercial Services	LART.NS	2014	64.78365
						LART.NS	2015	57.97619
						LART.NS	2016	58.00439
						LART.NS	2017	51.38889
						LART.NS	2018	54.67391

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
21	Mahindra and Mahindra Ltd	Sales Financing	Consumer Cyclicals	India	Automobiles & Auto Parts	MAHM.NS	2014	84.77723
						MAHM.NS	2015	80.64904
						MAHM.NS	2016	85.36325
						MAHM.NS	2017	78.91221
						MAHM.NS	2018	75.5814
22	Tata Motors Ltd	Custom Computer Programming Services	Consumer Cyclicals	India	Automobiles & Auto Parts	TAMO.NS	2014	78.15657
						TAMO.NS	2015	77.10396
						TAMO.NS	2016	82.8125
						TAMO.NS	2017	82.58547
						TAMO.NS	2018	83.68321
23	Tata Steel Ltd	Iron & Steel	Basic Materials	India	Mineral Resources	TISC.NS	2014	92.23993
						TISC.NS	2015	93.0602
						TISC.NS	2016	95.30744
						TISC.NS	2017	92.37705
						TISC.NS	2018	94.30693
24	Vedanta Ltd	Copper Ore & Nickel Ore Mining	Basic Materials	India	Mineral Resources	VDAN.NS	2014	72.14765
						VDAN.NS	2015	61.49666
						VDAN.NS	2016	55.13754
						VDAN.NS	2017	66.22951
						VDAN.NS	2018	83.16832
25	Titan Company Ltd	Watch, Clock & Part Mfg	Consumer Cyclicals	India	Cyclical Consumer Products	TITN.NS	2014	57.6087

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
						TITN.NS	2015	64.54082
						TITN.NS	2016	61.79245
						TITN.NS	2017	60.08772
						TITN.NS	2018	65.41667
26	Steel Authority of India Ltd	Steel—NEC	Basic Materials	India	Mineral Resources	SAIL.NS	2014	81.8686
						SAIL.NS	2015	83.76678
						SAIL.NS	2016	79.59866
						SAIL.NS	2017	78.15534
						SAIL.NS	2018	76.22951
27	Adani Enterprises Ltd	Industrial Suppliers	Industrials	India	Industrial & Commercial Services	ADEL.NS	2014	21.09375
						ADEL.NS	2015	27.5
						ADEL.NS	2016	33.82353
						ADEL.NS	2017	33.08824
						ADEL.NS	2018	22.79412
28	Dabur India Ltd	All Other Miscellaneous Food Mfg	Consumer Non-Cyclicals	India	Personal & Household Products & Services	DABU.NS	2014	45
						DABU.NS	2015	57.97414
						DABU.NS	2016	57.67857
						DABU.NS	2017	64.21875
						DABU.NS	2018	67.5
29	Lupin Ltd	Pharmaceutical Preparation Mfg	Healthcare	India	Pharmaceuticals & Medical Research	LUPN.NS	2014	30.29412
						LUPN.NS	2015	31.18132

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
						LUPN.NS	2016	32.57576
						LUPN.NS	2017	36.65254
						LUPN.NS	2018	30.23256
30	Sun Pharmaceutical Industries Ltd	Medicinal & Botanical Mfg	Healthcare	India	Pharmaceuticals & Medical Research	SUN.NS	2014	44.91758
						SUN.NS	2015	46.33838
						SUN.NS	2016	49.89407
						SUN.NS	2017	59.01163
						SUN.NS	2018	57.40385
31	Jindal Steel And Power Ltd	Cement Manufacturing	Basic Materials	India	Mineral Resources	JNSP.NS	2014	47.99488
						JNSP.NS	2015	37.03859
						JNSP.NS	2016	65.55184
						JNSP.NS	2017	70.4288
						JNSP.NS	2018	67.29508
32	Wockhardt Ltd	Research and Development in the Physical, Engineering, and Life Sciences	Healthcare	India	Pharmaceuticals & Medical Research	WCKH.NS	2014	11.12637
						WCKH.NS	2015	13.13131
						WCKH.NS	2016	16.31356
						WCKH.NS	2017	26.35659
						WCKH.NS	2018	25.86538
33	Godrej Consumer Products Ltd	Appliances & Households	Consumer Non-Cyclicals	India	Personal & Household Products & Services	GOCP.NS	2014	15.68182

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
						GOCP.NS	2015	33.62069
						GOCP.NS	2016	58.75
						GOCP.NS	2017	56.71875
						GOCP.NS	2018	65.9375
34	United Breweries Ltd	Beverages—Brewers	Consumer Non-Cyclicals	India	Food & Beverages	UBBW.NS	2014	28.60577
						UBBW.NS	2015	33.08824
						UBBW.NS	2016	39.58333
						UBBW.NS	2017	50.4717
						UBBW.NS	2018	47.91667
35	Divi's Laboratories Ltd	Pharmaceuticals	Healthcare	India	Pharmaceuticals & Medical Research	DIVI.NS	2014	33.82353
						DIVI.NS	2015	30.90659
						DIVI.NS	2016	47.09596
						DIVI.NS	2017	52.43644
						DIVI.NS	2018	55.71705
36	Maruti Suzuki India Ltd	Automobiles—4 Wheelers	Consumer Cyclicals	India	Automobiles & Auto Parts	MRTI.NS	2014	81.55941
						MRTI.NS	2015	87.86058
						MRTI.NS	2016	87.71368
						MRTI.NS	2017	86.73664
						MRTI.NS	2018	78.10078
37	Jaiprakash Associates Ltd	Cement Manufacturing	Industrials	India	Industrial & Commercial Services	JAIA.NS	2014	37.25962
						JAIA.NS	2015	33.80952

Table 13 (continued)

Sl. no	Company common name	Business sector	TRBC Economic Sector Name	Country of Headquarters	TRBC Business Sector Name	Company Code	Year	Social sustainability
						JAIA.NS	2016	33.33333
						JAIA.NS	2017	27.77778
						JAIA.NS	2018	27.93478
38	GMR Infrastructure Ltd	Other Airport Operations	Industrials	India	Industrial & Commercial Services	GMRI.NS	2014	64.0625
						GMRI.NS	2015	60.95238
						GMRI.NS	2016	62.39035
						GMRI.NS	2017	69.65812
						GMRI.NS	2018	65.32609
39	Bajaj Auto Ltd	Auto & Truck Manufacturers	Consumer Cyclicals	India	Automobiles & Auto Parts	BAJA.NS	2014	32.5495
						BAJA.NS	2015	34.97596
						BAJA.NS	2016	28.4188
						BAJA.NS	2017	48.5687
						BAJA.NS	2018	41.56977

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
1	46.654	44.376	44.376		2014	44.376	44.376
	44.21	43.807	88.183	66.2795	2015	88.131	43.755
	44.348	43.672	131.855	110.019	2016	131.778	43.647
	43.104	43.335	175.19	153.5225	2017	175.32	43.542
	43.565	43.565	218.755	196.9725	2018	218.755	43.435
					2019	262.084	43.329
2	43.53	53.336	53.336		2014	53.336	53.336

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
	47.166	55.788	109.124	81.23	2015	109.459	56.123
	53.461	58.662	167.786	138.455	2016	167.865	58.406
	59.64	61.263	229.049	198.4175	2017	228.648	60.783
	62.885	62.885	291.934	260.4915	2018	291.902	63.254
					2019	357.73	65.828
3	83.327	83.039	83.039		2014	83.039	83.039
	83.52	82.967	166.006	124.5225	2015	165.891	82.852
	82.404	82.782	248.788	207.397	2016	248.824	82.933
	82.769	82.971	331.759	290.2735	2017	331.838	83.014
	83.173	83.173	414.932	373.3455	2018	414.932	83.094
					2019	498.107	83.175
4	50.175	53.798	53.798		2014	53.798	53.798
	53.459	54.704	108.502	81.15	2015	108.572	54.774
	54.966	55.119	163.621	136.0615	2016	163.571	54.999
	54.957	55.196	218.817	191.219	2017	218.798	55.227
	55.435	55.435	274.252	246.5345	2018	274.252	55.454
					2019	329.935	55.683
5	43.55	40.865	40.865		2014	40.865	40.865
	41.597	40.194	81.059	60.962	2015	81.251	40.386
	40.806	39.726	120.785	100.922	2016	120.853	39.602
	40.577	39.187	159.972	140.3785	2017	159.686	38.833
	37.796	37.796	197.768	178.87	2018	197.764	38.078
					2019	235.102	37.338
6	36.275	37.075	37.075		2014	37.075	37.075
	38.613	37.276	74.351	55.713	2015	75.365	38.29

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
	41.552	36.83	111.181	92.766	2016	111.073	35.708
	39.129	34.469	145.65	128.4155	2017	144.373	33.3
	29.808	29.808	175.458	160.554	2018	175.429	31.056
					2019	204.391	28.962
7	52.841	54.377	54.377		2014	54.377	54.377
	53.631	54.762	109.139	81.758	2015	108.744	54.367
	53.666	55.138	164.277	136.708	2016	164.154	55.41
	53.713	55.875	220.152	192.2145	2017	220.626	56.472
	58.036	58.036	278.188	249.17	2018	278.18	57.554
					2019	336.838	58.658
8	75.941	74.292	74.292		2014	74.292	74.292
	75.537	73.88	148.172	111.232	2015	147.965	73.673
	75.103	73.327	221.499	184.8355	2016	221.313	73.348
	71.777	72.44	293.939	257.719	2017	294.337	73.024
	73.102	73.102	367.041	330.49	2018	367.041	72.704
					2019	439.423	72.382
9	38.974	42.306	42.306		2014	42.306	42.306
	41.206	43.139	85.445	63.8755	2015	85.439	43.133
	42.365	43.783	129.228	107.3365	2016	129.237	43.798
	43.828	44.492	173.72	151.474	2017	173.712	44.475
	45.156	45.156	218.876	196.298	2018	218.872	45.16
					2019	264.73	45.858
10	92.126	91.311	91.311		2014	91.311	91.311
	91.393	91.107	182.418	136.8645	2015	182.5	91.189
	91.619	91.011	273.429	227.9235	2016	273.418	90.918

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
	91.108	90.708	364.137	318.783	2017	364.065	90.647
	90.307	90.307	454.444	409.2905	2018	454.444	90.379
					2019	544.554	90.11
11	72.319	73.36	73.36		2014	73.36	73.36
	72.884	73.62	146.98	110.17	2015	146.877	73.517
	73.788	73.865	220.845	183.9125	2016	220.741	73.864
	73.044	73.904	294.749	257.797	2017	294.952	74.211
	74.764	74.764	369.513	332.131	2018	369.512	74.56
					2019	444.424	74.912
12	44.065	46.794	46.794		2014	46.794	46.794
	46.573	47.476	94.27	70.532	2015	94.167	47.373
	46.063	47.777	142.047	118.1585	2016	142.131	47.964
	48.084	48.634	190.681	166.364	2017	190.694	48.563
	49.184	49.184	239.865	215.273	2018	239.862	49.168
					2019	289.645	49.783
13	47.47	48.471	48.471		2014	48.471	48.471
	48.354	48.721	97.192	72.8315	2015	97.324	48.853
	49.288	48.843	146.035	121.6135	2016	146.014	48.69
	48.985	48.621	194.656	170.3455	2017	194.543	48.529
	48.256	48.256	242.912	218.784	2018	242.912	48.369
					2019	291.12	48.208
14	25.724	28.433	28.433		2014	28.433	28.433
	27.053	29.111	57.544	42.9885	2015	57.841	29.408
	28.379	29.797	87.341	72.4425	2016	87.498	29.657
	31.294	30.506	117.847	102.594	2017	117.404	29.906

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
	29.717	29.717	147.564	132.7055	2018	147.563	30.159
					2019	177.977	30.414
15	77.462	78.733	78.733		2014	78.733	78.733
	78.151	79.051	157.784	118.2585	2015	157.973	79.24
	78.728	79.35	237.134	197.459	2016	237.232	79.259
	80.314	79.662	316.796	276.965	2017	316.509	79.277
	79.009	79.009	395.805	356.3005	2018	395.805	79.296
					2019	475.119	79.314
16	57.455	59.317	59.317		2014	59.317	59.317
	56.599	59.783	119.1	89.2085	2015	118.762	59.445
	59.05	60.844	179.944	149.522	2016	179.709	60.947
	58.893	61.742	241.686	210.815	2017	242.196	62.487
	64.59	64.59	306.276	273.981	2018	306.261	64.065
					2019	371.946	65.685
17	80.187	88.071	88.071		2014	88.071	88.071
	84.128	90.042	178.113	133.092	2015	178.321	90.25
	88.686	92.014	270.127	224.12	2016	270.148	91.827
	92.511	93.678	363.805	316.966	2017	363.578	93.43
	94.844	94.844	458.649	411.227	2018	458.64	95.062
					2019	555.362	96.722
18	37.484	37.072	37.072		2014	37.072	37.072
	36.856	36.969	74.041	55.5565	2015	74.222	37.15
	37.709	37.006	111.047	92.544	2016	111.038	36.816
	37.333	36.655	147.702	129.3745	2017	147.522	36.484
	35.976	35.976	183.678	165.69	2018	183.677	36.155

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
					2019	219.507	35.83
19	73.694	73.385	73.385		2014	73.385	73.385
	73.597	73.308	146.693	110.039	2015	146.711	73.326
	74.371	73.212	219.905	183.299	2016	219.793	73.082
	72.575	72.633	292.538	256.2215	2017	292.632	72.839
	72.69	72.69	365.228	328.883	2018	365.228	72.596
					2019	437.582	72.354
20	57.365	55.054	55.054		2014	55.054	55.054
	55.511	54.476	109.53	82.292	2015	109.29	54.236
	54.689	54.131	163.661	136.5955	2016	163.558	54.268
	53.031	53.853	217.514	190.5875	2017	217.857	54.299
	54.674	54.674	272.188	244.851	2018	272.188	54.331
					2019	326.551	54.363
21	81.057	78.793	78.793		2014	78.793	78.793
	80.126	78.227	157.02	117.9065	2015	157.118	78.325
	79.952	77.593	234.613	195.8165	2016	234.521	77.403
	77.247	76.414	311.027	272.82	2017	311.013	76.492
	75.581	75.581	386.608	348.8175	2018	386.605	75.592
					2019	461.306	74.701
22	80.868	82.452	82.452		2014	82.452	82.452
	81.546	82.848	165.3	123.876	2015	165.363	82.911
	83.027	83.281	248.581	206.9405	2016	248.536	83.173
	83.134	83.409	331.99	290.2855	2017	331.972	83.436
	83.683	83.683	415.673	373.8315	2018	415.673	83.701
					2019	499.638	83.965

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
23	93.458	93.773	93.773		2014	93.773	93.773
	93.763	93.852	187.625	140.699	2015	187.543	93.77
	93.997	93.882	281.507	234.566	2016	281.444	93.901
	93.342	93.825	375.332	328.4195	2017	375.476	94.032
	94.307	94.307	469.639	422.4855	2018	469.639	94.163
					2019	563.933	94.294
24	67.636	72.038	72.038		2014	72.038	72.038
	66.508	73.138	145.176	108.607	2015	144.672	72.634
	68.178	75.348	220.524	182.85	2016	220.541	75.869
	74.699	78.934	299.458	259.991	2017	299.79	79.249
	83.168	83.168	382.626	341.042	2018	382.569	82.779
					2019	469.035	86.466
25	61.889	63.09	63.09		2014	63.09	63.09
	62.959	63.39	126.48	94.785	2015	126.201	63.111
	62.432	63.534	190.014	158.247	2016	189.971	63.77
	62.752	64.085	254.099	222.0565	2017	254.406	64.435
	65.417	65.417	319.516	286.8075	2018	319.514	65.108
					2019	385.301	65.787
26	79.924	78.156	78.156		2014	78.156	78.156
	79.438	77.714	155.87	117.013	2015	155.838	77.682
	77.995	77.139	233.009	194.4395	2016	233.029	77.191
	77.192	76.711	309.72	271.3645	2017	309.731	76.702
	76.23	76.23	385.95	347.835	2018	385.949	76.218
					2019	461.685	75.736
27	27.66	27.52	27.52		2014	27.52	27.52

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
	29.301	27.485	55.005	41.2625	2015	55.49	27.97
	29.902	26.879	81.884	68.4445	2016	81.836	26.346
	27.941	25.368	107.252	94.568	2017	106.651	24.815
	22.794	22.794	130.046	118.649	2018	130.026	23.375
					2019	152.043	22.017
28	58.474	63.362	63.362		2014	63.362	63.362
	61.843	64.584	127.946	95.654	2015	127.944	64.582
	63.132	65.497	193.443	160.6945	2016	193.505	65.561
	65.859	66.68	260.123	226.783	2017	260.057	66.552
	67.5	67.5	327.623	293.873	2018	327.618	67.561
					2019	396.201	68.583
29	32.187	32.336	32.336		2014	32.336	32.336
	32.661	32.373	64.709	48.5225	2015	65.041	32.705
	33.154	32.277	96.986	80.8475	2016	97.053	32.012
	33.443	31.838	128.824	112.905	2017	128.385	31.332
	30.233	30.233	159.057	143.9405	2018	159.053	30.668
					2019	189.07	30.017
30	51.513	55.145	55.145		2014	55.145	55.145
	53.162	56.053	111.198	83.1715	2015	111.494	56.349
	55.437	57.016	168.214	139.706	2016	168.32	56.826
	58.208	57.806	226.02	197.117	2017	225.628	57.308
	57.404	57.404	283.424	254.722	2018	283.423	57.795
					2019	341.707	58.284
31	57.662	64.331	64.331		2014	64.331	64.331
	60.079	65.999	130.33	97.3305	2015	131.074	66.743

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
	67.759	67.972	198.302	164.316	2016	198.211	67.137
	68.862	68.079	266.381	232.3415	2017	265.744	67.533
	67.295	67.295	333.676	300.0285	2018	333.675	67.931
					2019	402.008	68.333
32	18.559	22.759	22.759		2014	22.759	22.759
	20.417	23.81	46.569	34.664	2015	46.848	24.089
	22.845	24.94	71.509	59.039	2016	71.63	24.782
	26.111	25.988	97.497	84.503	2017	97.126	25.496
	25.865	25.865	123.362	110.4295	2018	123.356	26.23
					2019	150.341	26.985
33	46.142	57.527	57.527		2014	57.527	57.527
	53.757	60.373	117.9	87.7135	2015	118.016	60.489
	60.469	62.578	180.478	149.189	2016	180.23	62.214
	61.328	63.633	244.111	212.2945	2017	244.218	63.988
	65.938	65.938	310.049	277.08	2018	310.031	65.813
					2019	377.722	67.691
34	39.933	45.16	45.16		2014	45.16	45.16
	42.765	46.467	91.627	68.3935	2015	92.048	46.888
	45.991	47.701	139.328	115.4775	2016	139.447	47.399
	49.194	48.556	187.884	163.606	2017	187.362	47.915
	47.917	47.917	235.801	211.8425	2018	235.799	48.437
					2019	284.764	48.965
35	43.996	50.416	50.416		2014	50.416	50.416
	46.539	52.021	102.437	76.4265	2015	102.735	52.319
	51.75	53.848	156.285	129.361	2016	156.235	53.5
	54.077	54.897	211.182	183.7335	2017	210.945	54.71

Table 13 (continued)

Sl. no.	XD	XD^2	1 AGO	Mean GS	Year	Predict AGO	Predict actual
	55.717	55.717	266.899	239.0405	2018	266.89	55.945
					2019	324.099	57.209
36	84.394	82.84	82.84		2014	82.84	82.84
	85.103	82.452	165.292	124.066	2015	165.593	82.753
	84.184	81.568	246.86	206.076	2016	246.889	81.296
	82.419	80.26	327.12	286.99	2017	326.754	79.865
	78.101	78.101	405.221	366.1705	2018	405.213	78.459
					2019	482.291	77.078
37	32.023	29.642	29.642		2014	29.642	29.642
	30.714	29.047	58.689	44.1655	2015	58.579	28.937
	29.682	28.491	87.18	72.9345	2016	87.115	28.536
	27.856	27.896	115.076	101.128	2017	115.257	28.142
	27.935	27.935	143.011	129.0435	2018	143.009	27.752
					2019	170.378	27.369
38	64.478	65.534	65.534		2014	65.534	65.534
	64.582	65.798	131.332	98.433	2015	131.649	66.115
	65.792	66.203	197.535	164.4335	2016	197.643	65.994
	67.492	66.409	263.944	230.7395	2017	263.517	65.874
	65.326	65.326	329.27	296.607	2018	329.27	65.753
					2019	394.903	65.633
39	37.217	40.352	40.352		2014	40.352	40.352
	38.383	41.135	81.487	60.9195	2015	81.991	41.639
	39.519	42.053	123.54	102.5135	2016	123.883	41.892
	45.069	43.32	166.86	145.2	2017	166.028	42.145
	41.57	41.57	208.43	187.645	2018	208.43	42.402
					2019	251.088	42.658

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Declarations

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