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Measuring Inclusive Growth in India: An Application of Two-Stage Principal Component Analysis

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Abstract

This study tries to measure inclusive growth in the post-reform period of India and assesses its performance in different aspects of inclusiveness like economic inclusion, environmental sustainability, human capability, gender equity, and financial inclusion. We construct a composite inclusive growth index (IGI) using time series data for India over the period 1990 - 2020. Fifteen developmental indicator variables, categorized as economic expansion, environmental sustainability, gender equity, human capabilities, and financial inclusion, are used to construct the present IGI.

The two-stage principal component analysis (PCA) method is used to derive the weights of the indicators. Results show that India performed quite well during the period 1991-2000 and 2001-2010 in all aspects of inclusive growth. However, the improvement rates of all dimensions of inclusive growth decidedly slowed down in the recent period (2011-2020). The inclusive growth index increased from 11.925 percent during 1991-2000 to 12.403 percent during 2001-2010 and declined to 2.572 percent during 2011-2020. Our present index measure will help researchers and policymakers to assess the performance of a country to its inclusive growth achievements and to track the time trend over time. Hence, this index measure will be crucial for formulating inclusive growth policies.

Keywords: Inclusive Growth, Economic Inclusion, Environmental Sustainability, Gender Equity, Financial Inclusion, Human Capability, Principal Component Analysis.

JEL Classification Numbers: C_{180}, O_{150}, O_{50}

Introduction

The United Nations (UN) 2030 agenda recognizes that development must balance social, economic, and environmental sustainability to achieve sustainable development goals (SDGs). In the late 1990s, achieving high and rapid economic growth has been the central agenda to eradicate poverty for many developing countries. Studies [1, 2, 3] have also shown that high economic growth significantly contributed to a dramatic fall in poverty and has improved the average living standards of many people, particularly to the poor.

However, the necessity of rapid economic growth in reducing poverty has been questioned in the early 2000s when many developing countries witnessed income inequality with the rise of per-capita income. Some studies (Raballion and Chen, 2003) argued that high economic growth often accompanied by high income inequality can lower the impact of poverty reduction of a given rate of growth and can reduce the growth rate itself [4, 5, 6]. This defied the notion that growth and equity cannot be achieved until the benefits of growth are distributed fairly across society.

This has led to the foundation of building an alternative growth strategy to achieve sustainable development worldwide. Since then, several multifaceted developmental concepts such as broad-based equitable growth, pro-poor growth, sustainable economic growth etc., have emerged in the development spectrum. Inclusive growth is the latest addition to this list and emerged in the early 2000s. The term 'inclusiveness' itself indicates equity, new opportunity, social protection, and fair distribution and, therefore, is the key ingredients of any effective growth strategy.

However, the central focus remains on how to measure the term 'inclusiveness' so that the pace, pattern, and the distribution of growth are well reflected. Several initiatives have been taken in the development of literature to measure inclusive growth across countries. However, efforts to measure inclusiveness have remained limited due to the absence of a definite concepts of inclusiveness and due to a paucity of appropriate methodology.

The emerging literature of inclusive growth (IG) indicates that a clear and unanimous definition of IG along with available robust data are prerequisites for measuring IG both at the country and programme level. Moreover, a comprehensive measure of IG will allow us to identify its determinants and prioritize geographical constraints to build a successful inclusive growth strategy. On the contrary, lack of such comprehensive measurement will make growth policies challenging [7, 8]. Many attempts have been made earlier to measure IG by combining the growth of national income and poverty [9, 10, 11, 12, 13].

In most cases, either growth of national income or economic infrastructure or productive employment was regressed on poverty as a proxy for inclusive growth. Alongside, these measures quantify only one aspect of IG viz. the income-based measures and completely ignored the non-income measures of well-being such as better health and education, greater equality of opportunity, efficient economic institutions that also helps to make growth more inclusive. This issue triggers our interest and motivates us to provide a holistic measure of IG that will incorporate both its income based and non-income-based dimensions. Unlike the pro-poor growth [3], the measure of IG requires ex-ante analysis that examines the ways to increase the pace of growth by involving the participation of the poor people in the growth process.

Historically, two methods have been used in the emerging literature of inclusive growth to measure the term 'inclusiveness'- unified macro measure and composite index measure. In the former approach, inclusive growth is considered as a unidimensional phenomenon measured by integrating economic growth and income distribution into one single measure [11, 13, 14].

This measure is useful to identify the determinants of inclusive growth and prioritize country-specific constraints to build inclusive growth. However, this approach includes fewer numbers of dimensions of inclusive growth and unable to measure the degree of inclusiveness a country has attained. The later approach takes care about the flaws of first one and includes many dimensions related to the welfare of the people and measures the term 'inclusiveness' by constructing composite inclusive growth index [7, 15, 16, 17, 18].

This approach helps one to rank countries in terms of their inclusive growth achievements and can potentially be used to assess inclusive growth. This approach, however, has some issues particularly when it comes to assign the weights of different indicators. McKinley argues that weighting scheme implicitly involves value judgement and can oblige research with differing values to identify and clarify their differences. Another limitation of such index measure is the absence of an acknowledge theoretical framework which makes it difficult to test in practice and, hence, question the validity of such measure (Manning et al., 2006 and Kaufman et al., 2007).

The present study provides a composite approach to measure IG in India using time series data from 1990 - 2020. For this purpose, the study uses fifteen developmental indicators and categorized them into economic expansion, environmental sustainability, gender equity, human capability, and financial inclusion. In order to find the weights of the indicators and to make a choice of the indicator under different dimensions of inclusive growth (IG), the study applies two- stage PCA and also provided a conceptual framework for developing the IG index. Our measurement of IG is comprehensive3 in nature and combines information on all dimensions of IG with lesser number of developmental indicators proposed by McKinley.

In addition, this index will help us to diagnose India's inclusive growth performance over the last two decades. The rest of the paper is designed as follows. Section 2 discusses the importance of IG in the context of India. Section 3 provides a brief review of the existing literature. Section 4 describes the data and methodology for constructing the IG index and its sub-indices. Section 5 discusses the results and finally, Section 6 concludes.

Importance of Inclusive Growth in the Context of India

Over the last two decades, India has experienced an unprecedented economic growth and has become one of the fastest growing nations in the world. For instance, the decadal average real GDP growth in India between 1991 and 2000 has been 5.6% and has risen at 6.7% between 2001 and 2010 and remained same between 2011 and 2019 [11].

As a result of this rapid economic growth, poverty rates have fallen, and income level of many people have raised. According to the McKinsey Global Institute report (2018), India has pulled 170 million people out of poverty between 1990 and 2013 and has reduced the number of its citizens living in extreme poverty by 25%. Moreover, despite having better performance in income growth, Indian economy faces many challenges like growing inequalities (income and wealth)5, huge gender disparities6, dismal employment generation etc [19].

which in turn have created a range of health and social problems. As a result, a growing concern has aroused among the policymakers that the benefits of this growth have not been shared equitably among all sections of society. So, what can be done to maximize people's participation, particularly, to the poor, in the growth process so that they are no longer excluded and more empowered as well as ensured access to basic socioeconomic opportunities? This asserts the importance of inclusive growth in the context of India's development landscape.

We provide an overview of the indicators of each dimension of inclusive growth to understand the nature of the indicators and their expansion over time (see Table A.1 in Appendix). It is observed that most of the indicators have shown a continuous rise during 1990 – 2020. Carbon emission has shown a steady rise during the study period. This may have some serious impact on the economy, particularly on the environment and make growth less effective. However, IMR and drop-out rates have shown a declining trend indicating a good indication for the economy, particularly for human development. Similarly, financial inclusion indicators like c/d ratio have declined during 1990 – 2000 though steadily increased thereafter.

Table A.1: Indicators of Inclusive Growth in India, 1990-2020

	1990	1995	2000	2005	2010	2015	2020
GDP per capita (constant 2010 US$)	534.5	618.1	755.5	947.8	1238.0	1590.2	1813.5
Gross capital formation, per capita (constant 2010 US$)	119.1	133.5	162.4	292.7	462.5	510.7	553.2
GDP per person employed (constant 2017 PPP $)	5546.5	6549.2	7503.7	9667.4	12165.8	16309.9	19312.6
CO2 emissions (metric tons per capita)	0.6	0.8	0.9	1.0	1.3	1.6	1.6
Forest area (% of land area)	7.5	13.1	12.8	20.5	22.5	19.5	17.1
Adjusted net savings, including particulate emission damage (% of GNI)	21.5	22.1	22.7	23.1	23.4	23.8	24.3
Proportion of seats held by women in national parliaments (%)	5.4	6.8	9.0	8.3	10.8	12.0	14.4
Number of female students per hundred male students Enrolled (I-V)	70.0	75.0	79.0	88.0	92.0	93.0	90.6
Female teacher per 100 male teachers in primary education	39.0	46.0	52.0	64.0	84.0	90.7	104.2
Mortality rate, infant (per 1,000 live births)	88.8	78.0	66.7	55.7	45.1	35.0	26.8
School enrollment, primary (% gross)	91.4	94.0	94.3	108.7	109.1	100.1	99.9
Life expectancy at birth, total (years)	58.7	60.6	62.7	65.0	66.9	69.6	70.2
c/d ratio (%)	60.7	55.6	56.0	66.0	73.3	77.1	76.5
Domestic credit to private sector (% of GDP)	24.9	22.5	28.3	40.1	50.6	51.9	54.6
Bank accounts PER 1,00,000 population	671.3	1031.9	1153.0	1117.9	1157.7	1640.3	1767.0

Literature Review

In the early 2000's, the idea of 'inclusive growth' and its measurement gained momentum when Kakwani and Pernia, Prahlad, Ali, Ali and Son proposed an alternative strategy for pr-poor growth in the development economics. They argued that new economic opportunities created by rapid growth are unevenly distributed. As a result, the poor people benefit less from growth than the non-poor due to the circumstantial constraints or the market failures.

Therefore, pro-poor growth is no longer sufficient to tackle the challenges posed by rapid economic growth of global economies such as wide-spread inequalities, unemployment, social unrest etc. and therefore, policy makers and development planners should focus on another developmental strategy that will be more sustainable and effective in nature. Since then, numerous attempts have been made in the literature to measure inclusive growth both at the national and international level.

We can classify these measures into two broad groups: unified measure of inclusive growth and composite index measure of inclusive growth. The former approach was started with Ali and Son when they proposed a new approach to measure inclusive growth by introducing the idea of social opportunity function and commented that growth is defined as inclusive if it increases the social opportunity function, which depends on the average opportunities to the population and how the opportunities are distributed in the population'. They have also measured the degree of inclusiveness which depends on, (i) how much the social opportunity function (or the opportunity curve) shifts upward and (ii) in which part of the income distribution the shift takes place.

They conclude that their approach would allow an individual country to monitor its inclusiveness of growth over time. Anand et al. has applied the similar methodology as defined by Ali and Son and estimated a unified measure of inclusive growth based on a utilitarian social welfare function. They have measured the proposed inclusiveness index by obtaining the per-capita income for the ith person in the population for all i (i = 1, 2… N) and then determined the arithmetic mean of these incomes. They claimed that inclusive growth is said to occur if this index increases either due to overall income growth or equity.

Their results indicated that macroeconomic stability, human capital, and structural changes are the basic foundations for achieving inclusive growth. Following Anand et al, Munir and Ullah empirically estimated a unified measure of inclusive growth by incorporating social mobility function at macro level and determined the impact of macroeconomic stability, financial deepening, and structural changes on inclusive growth in Pakistan from 1987 to 2016 [14]. Their findings suggested that money supply growth, broad money, and domestic credit to privet sector are significant determinants of inclusive growth in the country.

They concluded that more financial development could lead to encourage more inclusiveness in the country. On another study, Mitra suggested methods to derive a measure of 'inclusive growth' and a subjective measure of 'inclusiveness of growth' and made a clear distinction between these two concepts. He commented that unlike the traditional index measures of inclusive growth, this subjective measures of 'inclusiveness' considered inequalities in growth rates of incomes characterized by large differences and neglected intra-block inequalities characterized by small differences in magnitude.

The later approach of inclusive growth measurement gained momentum when McKinley developed a composite inclusive growth index. He constructed this index at the country level as a diagnostic tool for assessing country progress on inclusive growth using suitable indicators in the arrears of (i) growth, employment generation and economic infrastructure; (ii) pov-

erty and inequality (including vertical, horizontal and gender inequalities); (iii) human capabilities (health, education, water, and sanitation) and (iv) social protection.

The composite index is constructed on a weighted average score of 0–10, based on country performance on each of its four components. The usefulness of the methodology of the index is then tested in case studies of six different countries namely, Bangladesh, Cambodia, India, Indonesia, the Philippines, and Uzbekistan. Using the similar methodology, Udah and Ebi constructed a time series composite inclusive growth index for Nigeria to diagnose the performance of the economy in terms of Inclusive growth in relation to several structural and political changes from 1981 to 2013 [15].

They have used four suitable indicators of inclusive growth identified by McKinley in the areas of (i) growth, productive employment and economic infrastructure; (ii) poverty and gender equity; (iii) human capabilities; and (iv) social protection. They have constructed the index on a weighted score of 0-10 for each year based on the performance of each of the chosen indicators in terms of the ranking of its growth and the weight assigned to it.

Their results showed that Nigeria performed better in inclusive growth between 2000 and 2013 as compared to the previous decade. Another composite index approach methodology has been used by Mitra and Das to measure inclusive growth in the Indian context. They have constructed an Inclusive Growth Index (IGI) for 16 Asian countries and also compared the IGI scores across the nations (Mitra and Das, 2018). They have used 24 developmental indicators as the components of inclusive growth and categorised them into four different dimensions as expansion, sustainability, equity in access, and efficiency on economic activities and institutions.

They employed two different weighting schemes namely an ad hoc weighting scheme and a weighting scheme based on principal component analysis in constructing the IGI. As per their calculated IGI scores, Malaysia ranked as Asia's most inclusive advanced economy while Afghanistan is the least advanced economy. India ranked at 11th among 16 Asian economies. A similar methodology is used by Vellala et al. in their study on the development of a composite index for measuring inclusive growth for 15 Indian states using 20 different socio-economic variables grouped under six dimensions for the period 2001 and 2011. They have calculated the composite index for the different states based on the normalized scores (based on Z-cores) and the weights were assigned by using PCA at the indicators level.

On similar lines, cross-states analysis has been attempted by Aggarwal. The author has constructed an 'inclusive development index' for the selected Indian states using 62 developmental indicators categorized into 14 dimensions under two pillars of growth namely, outcomes and process for the year 2017-18. Like the previous studies, the author has also used PCA for assigns appropriate weights to the indicators outlined by OECD (2008, Handbook on constructing composite indicators: methodology and user guide) for constructing a composite index.

Therefore, the findings of the literature on inclusive growth measurements are quite debatable particularly when it comes to the use of appropriate methodology to measure inclusive growth. The present study tries to bridge this gap and make a significant contribution in the literature.

Data and Methodology

Data Sources

The concept of 'inclusiveness' has several dimensions (or aspects). Sometimes it's difficult to identify the complete list of the indicators falling under different dimensions. The choice of indicators may vary across time and space and with the objectives of the study. The present study identifies some important indicators and categorizes them into five major dimensions for constructing a time series composite inclusive growth index in the context of India over the period 1990-2020.

The five dimensions are: economic inclusion, environmental sustainability, gender equity, human capability, and financial inclusion. The indicators falling under these dimensions have almost captured all the aspects of IG and have been widely used by the researchers and policy makers to construct other socio-economic indices in the development literature elsewhere. Hence, the accessibility, validity, and scope of this newly constructed IGI are beyond any doubt.

All indicators are taken from the different national and international sources like World Development Indicators, World Bank; Handbook of Statistics, RBI – Banking Statistics; Education Statistics of India, various years, MHRD, Government of India, EPWRF – India Time Series, etc. The list of indicators falling under different dimensions and their sources are presented in Table A.2. in the Appendix.

Table A.2: Data source and Indicators of different Dimensions of Inclusive Growth

Dimensions	Indicators	Abbreviation	Sources	Time Period
Economic Inclusion (EEI)	GDP per capita (constant2010 US$)	GDPPC	World Bank Database	1990-2020
	GCF per capita (constant 2010)	GCF	World Bank Database	1990-2020
	GCF per capita (constant 2010)	LABPRO	World Bank Database	1990-2020

Environmental Sustainability (ESI)	CO2 intensity (emissions of CO2 kt. per 2010 US$ of GDP)	CO2	World Bank Data; Knoema.com/atlas/India/CO2emission per-capita	1990-2020
	Forest area (% of land area)	ANS	World Bank Database	1990-2020
	Adjusted net savings, excluding particulate emission damage (% of GNI)	FOREST	World Bank Database	1990-2020
Gender Empowerment (GEI)	Proportion of seats held by women in national parliaments (%)	WMNP	https://www.indexmundi.com/facts/india/indicator/SG.GEN.PARL.ZS	1990-2020
	Number of Female per hundred Male Enrolled in Primary education	GERS	Education Statistics of India, various years- MHRD, GoI	1990-2020
	Number of Female Teachers per hundred Male Teachers in Primary education	GERT	Education Statistics of India, various years- MHRD, GoI	1990-2020
Human Capability (HCI)	Mortality rate, infant (per 1,000 live births)	IMR	Health Statistics of India, Ministry of Health and Planning Various Years, GoI.	1990-2020
	Gross enrollment Ratio (I-V)	GER	EPWRF India Time Series, Education Statistics of India, various years- MHRD , GoI	1990-2020
	Life expectancy at birth, total (years)	LFEX	World Bank Database	1990-2020
Human Capability (HCI)	C/D ratio (%)	CDR	Hand Book of Statistics, RBI – Banking Statistics	1990-2020
	Domestic credit to private sector (% of GDP)	DOMSAV	World Bank Database	1990-2020
	Number of bank account per 100000 populations	ACCOUNT	Hand Book of Statistics, RBI -Banking Statistics	1990-2020

Research Methodology

Conceptual issues in Constructing Inclusive Growth Index (IGI)

An acknowledged theoretical framework is a prerequisite for constructing any composite index. The validity of a composite index measure is also difficult to test in practice as it implicitly involves value judgments (Kaufmann et al., 2007) [7]. Therefore, this study provides a conceptual framework for developing a composite inclusive growth index (IGI). For constructing IGI, the study adopts the same conceptual framework considered by Sarma [20]. We consider n quantifiable dimension of an inclusive growth trajectory, as $x_1, x_2,.....x_n$. Here, the IGI is considered as a function of n variables in the n-dimensional real space and it can be written as:

$$IGI\ (x_1, x_2,.....x_n)$$

The IGI is therefore a multidimensional measure and incorporates information on various aspects in a single number. This index measure is easy to interpret and can track the time trend of a particular country to its respective inclusive growth achievement. Our next step is to aggregate these dimensions in a meaningful manner so that it satisfies some inherent properties like, homogeneity [21], monotonicity [22], boundedness [23], and unit free measure [4].

However, the method of aggregation is very sensible to the weight assignment to the indicators. Giving more or less weight to one or more indicators makes the index measurement questionable as any subjective weighting scheme implicitly involves value judgment [7].

There are several methods to construct a composite index. Among them ad-hoc weighting scheme and the weighting scheme based PCA are widely used methodology for constructing composite indices. Unlike the former method which assigns equal weightage to each indicator irrespective of their importance, the later one computes weight through an orthogonal transformation of the linearly uncorrelated principal components.

Thus, the present study applies Principal Component Method of Factor Analysis to derive the weights of the indicators and then constructs inclusive growth index and infrastructure index and their sub-indices. Unlike other weightage methods, the weightage scheme based on PCA satisfies some useful criteria for any socioeconomic index construction. These are as follows:

a. It attached higher weight to the variables having strong interlinkage with others.
b. It also assigned higher weight to the variables having high variance or greater disparity.
c. It doesn't give negative weight to the variables as long as they exhibit positive implications for development etc. Therefore, the PCA method is emerged as the preferred method of constructing composite indices of inclusive growth.

In this paper, we use two-stage principal component analysis to construct the inclusive growth index and its sub-indices. Since the different sub-indices are likely to contain inter-correlated indicators, we estimate the sub-indices first rather than directly estimating the overall inclusive growth index. Firstly, we calculate the normalized values for all the indicators so that they become unit free.

Secondly, we construct different sub-indices of inclusive growth. Here the index value of each sub-dimension is obtained by taking the indicators of that dimension at each stage by using the principal component method. Finally, in the last stage, the overall inclusive growth index is constructed using these sub-dimensions. The detailed methodology of constructing composite indices for the analysis of the present study is discussed in the next section.

Theoretical Framework of PCA

In a multivariate analysis, a greater number of highly correlated explanatory variables relative to the sample sizes make testing of hypothesis ineffective and may create multicollinearity problem in estimating a regression model [8]. In such a situation, Principal Component Analysis (PCA) can be used to reduce the dimension of the data. PCA is a multivariate statistical technique where the mutually correlated indicator variables are summarized by a fewer number of linearly uncorrelated principal components through an orthogonal transformation, and these principal components then get weighted for the final Index construction.14 The concept of PCA can be described as: Suppose, Y is a set of normalized15 latent variables, and it can be expressed as a linear combination.

$$Y = \alpha_1 Y_1 + \alpha_2 Y_2 + \ldots + \alpha_6 Y_n + \varepsilon_t \ldots\ldots\ldots (1)$$

$$NV_i = \left[\frac{Y_i - \min Y_i}{\max Y_i - \min Y_i}\right] \forall i = 1 \ldots\ldots\ldots, n;$$

Here, the calculated normalized values vary from zero (when Yi = min Yi) to one (when Yi = max Yi). For some variables like GDP per-capita, Capital, Labour productivity etc. zero indicates the worst value and one indicates the highest value. However, for some indicators like CO2, and IMR we use the following formula (equation 1b) to calculate their normalized values as in such variables their maximum value is the worst value, and the minimum value is the best value.

$$NV_i = 1\text{-}\left[\frac{Y_i - \min Y_i}{\max Y_i - \min Y_i}\right] \forall i = 1 \ldots\ldots\ldots, n;$$

We denote λ_m (m=1, 2, …., n) as the mth Eigen value and p_m as the mth principal component for equation (1). Here the subscript 'm' refers to the number of principle components which coincides with the number of corresponding variables (n). Now we get the corresponding estimator of the variable Y according to the following weighted average:

$$Y_t = \sum_{m=1}^{n} \lambda_m * p_m / \sum_{m=1}^{n} \lambda_m$$

Here, the whole set of the causal variables is replaced by a few principal components, which accounts for a substantial percentage of the total variation in all the sample variables [19]. The components are ordered in such a way that the highest weight λ_1 is attached to the first principal component as it explains the largest proportion of total variation in the data.

Similarly, the weight λ_2 ($\lambda_2 < \lambda_1$) is attached to the second principal component which is completely uncorrelated with the first component and explain the less variation than the first component. In this way, each component captures an additional dimension in the data, while explaining smaller and smaller proportion of the variation of the dataset [24]. Using matrix algebra, we can express p_m as a linear combination of the nth variables as:

$$\begin{bmatrix} PC_1 \\ PC_2 \\ . \\ . \\ . \\ PC_m \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & . & . & . & a_{1n} \\ a_{21} & \sigma_{22} & . & . & . & \sigma_{2n} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ a_{m1} & a_{m2} & . & . & . & a_{mn} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ . \\ . \\ . \\ Y_n \end{bmatrix}$$

Construction of Inclusive Growth index (IGI): An Application of Two-Stage PCA

We assume that the latent variable [17] like IGI can be expressed as a linear function as follows:

$$IGI_t = \propto_1 I_t^{EEI} + \propto_2 I_t^{ESI} + \propto_3 I_t^{GEI} + \propto_4 I_t^{HCI} + \propto_5 I_t^{FII} + e_t$$

for instance, the overall inclusive growth index is supposed to be determined by the latent variables like economic inclusion (I_t^{EEI}), environmental sustainability (I_t^{GEI}), gender equity (I_t^{GEI}, human capability (I_t^{GEI}) and financial inclusion (I_t^{ESI}).

Here, economic inclusion (I_t^{EEI}) index again is supposed to be determined by variables like per- capita GDP (X_{1t}), per-capita gross capital formation (X_{2t}), and labour productivity (X_{3t}). In linear form it is represented as:

$$I_t^{EEI} = \propto_{11} X_{1t} + \propto_{12} X_{2t} + \propto_{13} X_{3t} + \mu_{1t}$$

Similarly, in case of environmental sustainability (I_t^{EEI}), the corresponding index as a latent form is supposed to be determined by a number of developmental indicators like, CO_2 emissions (Y_{1t}), forest area as % of land area (Y_{2t}), and Adjusted net savings, excluding particulate emission damage, % of GNI (Y_{3t}) respectively, and in linear form it is stands as

$$I_t^{ESI} = \propto_{21} Y_{1t} + \propto_{22} Y_{2t} + \propto_{23} Y_{3t} + \mu_{2t}$$

Further, in case of gender equity (I_t^{EEI}), we consider the corresponding index as a latent variable linearly determined but three relevant components. The components are denoted as proportion of seats held by women in national parliaments, % (Z_{1t}), number of females per hundred males enrolled in primary education ((Z_{2t}), and number of female teachers per hundred male teachers in primary education (Z_{3t}) respectively, and in linear form it is expressed as:

$$I_t^{GEI} = \propto_{31} Z_{1t} + \propto_{32} Z_{2t} + \propto_{33} Z_{3t} + \mu_{3t}$$

In this way, for human capability, financial inclusion we consider the following linear forms:

$$I_t^{HCI} = \propto_{41} U_{1t} + \propto_{42} U_{2t} + \propto_{43} U_{3t} + \mu_{4t}$$

$$I_t^{FII} = \propto_{51} V_{1t} + \propto_{52} V_{2t} + \propto_{53} V_{3t} + \mu_{5t}$$

U_{2t} stands for Mortality rate, infant (per 1,000 live births); U_{2T} stands for school enrollment, primary (% gross); U_{3t} stands for life expectancy at birth, total (yeas); V_{1t} stands for credit-deposit ratio; V_{2t} stands for domestic credit to private sector (% of GDP) and V_{3t} stands for Bank accounts PER 1,00,000 population.

Our next task is to estimate each dimension of inclusive growth, and this is done according to the following weighted averages:

$$I_t^{EEI} = \sum_{k=1}^{3} \lambda_k^{EEI} * P_k^{EEI} / \sum_{k=1}^{3} \lambda_k^{EEI}$$

$$I_t^{ESI} = \sum_{k=1}^{3} \lambda_k^{ESI} * P_k^{ESI} / \sum_{k=1}^{3} \lambda_k^{ESI}$$

$$I_t^{GEI} = \sum_{k=1}^{3} \lambda_k^{GEI} * P_k^{GEI} / \sum_{k=1}^{3} \lambda_k^{GEI}$$

$$I_t^{HCI} = \sum_{k=1}^{3} \lambda_k^{HCI} * P_k^{HCI} / \sum_{k=1}^{3} \lambda_k^{HCI}$$

$$I_t^{FII} = \sum_{k=1}^{3} \lambda_k^{FII} * P_k^{FII} / \sum_{k=1}^{3} \lambda_k^{FII}$$

Here, we denote $\lambda_k^{EEI}, \lambda_k^{ESI}, \lambda_k^{GEI}, \lambda_k^{HCI}, \lambda_k^{FII}$ as the k^{th} eigenvalues [25] for each dimension of inclusive. growth. Subscript k refers to the number of principal components in each respective dimension i.e., for case EII, k = 1, 2, 3; for ESI, k = 1, 2, 3 and so on We also denote $P_k^{EEI}, P_k^{ESI}, P_k^{GEI}, P_k^{HCI}, P_k^{FII}$ as the K^{th} principal components [2] for each dimension of inclusive growth. The value of P_k gradually falls as the suffix increases in each case. Table A.3 - A.9 (see appendix) presents the eigenvalues of the different sub-indices and their respective factor loadings.

Table A.3: Index Scores of IG and its sub-indices, 1990-2020

Year	EEI	ESI	HCI	FII	GEI	IGI
1990	0.015009	-0.41882	0.008336	0.150139	0	-0.11091
1991	0.006943	-0.40344	0.030394	0.295431	0.051776	-0.01452
1992	0.029314	-0.32002	0.067869	0.240366	0.103551	0.046401
1993	0.042035	-0.25764	0.143407	0.265578	0.131402	0.134723
1994	0.076606	-0.13706	0.204145	0.211942	0.26415	0.262095
1995	0.106797	-0.06412	0.224649	0.190144	0.257568	0.303159
1996	0.132028	-0.03178	0.250368	0.28703	0.301199	0.397977
1997	0.15379	0.016281	0.270595	0.250381	0.320905	0.429609
1998	0.177162	0.025246	0.25457	0.227175	0.405003	0.461671
1999	0.232067	0.071768	0.305535	0.254204	0.44627	0.555291
2000	0.232052	0.082837	0.385753	0.335515	0.529314	0.665185
2001	0.257158	0.090866	0.412379	0.378539	0.518261	0.703827
2002	0.281033	0.168777	0.464929	0.492126	0.574764	0.842482
2003	0.343761	0.279478	0.72243	0.491549	0.830808	1.138648
2004	0.436494	0.395041	0.902872	0.507511	0.818192	1.307384
2005	0.518039	0.450521	0.953474	0.666273	0.801903	1.446192

2006	0.597707	0.551439	1.002119	0.795955	0.786123	1.59131
2007	0.695478	0.616246	1.049366	0.876769	0.86444	1.746599
2008	0.688116	0.569017	1.096798	0.936919	1.050237	1.848267
2009	0.795496	0.653508	1.089051	0.93139	1.115426	1.949734
2010	0.908993	0.716288	1.107861	0.9651	1.205016	2.08274
2011	0.965103	0.701337	1.062902	1.022278	1.151422	2.079678
2012	1.028002	0.762689	1.190548	1.147705	1.19978	2.261336
2013	1.070145	0.762051	1.04628	1.200912	1.288861	2.273947
2014	1.17929	0.798337	0.986411	1.261291	1.296205	2.334959
2015	1.289529	0.805905	1.01978	1.275482	1.352905	2.426748
2016	1.405457	0.787829	1.029842	1.325624	1.378036	2.500891
2017	1.547239	0.861144	1.003548	1.286399	1.391606	2.566738
2018	1.697953	0.877161	1.015839	1.295307	1.394332	2.643729
2019	1.680965	0.826236	1.018634	1.332029	1.569768	2.70592
2020	1.569615	0.784322	1.089853	1.361238	1.544809	2.676758

Table A.4: Construction of Economic Inclusion Index (Factor Loadings and Eigen values)

Economic Inclusion Indicators	PC1	PC2	PC3	Eigen Values
GDP	0.578882	-0.23474	-0.78089	2.978177
GCF	0.575694	0.795871	0.187528	0.020386
LABPRO	0.577471	-0.55811	0.595851	0.001437

Table A.5: Construction of Environmental Sustainability Index (Factor Loadings and Eigen values)

Environmental Sustainability Indicators	PC1	PC2	PC3	Eigen Values
CO2	-0.58356	0.521907	0.622155	2.613628
ANS	0.541341	0.821084	-0.18103	0.345199
FOREST	0.605321	-0.23116	0.761677	0.041173

Table A.6: Construction of Gender Empowerment Index (Factor Loadings and Eigen values)

Gender Empowerment Indicators	PC1	PC2	PC3	Eigen Values
GERS	0.568306	0.784487	0.248211	2.814155
GERT	0.5869	-0.17505	-0.79051	0.143836
WMP	0.576694	-0.59493	0.559898	0.042009

Table A.7: Construction of Human Capability Index (Factor Loadings and Eigen values)

Human Capability Indicators	PC1	PC2	PC3	Eigen Values
GER	0.476317	0.878871	0.026589	2.411812
IMR	0.624356	-0.31678	-0.71403	0.586228
LFEX	0.619113	-0.3567	0.699615	0.00196

Table A.8: Construction of Financial Inclusion Index (Factor Loadings and Eigen values)

Financial Inclusion Indicators	PC1	PC2	PC3	Eigen Values
DOMSAV	0.609962	-0.31467	-0.72727	2.506986
CDR	0.599798	-0.41645	0.683236	0.450102
ACCOUNT	0.517869	0.852965	0.06528	0.042911

Table A.9: Construction of Overall Inclusive Growth Index (Factor Loadings and Eigen values)

Dimensions of Inclusive Growth	PC 1	PC 2	PC 3	PC 4	PC 5	Eigen Values
EEI	0.440772	-0.6082	-0.15327	0.328512	0.55172	4.746256
ESI	0.453171	0.261981	-0.37395	0.566843	-0.51464	0.19606
HCI	0.435815	0.689592	0.282455	-0.02303	0.504199	0.033766
FII	0.450597	-0.28957	0.730445	-0.11485	-0.40789	0.013745
GEI	0.455393	-0.04545	-0.47259	-0.74636	-0.10081	0.010172

Here, we replace the whole set of causal variables by fewer principal components which accounts for a substantial percentage of the total variation in all the variables. We also consider as many components as the number of explanatory variables.

This is because of the concern to estimate accurately the sub-indices of inclusive growth and infrastructure rather than truncating the whole data to avoid discarding information that could affect our calculated estimates. In this way, this procedure accounts for 100% of total variation in the data. In the second stage of PCA analysis, we compute the overall inclusive growth index by the following steps outlined above, whereby we get.

$$IGI_t = \left[\sum_{k=1}^{5} \lambda_k' P_k' / \sum_{k=1}^{5} \lambda_k'\right]$$

Here, λ_1' and λ_1'' are the highest weights which are attached to the first principal component of IGI.

The first principal component explains the largest proportion of the total variation in all explanatory variables. Similarly, the second principal component accounts for the second largest variation in all explanatory variables and is uncorrelated to the first principal component. In this way, as the suffix increases the proportion of variation explained by the respective principal components will reduce [19]. Using matrix algebra, we can express each.

component of p_k' and p_k'' as a linear combination of the five sub-indices of inclusive growth as:

$$\begin{bmatrix} P_1' \\ P_2' \\ P_3' \\ P_4' \\ P_5' \end{bmatrix} = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \sigma_{14} & \sigma_{15} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \sigma_{24} & \sigma_{25} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \sigma_{34} & \sigma_{35} \\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44} & \sigma_{45} \\ \sigma_{51} & \sigma_{52} & \sigma_{53} & \sigma_{54} & \sigma_{55} \end{bmatrix} \begin{bmatrix} EEI \\ ESI \\ GEI \\ HCI \\ FII \end{bmatrix}$$

Hence the overall inclusive growth index (IGI) can be written as:

$$IGI = \left[\sum_{k=1}^{5} \lambda_k' (\sigma_{k1} EEI + \sigma_{k2} ESI + \sigma_{k3} GEI + \sigma_{k4} HCI + \sigma_{k5} FII) / \sum_{k=1}^{5} \lambda_k'\right]$$

Results and Discussion

Descriptive Statistics

To understand the nature of the Inclusive growth index (IGI) and its sub-indices, we provide a detailed description of the calculated indices. Table 1 presents the descriptive statistics. The Results show that the difference between maximum and minimum values for all the indices under consideration are substantial.

Table 1: Descriptive Statistics

	IGI	EEI	ESI	HCI	GEI	FII
Mean	1.363	0.650	0.356	0.691	0.805	0.718
Median	1.446	0.518	0.451	0.953	0.818	0.666
Maximum	2.706	1.698	0.877	1.191	1.570	1.361
Minimum	-0.111	0.007	-0.419	0.008	0.000	0.150
Std. Dev.	0.959	0.557	0.425	0.413	0.492	0.442
Skewness	-0.058	0.541	-0.370	-0.384	-0.076	0.168
Kurtosis	1.484	1.945	1.728	1.423	1.650	1.406
Jarque-Bera	2.984	2.947	2.797	3.972	2.383	3.428
Probability	0.225	0.229	0.247	0.137	0.304	0.180

Source: The authors

The skewness of the data measuring the asymmetry of the probability distribution of the series around its mean indicates that EEI and FII are positively skewed while IGI, ESI, HCI and GEI are negatively skewed. The kurtosis measuring the 'tailedness' of the probability distribution of the series reveals that all indices are platykurtic in nature. Finally, the findings of the Jarque-Bera statistics confirm that all the indices are normally distributed (i.e., the distribution is bell- shaped).

Trends in Inclusive Growth Indices

In this section, we present the scenario of inclusive growth in India by analyzing time trend of the indices. Fig 1 and 2 below shows the time trend of IGI and its sub-indices from 1990 to 2020. The y – axis measures the index scores and x – axis shows the years under review. The IGI has shown a continuous and steady growth and rose throughout the study period.

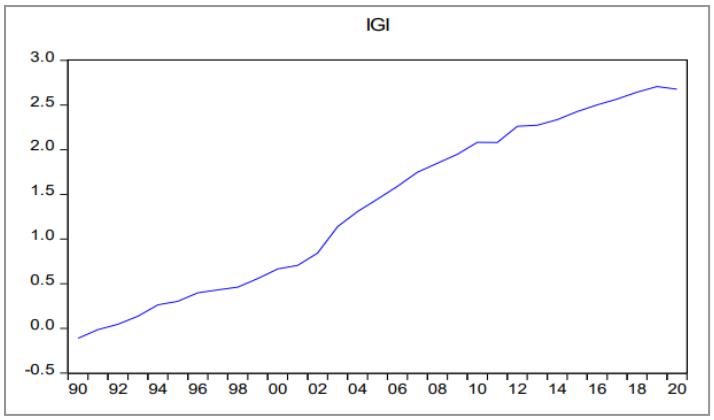

Figure 1: Trend in IGI During 1990-2020
Source: The authors

Like IGI, EEI also exhibited a rising and upward trend during 1990-2018 and have decreased thereafter. In case of ESI, a steady growth has observed during 1990 to 2001 then it has fluctuated thereafter. If we look at GEI index, we find that the index scores have shown a continuous rise though some fluctuations have been seen during the study period.

HCI have also exhibited a steady and continuous rise during 1990 – 2010 then it fluctuated for the rest of the study period. Finally, if we look at FII, it is observed that FII fluctuated during 1990 – 1999, and then steadily increased in between 2000 - 2008. It has declined in the very next year and increased thereafter. The index scores of IGI and its sub-indices are presented in Table A.2 in the appendix.

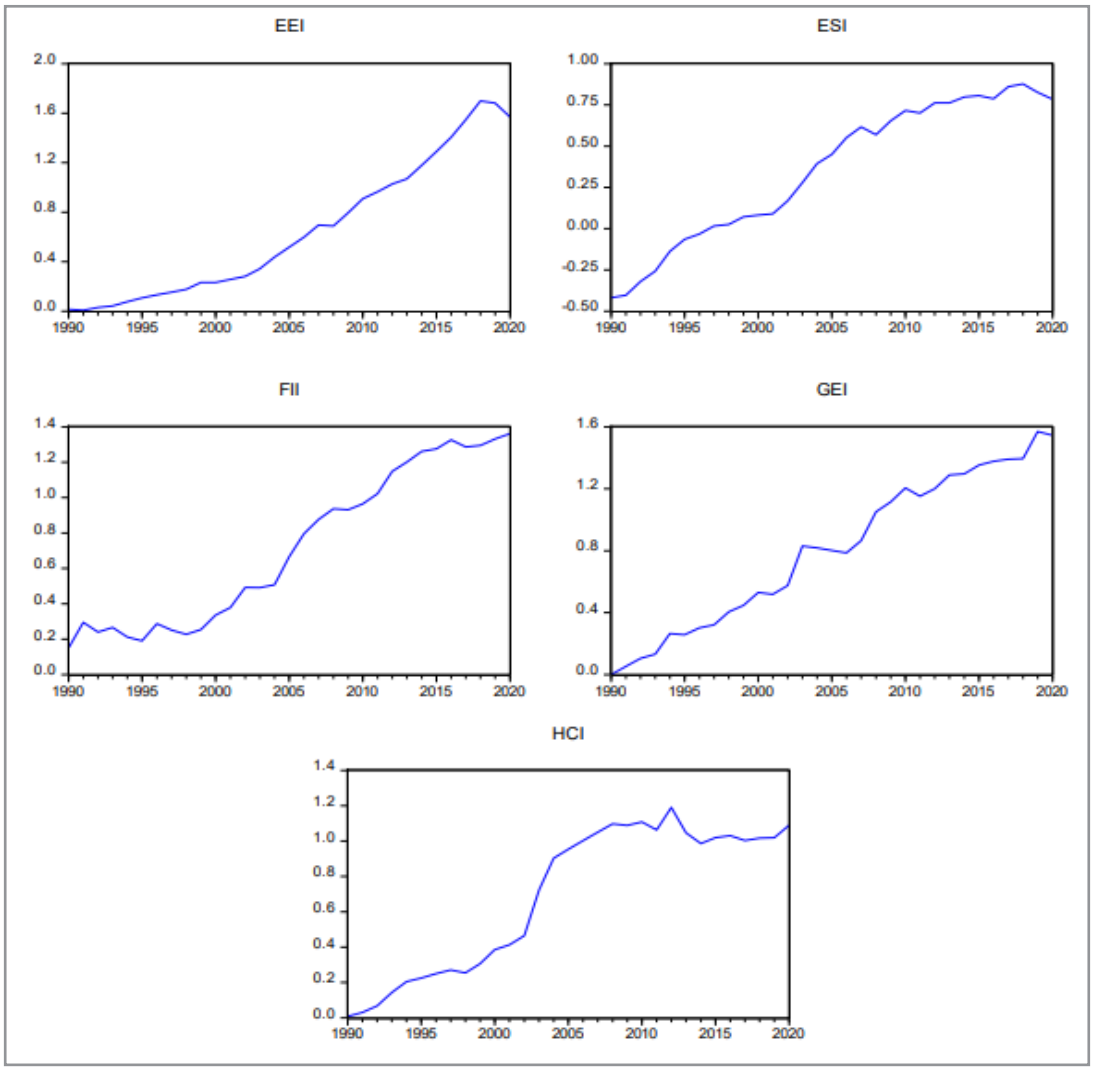

Figure 2: Trends in sub-indices of IGI During 1990-2020
Source: The authors

Overall, we conclude that during 1990-2020, India has experienced a steady and sustained rise in the 'inclusiveness' in growth including its economic activities, sustainability of environment, gender empowerment, development of human capabilities and expansion of financial activities. However, though the inclusiveness in growth seems impressive, it's still not satisfactory when we compared it to the international standard [14].

Diagnosis of India's Inclusive Growth

In this section, we compute the decadal average annual growth rate of IG index and its sub-indices (presented in Table 2) to assess the performance of India in its growth inclusiveness. It is observed that in the first two decades (1991-2000 & 2001-2010) preceding the post-reform, the average annual improvement rates in the IG indices are quite substantial.

During 1991-2000, the highest improvement rates are exhibited by human capabilities at 61.15 per cent and the least by environmental sustainability by -9.075 per cent. During 2001-2010, the highest improvement rates are exhibited by environmental sustainability by 26.736 per cent and the least by gender equity by 9.358 per cent.

Table 2: Decadal Average Annual Growth rates in the Composite Indices of Inclusive Growth in India, 1990-2020

Year	EEI	ESI	HCI	FII	GEI	IGI
1991-2000	51.978	-9.075	61.150	13.094	30.391	11.925
2001-2010	14.863	26.736	12.097	11.675	9.358	12.403
2011-2020	5.753	1.033	0.041	3.567	2.615	2.572

Source: The authors

However, the improvement rates decidedly slowed down for all the sub-indices of IG in the last decade (2011-2020). This is basically since the initial levels of inclusiveness were too low during 1990. During 2011-2020, the highest improvement rates are exhibited by economic inclusion by 5.753 per cent per cent and the least by human capability by 0.041 per cent. Overall, The average annual improvement rates in inclusive growth shown a mix trend. It has increased from 11.925 per cent during 1991-2000 to 12.403 per cent during 2001-2010 and declined to 2.572 per cent during 2011-2020, respectively. Thus, it can be said that the performance of the India in terms of its inclusive growth are though significantly better in the post reform period, but the improvement rate decidedly slowed down in the recent periods.

Conclusion

This study constructed a time series composite inclusive growth index for India and diagnosed its performance in terms of its inclusive growth achievements over the period 1990 to 2020. We have applied two stage principal component analysis method to construct an IG index. In the first stage we have constructed different sub-indices of inclusive growth such as economic expansion, environmental sustainability, gender equity, human capability, and financial inclusion. In the next step, overall inclusive growth index is constructed using the above-mentioned dimensions as explanatory variables.

The indicators used in our study for constructing the IG index and its sub- indices have been widely used elsewhere in the development literature to measure other socio- economic indices. Hence, the validity of our index measure is beyond any doubt. Our study is in line with some other previous studies in the Indian context particularly, in terms of methodological standpoint [16, 17, 18].

However, differ in terms dimensions, nature of the indicators, and the time. While the above-mentioned studies attempted cross country/cross states analysis, this study focuses on time series analysis in the context of Indian economy with a hope that it can track the progress of the economy in terms of its inclusive growth in general, and the rate of achievements of inclusive growth in the post reform periods [26-30].

The results of our study indicated that India's performance in terms of inclusive growth the post reform period is quite satisfactory. All the sub-indices along with the overall IG index have increased during this period. The results of decadal average annual improvement rates revealed that the average annual improvement rates were much higher in the first two decades (1991-2000 & 2001-2010) preceding the post-reform period. However, the improvement rates decidedly slowed down for all the sub-indices of IG in the last decade (2011-2020). This is basically since the initial levels of inclusiveness were too low during 1990.

The major contribution that our paper made is provided a methodological ground for measuring inclusive growth for a particular country. This will settle the issue of country specific measurement of inclusive growth, its achievements, and expansions over time. Therefore, the present index measure would be critical for formulating inclusive growth policies particularly, for developing nations.

However, this study has some limitations. Firstly, we present few dimensions of inclusive growth and cannot capture some crucial dimensions like poverty, inequality, social protections due to lack of appropriate data. Secondly, our study present and assess India's performance in its inclusiveness in growth but fail to identify the factors that can affect inclusive growth. Identifying theses would be very crucial for designing of effective inclusive growth policies. Researchers may explore these areas and make further contribution in development literature.

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References

1. Son HH, Kakwani N (2004) Economic Growth and Poverty Reduction: Initially Conditions Matter, UNDP, Working Paper No. 2.
2. Mulok D, Kogid M, Asid R, Lily J (2012) Is economic growth sufficient for poverty alleviation? Empirical evidence from Malaysia, Cuadernos Economia, 35: 26-32.
3. Agarwal P (2015) Reducing Poverty in India: The Role of Economic Growth, IEG Working Pg no-349.
4. Kakwani N, Pernia ME (2000) What is Pro Poor Growth. Asian Development Review 18: 1-6.
5. Prahlad CK (2004) The Fortunes at the Bottom of the Pyramid: Eradicating Poverty through Profits, Financial Times/ Prentice Hall.
6. Ali I (2007) Inequality and the imperative for Inclusive Growth in Asia, Asian Development, Review 24: 1-16.
7. 7. McKinley T (2010) Inclusive Growth Criteria and Indicators: An Inclusive Growth Index for Diagnosis of Country Progress, Asian Development Bank, Working Paper 14.
8. Klasen S (2010) Measuring and Monitoring Inclusive Growth: Multiple Definitions, Open Questions and Some Constructive Proposal, Asian Development Bank, Working PaPer No. 12.
9. Tsangarides CG, Ghura D, Leite C (2002) Is Growth Enough? Macroeconomic Policy and Poverty Reduction, IMF Working Paper No. 118.
10. Kraay A (2004) When is Growth Pro-poor? Cross-Country Evidence, International Monetary Fund, Working Paper No. 47.
11. Ali I and Son HH (2007) Measuring Inclusive Growth, Asian Development Review. 24: 11-31.
12. 12. Rauniyar G, Kanbur R (2010) Inclusive Development: Two Papers on Conceptualization, Application, and the ADB Perspective, Asian Development Bank, Working Paper No. 1.
13. Anand R, Mishra S, Peiris SJ (2013) Inclusive Growth: Measurement and Determinants,International Monetary Fund, Working Paper No. 135.
14. 14. Munir F, Ullah S (2018) Inclusive Growth in Pakistan: Measurement and Determinants, The Pakistan Journal of Social Issues.
15. Udah BE, Ebi BO (2016) Diagnosis of Nigeria Inclusive Growth: A Composite Index Approach, British Journal of Economics, Finance and Management Sciences 12: 49-58.
16. Vellala PS, Madala MK, Chhatopadhyay U (2016) The Development of Composite Index for Inclusive Economic Growth: An Indian Perspective, International Journal of Economic Perspective 10: 454-471.
17. Mitra A, Das A (2018) Inclusive Growth: Economics as if People Mattered, Global Business Review 19: 1-15.
18. Aggarwal SC (2021) How Inclusive Are Indian States: Evidence from Inclusive Development Index, Arthaniti: Journal of Economic Theory and Practice 15: 1-30.
19. Datta SK, Ghosh D (2016) Analysis of Motivation Issues and Link with Profitability: Case Study of Entrepreneurial Firms in a Rural Cluster in West Bengal, India, Business and Economic Journal 7: 1-6
20. GoI (2006) Towards Faster and More Inclusive Growth: An Approach to Eleventh Five Year Plan, Planning Commission, New Delhi.
21. GoI Economic Census (2011) Registrar General & Census Commissioner, India.
22. GSDR (2015) Inclusive Growth, University of Birmingham.
23. Ianchavichina E, Lundistoram S (2009) Inclusive Growth Analytics Framework, Policy Research Working Paper, World Bank, Economic Policy and Debt Department, Economic Policy Division, 4851.
24. Vyas S, Kumaranayake L (2006) Constructing socio-economic status indices: how to use principal components analysis, Oxford University Press, The London School of Hygiene and Tropical Medicine, London, UK 21: 459-468.
25. Mitra S (2017) A Note on Measuring Inclusive Growth and the Inclusiveness of Growth, South Asian Journal of Macroeconomics and Public Finance 6: 1-15.
26. Alvaredo F, Chancel L, Piketty T, Saez E, Zucman G (2018) World Inequality Report 2018,World Inequality Lab.https://wir2018.wid.world/files/download/wir2018-summary- english.pdf.
27. Oluseye IC, Gabriel AA (2017) Determinants of Inclusive Growth in Nigeria: An ARDL Approach, American Journal of Economics 7: 97-109.
28. Sarma M (2015) Measuring Financial Inclusion, Economics Bulletin 35: 604-611.
29. 29. The Inclusive Development Index (2018) World Economic Forum.http://www3.weforum.org/docs/WEF_Forum_IncGrwth_2018.pdf.
30. World Bank (2009) What Is Inclusive Growth? PRMED Knowledge Briefs, Washington, DC: World Bank.