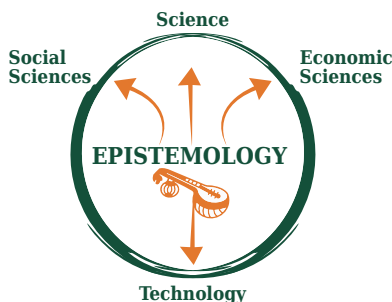
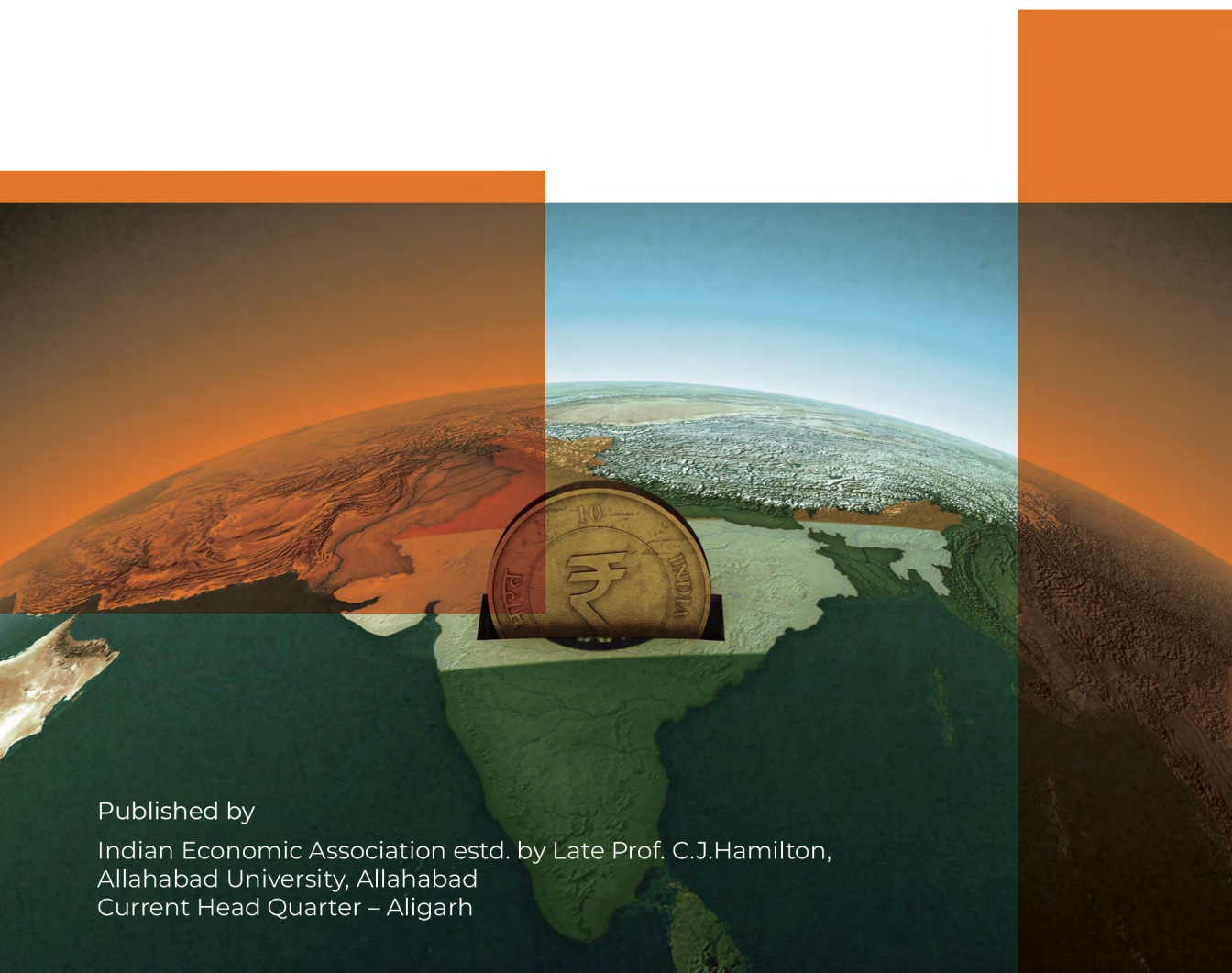




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ABOUT THE JOURNAL

The Indian Journal of Economy and Policy (IJEP) is a peer reviewed / refereed quarterly journal in the discipline of Economics edited for the first time by Dr Shri Prakash. The journal is owned by Indian Economic Association. The executive council of Indian Economic Association in its online meeting held on 7th April 2022 appointed Prof Shri Prakash as editor of the journal. The journal intends to provide researchers, academicians, professionals and practitioners a platform to share knowledge through genuine research in the areas largely pertaining to the problems of the economies and economic policies. The journal is designed to promote high quality original and innovative empirical research, methodological and realistic analysis and provide policy frameworks on existing economic problems. The journal encourages researchers and policymakers to share their thoughts and experience in the area of policy making and spread this knowledge to the academic community. The journal also aims to provide an interface for multidisciplinary research by providing a platform to researchers to share the research findings focusing on economic aspects of social, political, ecological and technological phenomena.

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From Editor's Pen

The Vol 2, No 4, January – March'2025 of Indian Journal of Economy and Policy is now in the hands of the readers. The issue contains papers on highly interesting themes which are relevant both for current period and future. The themes are as diversified as usual.

Shashank Sharma explores the direct and indirect spillover effects of volatile changes in the equity prices listed in NIFTY and he examines the effect of these volatile changes on the indices of the selected sectors of the Indian economy. He explores, the opportunities for investors while the Nifty is in the grip of volatile changes. He uses Granger causal direction of relation between volatile changes and opportunities for investors on the one hand and conditional correlation on the other hand. He also uses two other alternative models for examining conditional autocorrelation and conditional heteroscedasticity. This aspect of the paper is relevant in the context of the fact that the time series data are generally adversely affected by the non-stationary nature of time series. Besides, the US decision to impose heavy tariff on imports from 60 countries including India has sent the global stock markets into turmoil. Obviously, the study does not depend upon the outcomes of application of one particular method since every method has its own assumptions. The author also focuses on other important aspect of the volatile changes in equity prices. The fact is that the prices of equities in any market do not change uniformly or the pattern of change is seldom identical. He attempts to identify the opportunities in the diversified nature of the changes that occur in the equity prices of stocks listed in Nifty. The findings of this paper may probably require evaluation on the basis of conditional probability. In our opinion, it may be noted that big – bang change in equity prices occurs only occasionally in response to some abnormal event. But previous studies show that the big – bang changes in the equity prices generally tend to converge towards the normal level.

Sumitra Choudhary has taken up a very interesting topic for study. In the context of this study, it may be noted that the technological changes have been occurring almost continuously in a systematic fashion ever since the evolution of civilizational. But the nature and impact of technology has been diverse on diverse segments of the global economy and sectors of national economies. Digitalization has come as the latest technological advancement. Country after country has been adopted digital technologies. Economies of Asia are no exception to this. The author has examined the impact of digitalization on the nature of pattern of governance and the alleviation of poverty in Indian economy. She notes that the percolation based model of planned economic development of India failed to realize it's one of the most important objectives that is alleviation of poverty. She highlights that the poor are spread across the nook and corners of the country whereas the model of poverty alleviation was centralized due to which it failed to realize the objective. It failed to capture the problems at regional or local levels. Therefore, it is interesting to note that the digitalization activates the factors and the schemata that empowers poor at grass roots levels. So it is expected to reduce poverty substantially. So far as governance is concerned digitalization is expected to reduce the cost and time involved in the percolation of the changes that take place in the local economies. The example of banking sectors may be cited here wherein the use of online payments

has significantly reduce the time and cost of payment mechanisms. The findings of this paper will be interesting for readers and potential authors.

The third paper authored by Amit Sharma, Shriprakash and Rebecca Donald offers alternative method of modeling time series which obviates the need for the use of test of stationarity of the time series data as it does not use regression in analysis. This study first provides the explanation of the differences between the stationarity, static and dynamic state of the economy. The study prefers Mehta's concept to Hick's concept of stationarity for conceptual strength. So, this classification is nearer the real state of economies of the nation. The authors use the principle of elasticity which is based on the relative rates of growth of the variables. The authors have used four alternative methods to estimate rates of change in GDP of India and the total stock of capital accumulated from 2000-2023-24 for the determination of the coefficient of elasticity which relates the two variables. They prefer the use of principle of compounding for estimating rates of growth, since this method appears to offer relatively precise estimates of growth rates. This study offers the opportunity to researchers, who do not know econometrics, for modeling time series.

Ruchi Tyagi has used the method and model proposed by Shri Prakash et al. She has used the data of GDP, employment and accumulated capital in Indian economy from 2011 to 2023. She has also estimated labor and capital productivity as the basic pillars of growth. She shows that labor productivity rises from year to year in the initial sub-period till an inverted U occur in the graph and the labor productivity continues to rise further. This implies that the labor productivity in Indian economy has still to reach its peak. As against this, productivity of capital traces the horizontal straight line but a couple of years before the end of the period the productivity starts falling. This implies over capitalization which means technical correction.

The last paper is by Anju Agarwal who has used econometric modeling for determining the relationship between growth of GDP of India and the growth of tertiary sector. In other words, she examines the causal relationship between the growth of the tertiary sector and the growth of the Indian economy. She has specified GDP as the dependent variable and output of tertiary sector as the exogenous variable. Emergence of linear economics has been accompanied by the postulation that all variables are multilaterally related with each other. In our perception, some relationships are characterized by lead-led structure while others are in con-current relationship. She has covered a period of twenty four years from the year 2000 – 2024 in her study. In view of the use of time series data in the econometric modeling, she has examined the stationary nature of time series through the use of Dickey fuller test based on the three versions of Random Walk Model. She has also used the Engel granger Test of co-integration for validating the empirical findings. This paper is relevant in lieu of the fact that the Indian economy has been led by the growth of the tertiary sector.

Readers of the current issue of IJEP are welcome to offer suggestions for improvement. The editors will also welcome the critical comments on the contents included in this issue.

- Shri Prakash

A report on the completion of two years of continuous publication of the Indian Journal of Economy and Policy (IJEP)

The continuous publication of IJEP during last two years offers an opportunity to present the report card to the readers, authors, reviewers and the members of the editorial board.

IJEP has acquired the distinctive individuality of its own during the two years. The following features are associated with the contents of the issues published so far; IJEP especially focuses on methodological innovations on one hand and extension and modification of theoretical paradigms in several cases. The methodological innovations include alternative diagnostic tests of autocorrelation and heteroscedasticity on one hand and the development of an alternative model in terms of linear difference equations to test whether the time series is stationary. In the same way the use of t test has been extended to test the distribution of the values of the variables over given period of time. The null hypothesis formulated in this part is that the distribution is normal and hence the mean and median are equal to each other; this assumption enables the authors to use t statistics for determining whether time series diverges from normal distribution. Even more important is the evolution of the alternative method of modeling time series in terms of the elasticity coefficients and alternative methods of the calculation of the rates of change / growth.

The issues published so far cover all three sectors of the economy – agriculture, industry and tertiary sectors of the Indian economy. The published papers also relate to the components or the subsectors of these main sectors of the economy. The contents cover trade and FDI and their relationship with the growth of the economy. The evaluation of the growth effect of trade is not confined to the Indian economy alone as it focuses on India's trade with Japan, Malaysia, South Korea, China, Hungary, as well as global trade taken as a whole.

The published papers also empirically examine the inter relation between the growth of the tertiary sector and the growth of the GDP of India. The rationale of this part of the contents is important in view of the fact that the growth of the Indian economy has been dominated by the fact that the tertiary sector. At the industry level, the papers cover the electronic goods industry, construction industry and the like. The study is also examined the relationship between growth and employment, interest rate and inflation in the member countries of EU, Indo Chinese inter dependence etc.

Two studies have used Input Output modeling on basis of great deals of innovations. One study uses a specially constructed final demand vector which contains 106 zeroes and one non zero element which relates to construction industry of UP. The second study uses the same innovative approach to the I-O modeling. This study constructs special final demand vector which contains 106 zeroes and one non zero element which relates to the healthcare sector of UP. These studies find that the growth effect of construction and healthcare industries are important segments of economy of UP. The growth effect of these two sectors ranges from 16-20% of the GSDP of economy of UP in 2017.

The contents of the two volumes contain a wide variety of empirical applications of a variety of methods and models. Econometric modeling and non-parametric statistical methods of data

analysis are also a part of the studies published in the journal. Sign test, sign rank test, chi square test etc. offer a variety of methods of data analysis used in the papers published.

This report card offers a birds eye view of the contents published in the different numbers of volume 1 and 2. Interestingly, the inter relations between Indian stock markets and foreign stock markets also offer good study. The direct and indirect spillover effects of the changes in the prices of the equities in the stock markets of India also offer a highly interesting part of academic literature. In addition of the above, a distinctive aspect of the journal has been the focus on policy.

One study focuses on the Deen Dayal Upadhyay policy of the revival of the last in Uttar Pradesh. The study finds positive and significant impact of the implementation of this policy on the growth of the economy of UP especially agriculture based growth. Different varieties of policies constitute the subject matter of the papers published in the journal for example, the utilization of the borrowed capital, the determination of the minimum and maximum amount of the borrowed capital, the pattern of utilization of the borrowed capital etc. is an important aspect. The theory of policy and the focus on the causes of the failures of the policy at the implementation level, richly illustrated by specific policy failures in different states in different parts of India makes the reading interesting. The studies in this area also come out with the divergence between the individual academic research and the public research undertaken by the public organizations and the causes of this divergence are also aptly highlighted. In view of the above it gives great deal of pleasure and satisfaction at this point of time.

Editors are extremely thankful to all the authors who have patronized the journal even when we did not have ISSN number. We are also thankful all the referees who spared their valuable time in reviewing the papers despite their busy schedule. No words will suffice and no amount of expression of thanks to the members of the editorial board will really discharge the obligation which we feel towards the members of our editorial board. It is also a matter of satisfaction that members of the editorial board come not only from India, but they come from Europe, Asia and Africa also. The members have former vice chancellors, directors of the institutions, senior professors and the like so, we end this report card with the hope that the same degree of cooperation extended by the authors, referees and the members of the editorial board will continue in future also and this cooperation will further enrich and enhance the reputation of the journal.

- Shri Prakash

Capturing Symmetric and Asymmetric Spillover from Nifty to Sectoral Indices: A Study of Identifying diversification opportunities

Shashank Sharma¹

Abstract

The study attempts to examine the volatility spillover effect from Nifty to sectoral indices to identify the suitable diversification opportunities while investing in Indian benchmark index. In order to encompass integration and establishing lead and lag relationship, we have applied, initially, Granger Causality and VAR models. The study has considered eight sectors i.e. Banking, Automobile, Information Technology, Pharmaceuticals, FMCG, Metals, Realty and Energy. The study captures both symmetrical and asymmetrical volatility transmission from Nifty to sectoral indices by applying several of models. The bivariate dynamic conditional correlation (DCC) has been applied to capture symmetric spillover while asymmetric volatility or leverage effect has been captured using Dynamic Conditional Correlation Exponential Generalized Autoregressive Conditional Heteroskedasticity (DCC-EGARCH) and Dynamic Conditional Correlation Glosten- Jagannathan- Runkle Generalized Autoregressive Conditional Heteroskedasticity (DCC-GJRGARCH) respectively. In addition, we have also employed Diebold Yilmaz (2012) spillover method. The result reveals that there is substantial time-varying co-movement among the indices DCC method while Diebold Yilmaz (2012) spillover method reveals that Nifty is more dominant index and has high spillover derived from other indices. There may be some reasons for the information transmission like equity market determinants or herd behavior and decrease in the variability of information. These findings suggest that an investor must be cautious while investing and diversifying their portfolio in Indian stock market especially with respect to Nifty as a benchmark index.

Keywords

Volatility Spillover, Symmetric Volatility, Asymmetric Volatility, Nifty, Sectorial Indices, Portfolio Diversification

Introduction and background of the study

Liberalization and Globalization triggers overall momentum in the Indian Stock Market in terms of tremendous growth in volumes (Singh, A, 1998). The domestic retail investors find the Indian market as a lucrative alternative to invest in; thus, the domestic household's portfolio is diverging from traditional investment avenues to capital market (Sharma, S et al. 2018). Further, the Indian market as an emerging and developing economy has featured as one of the fastest growing economy and has shown weak form of efficiency Henceforth, it provides considerable opportunities to various investors to generate abnormal returns (Prasanna, P. K., 2008) and considered as one of the most attractive investments.

¹ Executive Director , JP Morgan Chase & Co.

The Indian market does not only attract the domestic investors but also foreign portfolio investors (Jalota, S., 2017). The active participation of foreign investors in capital market increases its depth and breadth that provides volatility. However, high volatility is a two-edged sword which signifies volatility provides returns coupled with high risk and that could be in various forms such as political, currency and interest rate risk to name a few. The current slowdown in the Indian economy due to demand recession and later accentuated via pandemic that provides huge volatility in the Indian stock market. It would be interesting to study diversification opportunities to hedge against the probability of loss. The various categories of investors like domestic, foreign institutional and retail investors are looking for diversification opportunities to hedge their investment strategy to other asset classes. Passive investors and passive fund managers are particularly replicating the sectoral weights of various industries, and thus they are looking for diversification opportunities while investing in benchmark index. Moreover, the passive investment strategy becomes more advisable during this volatility amid pandemic crisis. With this background, it provides a motivation to us to examine the diversification opportunities taking into consideration of current situation and perspective of passive investors who are investing in an Indian benchmark index.

The current study on Nifty and its indices volatility spillover provides considerable research gap. The Nifty volatility and spillover have been done under three categories that are sectoral volatility (Chakrabarty et al., 2015; Ahmad, 2014 and Tiwari et al., 2020), secondly, spillover among Index and other countries (Palakkod, S., 2012; Karmakar, M., 2009 and Badhani, K.N., 2009) and finally, spillover among Index and other asset classes i.e. commodity, crude oil etc. (Purankar et al., 2020). But none of the study has captured an integration, volatility transmission from Nifty, as a benchmark index to another sectoral index. Henceforth the study has shown potential to fill the existing research gap which makes study peculiar or novel from current stock of literature.

The objective of the study is to identify diversification opportunities by capturing volatility transmission, integration and causality flows. It provides significant insight to investors, particularly passive investors and fund managers to hedge against the volatility perceived in the Indian benchmark index. The study considers wide range of sectors i.e. Banking, Automobile, Information Technology, Pharmaceuticals, FMCG, Metals, Realty, Energy and Infrastructure. The rationale behind taking the sectoral indices is to identify diversification opportunity within Indian capital market against its perceived volatility. Sectoral indices have peculiar pattern and sensitivity or elasticity with the benchmark index. The low positive correlation among the benchmark index and select sectoral index will provide the gateway of diversification. We have also examined the lead and lag structure pattern among benchmark index that is Nifty and other sectoral indices. The level of volatility spillover has been captured from the benchmark index with respect to Nifty to various sectors. Insignificance of volatility transmission will provide the opportunity of diversification. The paper analysed the volatility transmission in both ways that is symmetrical and asymmetrical. Symmetrical volatility captures the overall volatility from one asset class to another and asymmetrical volatility captures the impact of bad news. Bad news like Great Depression of 1930, Mexican crisis (1994), Asian Currency crisis (1997) and Global Financial crisis of 2008 and now outbreak of COVID -19 as a pandemic crisis etc. have shown great volatility in the emerging stock markets (Mert, T and Omer S. G., 2020). Asymmetrical volatility perceives that the news could be good or bad, the bad news is showing high volatility in comparison to good news. The depth understanding of volatility spillover effect is a great relevance to investors in creating appropriate hedging strategies (Natarjan et.al, 2014). The study first establishes causal and

lead-lag relation applying Granger causality and VAR models respectively and then the volatility transmission from the market index to the sectoral indices have been investigated by the dynamic conditional correlation (DCC). The plain vanilla or standard Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) has been applied to understand the signs of symmetric volatility and Dynamic Conditional Correlation Exponential Generalized Autoregressive Conditional Heteroskedasticity (DCC-EGARCH) and Dynamic Conditional Correlation Glosten-Jagannathan-Runkle Generalized Autoregressive Conditional Heteroskedasticity (DCC-GJR-GARCH) have been applied to check the presence of asymmetric volatility. Further, Diebold Yilmaz (2012) spillover method has been applied to check the level of spillover among Nifty and its sectoral indices. As per DCC method, it is found that there is substantial time-varying co-movement among the indices. To corroborate the result obtained from DCC, Diebold Yilmaz (2012) spillover method reveals that the most contributing sectoral index, with respect to return spillover, to others within the sample indices is Nifty Bank followed by Nifty Auto (11.48%). As regards with net spillover (difference between contribution received from others and made to others), Nifty is witnessed with highest value (6.3%) followed by Nifty IT (2.45%) which indicates that Nifty is most dominant compared to its sectoral indices. There may be some reasons for the information transmission like equity market determinants or herd behavior and decrease in the variability of information. These findings suggest that an investor has to be cautious while investing and diversifying their portfolio in Indian stock market especially with respect to Nifty as a benchmark index. The study is relevant for passive investors, passive fund managers and foreign portfolio managers.

The remainder of the sections have been categorized as follows: Section 2 furnishes extensive literature related on spillover from one market to another market. Section 3 provides data and econometric models followed by empirical analysis and conclusion and policy implication in section 4 and section 5 respectively.

Literature Review

Tremendous studies are available on the keywords that are “spillover”, “volatility transmissions” and “contagion”. The literature on spillover had been triggered after the advent of portfolio construction propounded by H. Markowitz (1952) which is further extended by Sharpe (1964), thereafter with the arrival of globalization in 1990’s and finally with the advent of international portfolio in 1974 given by Solnik. The signs of cointegration, causality and volatility transmission have been emerged in various studies. The evidences of low spillover or volatility transmission provide enough background of diversification opportunities and price discovery. These studies are in the interest of portfolio managers, hedgers, and arbitrageurs. This section of the study reviewed selected papers based on the literature of spillover, volatility, causality and integration with reference to Indian stock market. For systematic reporting of the literature, the studies have been divided into three sections that are: firstly deals with the studies related to spillover among sectors; secondly, studies related to Indian stock market and other countries and lastly, studies related to Indian stock market and other asset class. The detailed literature reviews in three sections are as follows:

Studies related to spillover among sectors

This section of the study includes the review of research papers based on volatility transmissions among sectors. According to the current study, this section is directly related to understand the spillover effect from benchmark to other indices.

Karmakar, M. (2010) has done a unique study from the existing literature by establishing the contagion effect among small and large cap companies listed in NSE. The study has taken three indices that are: S&P CNX Nifty, CNX Nifty Junior and CNX Midcap. The study has applied VAR model supplementing it with variance decomposition function and impulse response function. The result provides evidences of volatility transmission from large cap index to small cap. To capture both symmetrical and asymmetrical volatility the study has applied plain vanilla or standard BEKK and dynamic BEKK. According to standard BEKK, unidirectional volatility has been identified whereas by applying dynamic BEKK, bidirectional volatility has been perceived among them. Later the study done by Ahmad (2014) had applied various univariate models i.e. GARCH, EGARCH and CGARCH to examine symmetric and asymmetric volatility of Indian sectoral indices. There are significant evidences captured of asymmetric volatility in various indices that are BSE-IT and BANKEX. It has been finally concluded that BSE Metal and BSE PSU both considered as good investments during negative volatility because low evidences of leverage effect. The study is limited to univariate volatility models thus leaves scope for further analysis. Another study done by Chakrabarty et al. (2015) had analysed volatility spillover among nine sectoral indices of BSE. The paper applied wavelet based MRA-EDCC-GARCH model to understand the conditional correlation and established the lead lagged pattern among the indices based on time and frequency. The study further contrasted the results with VAR EDCC GARCH model and found the robustness in the results of wavelet based DCC GARCH model. The study finally concluded that the investor can find diversification opportunities among sectoral indices in short term rather long term. The study is interesting but limited to find diversification among sectoral indices only. Henceforth the study leaves research gap. Chopra, M. (2018), has done a unique study that is among Indian stock market and Volatility index. Volatility Index (VIX) is a measure of volatility persistence in the market. The study is based on various models i.e. EWMA, GARCH, EGARCH & TGARCH. Purankar et al. (2020) had captured in their study the volatility transmission from Indian commodity market to equity indices. The objective of the study is to find evidences of spillover both static and dynamic. Henceforth both symmetric and asymmetric volatility spillovers are evaluated. The rationale of the study is to identify the conditional correlation among agricultural, metal, energy and commodity prices. The study also analysed the fundamental factors affecting the stock prices and commodity prices. To identify the objective of the study various models of DCC-GARCH have applied. The study provides weak conditional correlation among commodity prices and the stock prices. It has been finally captured negative correlation among these two which provides opportunity of diversification.

These papers are close to the study undertaken but leave scope of further research. As the study has analysed spillover among sectors but the current study is considering spillover effect from benchmark index to other sectors.

Studies related to spillover among Indian stock market and other countries

This section has found huge literature, the papers related to- spillover among Indian commodity, capital and currency market; spillover among future and spot market and spillover among Indian stock market with other countries stock markets. In order to provide systematic review, this section firstly deals with the papers on spillover among spot and futures markets, then reviewed studies related to spillover among Indian capital, commodity and exchange markets and lastly deals with spillover among Indian capital market and other countries. Although these studies are indirectly related to the current study but at the same time important to understand the overall dynamics of volatility transmissions.

Karmakar, M. (2009), has highlighted market imperfections in Indian stock market, henceforth there is a presence of asymmetrical volatility. There are evidences of varied reactions on information from one market to another. That causes lead lag structure among various markets. On this rationale, the study analysed the volatility spillover between Nifty and Nifty future market and establishes the lead lag relation among them. It has applied wide range of models that are Multivariate Cointegration Model, VECM and BEKK to capture the relationship among these two markets. The results shown that Nifty future is more volatile than spot and the two markets are showing long term association. With the same objective, another study done by Sakthivel, P. et al., (2010) had analysed long run relation among future and spot. Mallikarjunappa, T. et al., (2010) had also done a study on price discovery and volatility transmission among spot and future markets. The study identified arbitrage opportunities by analyzing information transmissions among these two markets. There is a bi-directional relationship among these two markets and the markets are co-integrated in long run. Price discovery has captured in both the markets at a same time. Sehgal, S. et al. (2016), with the same objective, had studied the contagion effect of domestic and international information on spot and future of benchmark index. In the same context, another study done by Sehgal, S et al. (2015) based on volatility transmission among spot and futures in India. In the same league with different data set, the study done by Sampath, A. et al. (2019) has analysed the relation among returns and volumes in Nifty futures.

Mishra et al., (2007) had analysed spillover among foreign exchange market and stock market. To capture the volatility spillover various models like Multivariate- GARCH & EGARCH, finally cointegration have been applied to analyze the long run association. It had captured that there is an existence of bi-directional volatility and both the markets are having long term relationship. The result of bidirectional volatility provides the inference that information has been transmitting from both the ways. In the same context, Palakkod, S. (2012) has analysed the integration and interrelationship among the Indian capital market, currency market and commodity market through the volatility spillover framework that is AR (1)-GARCH (1, 1) approach. This study differentiates from the earlier studies by including all three segments of the markets. It has been explored that volatility transmission captured from currency and commodity to capital markets. It has also been captured that transmission has not coming from commodity to currency markets. Rajput, N. (2012) has established lead and lag relation and volatility transmissions among FIIs and stock market. Initially the study explored the evidences of increase in volatility post liberalization. Later the study examined the volatility spillover from FIIs and Indian stock market. To examine the objectives, various models have applied that are: Cointegration, VECM, Variance De-composition analysis and models of ARCH-GARCH family.

It has been finally perceived bi-directional volatility among them. Further, Panda, P. (2014) has investigated volatility transmission from stock market to foreign exchange market. The uniqueness of the study is that it captures the impact of financial crisis. Henceforth the study has been furnished in three window periods that are: pre, post and during the crisis. The various volatility models that are: GARCH & EGARCH have been applied and various evidences of symmetrical and asymmetric volatility have been captured in three window periods. Mitra, P.K. (2017), has also analysed the spillover effect and transmission from International market to Indian stock market. To address this objective, two benchmark indices (SENSEX and Nifty) and four pair of currencies have taken. The study had applied GARCH and cointegration models to understand the long-term association and spillover effect. The result of the study provides bi-directional causality and long-term relations among them. With the same objective another study done by Bal, G. R., et al. (2018) had analysed the asymmetric volatility among Indian stock market and exchange market. The study has been done in two window periods i.e. before and after crisis. Henceforth, it captures the impact of subprime crisis on the volatility transmissions at two window periods. The methods applied in the research are GARCH (1, 1) and EGARCH (1, 1), to capture both symmetric and asymmetric spillovers. The findings have shown that USD is having strong evidences of spillover in comparison to other two currencies i.e. GBP and Yen. Maitra, D. et al., (2019), this research has developed the dynamic relation among three markets i.e. commodity, stock and exchange rate markets. The study has done meticulously to understand the change in volatility before and after crisis by applying various methods and models like VAR. Granger Causality, Multivariate volatility models etc. It has been captured a unidirectional causality from commodity to stock and exchange markets. Evidences of causality have been captured from exchange market to stock indices. Particularly, USD causes high volatility in Indian stock market and the results are in consensus with previous studies. However evidences of spillover effect have been found among the markets. Specifically, commodity market shown significant spillover evidences on stock market.

Badhani, K.N. (2009) has captured asymmetric volatility spillover from US to Indian capital market. Kumar, K.K. et al (2002), this study has also identified volatility transmission among US and India. Another study done by Kumar, M. (2013), this study explored the volatility spillover among exchange rates and stock returns of IBSA countries (India, Brazil, South Africa). The study used VAR model and model given by Diebold and Yilmaz to capture volatility transmission among them. Additionally, the study has also applied multivariate GARCH – BEKK model. The paper is sound in terms of methodology and the results shown are bi-directional. Habiba, U. E. et al. (2019) analysed the dynamics of spillover among Indian stock market and Asian emerging markets by applying extended E-GARCH model. The study found bidirectional volatility spillover in majority of the countries and some interrelations are coming insignificant. Thus, provides opportunities of diversifications. Nath Mukherjee, K. et al. (2010), the study identified integration and spillover among India and select Asian countries. It has been found bi-directional positive significant effect of transmissions. Earlier he has done study in 2006 on volatility transmission from India and other 12 developed and emerging countries.

Studies related to spillover among Indian stock market and another asset class

This section of the literature deals with the review of papers based on volatility spillover among Indian stock market and other asset class that are exchange rates, gold prices, crude oil prices etc. However, this section is indirectly related to the study but still understanding the dynamic relation

of Indian stock Market with other asset class provides relevant insights.

Kumar et al. (2013) has analyzed the spillover from crude oil prices and the US\$/INR exchange rate to the sectoral indices of India. For the analysis GARCH models based generalized error distribution and VAR models have been applied. Significant spillover evidences have been captured among various combinations of asset class. Another study done by Kumar et al. (2013) investigated the spillover effect among crude prices and Indian sectors to find the portfolio opportunities. The study applied wide range of MGARCH models i.e. Diagonal CCC and DCC to find the evidences of volatility transmissions. Finally, the study concludes that the DCC is one of the most robust models among all. The study also finds that the spillover changes over time and shown high level of spillover during financial crisis. The study also reported the hedge ratios and weights of optimal portfolio. Study done by Tiwari et al. (2018) had analyzed the impact of volatility transmission of oil price risk on various sectoral indices of India and provides the implications of diversification opportunities. In the same context another study by Tiwari et al. (2020) with different asset class, examined the impact of Gold prices on BSE sectoral indices. The study applied various GARCH models. The paper finds interesting results for the investors that the yellow metal is independent from the sectoral returns. Finally, it has been concluded that the gold as a base commodity, provides diversification opportunity to hedge against volatility with IT index. The paper provides significant useful insights to the investors.

Finally, after studying the existing literature on spillover effect in the context of Indian stock market, it has been concluded that to the best of my knowledge, none of the study addressed the objective undertaken in the study. Henceforth, we have found relevant research gap in the current literature of portfolio diversification in the context of Indian stock market.

Data and Econometric Models

Data

The objective of the study is to identify diversification opportunities among sectoral indices while investing in benchmark index that is NIFTY. Henceforth, the study has considered eight sectoral indices that are Banking, Automobile, Information Technology, Pharmaceuticals, FMCG, Metals, Realty and Energy. The daily adjusted closing price has been extracted from July 13, 2011 to August 14, 2020 and converted into log returns using following formula:

$$R_{it} = \log (P_{it} / P_{it-1})$$

Where R_{it} log return at time t , and $P_{i,t-1}$ and $P_{i,t}$ are two successive daily closing prices of i^{th} index.

Econometric Models

To examine the volatility spillover and identify the diversification opportunity, the study has applied wide range of econometric models which include descriptive statistics, Granger causality, Vector Auto Regression Model, bivariate volatility models that captures both symmetric and asymmetric volatility i.e. DCC- GARCH(1,1), DCC-EGARCH (1, 1) and DCC-GJRGARCH (1, 1) and Diebold Yilmaz (2012) spillover index model.

This section of the paper deals with the explanation of respective models with its rationality to achieve the objective of the study.

Granger Causality Method

The diversification opportunity is based on the low correlation among two asset class; thus, it is wise enough to analyze the causal relation among asset classes. The causality has been identified in three ways that are unidirectional, bidirectional and none. In order to capture causality, the basic and the most popular method is Granger Causality (Granger, 1969). The causal relation can be defined as X causes Y if the past behavior of the time series of X series able to capture the behavior of Y series (Friston et al., 2003). The peculiarity of the Granger Causality is that the model is able to identify the causal relation between two time series without having any a priori hypothesis. Causality is based on two prerequisites that are (1) the lead and lag relation has been established where cause occurs before effect and (2) the series taken into consideration should be stationary, if the series under study are not stationary then it should be converted into stationary and then it would be considered for the model. Granger causality equation can be written as follows:

$$X_{(t)} = \sum_{j=1}^p A_{11,j} X_{(t-j)} + \sum_{j=1}^p A_{12,j} Y_{(t-j)} + \varepsilon_{1(t)} \dots \dots \dots (1)$$

$$Y_{(t)} = \sum_{j=1}^p A_{21,j} X_{(t-j)} + \sum_{j=1}^p A_{22,j} Y_{(t-j)} + \varepsilon_{2(t)} \dots \dots \dots (2)$$

Where, p denotes the lagged of observations included in the model.

After identifying the causal relationship among Nifty and its various sectoral indices, Vector Auto-regression has been applied to check whether Nifty causes its sectoral indices and vice-versa.

Vector Auto-regression (VAR) and Variance Decomposition

VAR model is used for multivariate time series to establish the relationship between two variables. There are many models in VAR; one of the models is reduced form of VAR which does not differentiate among exogenous and endogenous variables (Yadav and Pandey; 2020). In this study, reduced form of VAR has been used to establish the lead and lag relation among the variables under study to understand the interdependencies. VAR model can be explained for two time series, denoted as $X_{t,1}$ and $X_{t,2}$:

$$X_{t,1} = \alpha_1 + \phi_{11} X_{t-1,1} + \phi_{12} X_{t-1,2} \dots \dots \dots (3)$$

$$X_{t,2} = \alpha_2 + \phi_{21} X_{t-1,1} + \phi_{22} X_{t-1,2} \dots \dots \dots (4)$$

In the model each variable is a linear function of the lag values for all variables. The model is applied on stationary time series which requires optimal lag(s) for its application. The selection of optimal lag is based on the various criteria that are AIC, BIC or HQ. Further to check the variability, we apply variance decomposition which allows to compute the extent of the variability in dependent variable

lagged by its own variance. This method is also referred as forecast error variance decomposition. In this paper, variance decomposition is applied to investigate the variability Nifty and its own lag along with various sector indices lags. Finally, we apply dynamic conditional correlation (DCC) to examine the volatility spillover from Nifty to its sectoral indices.

Symmetric and asymmetric Dynamic Conditional Correlation

Dynamic conditional correlation generalized autoregressive conditional heteroscedasticity (DCC-GARCH) is one the methods to capture the volatility transmission or spillover from one market to another. This model is propounded by Engle (2002). In this paper, both symmetric and asymmetric DCC-GARCH models have been applied. Symmetric DCC-GARCH cannot capture the spillover where there is asymmetry in financial return. Hence, to capture the magnitude of various news (the magnitude of bad news is high than the magnitude of good news), asymmetric DCC-GARCH has been also applied to examine the bivariate volatility spillover or transmission from Nifty to its various sectoral indices. Previously the model has been applied by Arouri et al. (2012), Lin and Appiah (2014) and Tiwari et al. (2019). DCC-GARCH captures the time varying conditional correlations which is depicted as follows:

$$H_t = D_t R_t D_t \dots\dots\dots (5)$$

$$D_t = \text{diag}(h_{11t}^{1/2}, \dots, h_{22t}^{1/2}) \dots\dots\dots (6)$$

$$R_t = \text{diag}(q_{11t}^{-1/2}, \dots, q_{22t}^{-1/2}) Q_t \text{diag}(q_{11t}^{-1/2}, \dots, q_{22t}^{-1/2}) \dots\dots\dots (7)$$

Where, H_t is the estimator of conditional correlation. It is derived in two basic steps explained in equation 5 & 6. In equation 6, D_t is conditional standard deviation which is $n \times n$ diagonal matrix, or it is GARCH parameters, R_t is the conditional correlations and $Q_t = (1 - \theta_1 - \theta_2) \bar{Q} + \theta_1 \xi_{t-1} \xi'_{t-1} + \theta_2 Q_{t-1}$ that is furnished equation 7.

It signifies a 5×5 unconditional correlation matrix based on the idiosyncratic residual ξ_{it} . α_{DCC} and β_{DCC} parameters are non-negative, which should be less than the sum of unity. Below is the correlation estimator:

$$\rho_{i,j,t} = \frac{q_{i,j,t}}{\sqrt{q_{i,i,t} + q_{j,j,t}}}$$

In the case of CCC specification, $R_t = R$. The diagonal specification is a restrictive model, as it considers DCC to be zero between variables. In order to compute the unconditional covariance matrix, standardized residuals derived from the MGARCH diagonal is used. In addition, asymmetric DCC-GARCH has been applied to support the fact that conditional variance of Nifty return reacts asymmetrically. If the asymmetric effects are significant and ignored, it will lead to the potential misspecification. Therefore, exponential GARCH and GJR GARCH have been applied in form of asymmetric GARCH.

Diebold and Yilmaz (2012) Spillover Index

Diebold and Yilmaz Spillover Index Method (2012) is an extended form Diebold and Yilmaz (2009) which uses a generalized vector autoregressive (VAR) framework to check within and cross market spillovers. It is developed by Diebold, F.X. and Yilmaz, K. (2012) and measures the contribution of shocks to and from variables. It furnishes the magnitude and spillover direction in form of variance decomposition analysis (Pesaran, M.H. and Shin, Y.,1998). Indeed, existing spillover models consider the mean of the distribution and OLS to determine the VAR that undervalues the effects of spillover among variables.

In this model, H-step forecast error variance decomposition can be accredited to the shocks for the variable as below:

$$\theta_{i \leftarrow j}^g(H) = \frac{\sigma_{ii}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \sum e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \sum A_h' e_j)}, \text{ for } i, j = 1, \dots, N$$

In the above equation $\sum$ is termed as the estimated variance for the given error components of vector autoregressive model, σ_{ij} signifies the standard deviation for the i^{th} equation. The forecast error variance decomposition can be normalized following the sum of following row:

$$\theta_{i \leftarrow j}^g(H) = \frac{\theta_{i \leftarrow j}^g(H)}{\sum_{j=1}^N \theta_{i \leftarrow j}^g(H)}$$

The cross variance of the variables helps to calculate total connectedness which are presented as the fraction of the H step ahead to forecast Y_i because shocks to Y_j . The shocks obtained by vector i from other vectors J is determined by directional connectedness and net connectedness is calculated differentiating the shocks obtained from others and shocks contributed to other markets or economies.

Empirical Analysis

We examine the volatility spillover from Nifty stock exchange to various sectors such as Nifty Bank, Nifty FMCG, Nifty Metal, Nifty Realty, Nifty Energy, Nifty Auto, Nifty IT and Nifty Pharma. All selected indexes along with Nifty have been converted into log returns. Table 1 depicts the summary statistics of all the sample series which have been considered in this study. The daily closing price of these series has been considered from July 2011 to August 2020 containing 2247 observations with no null value. The average return and risk of these indices are presented by the mean and standard deviation of these log-returns respectively. The Rnifty FMCG (0.0005) and Rnifty IT (0.0005) realized the high average return. Rnifty Realty is a risky sector as its standard deviation (0.0211) is high with a negative return (-0.0001). It signifies that Real state is more volatile or it has high inherent risk than the rest of the sectors in India. As regards skewness, each index has negative skewness which implies that these sectors have a high probability of generating negative returns. All sectors have a leptokurtic distribution which signifies that these sectors including Nifty may realize either very large or very less future returns. It means investors must have an appetite for extreme risk for investing in these sectors. The p-value of the Jarque-Bera test is significant in the case of each return series; therefore, no series is normally distributed. In order to examine the

information transmission from Nifty to various sectors in India, the dynamic conditional correlation (DCC) GARCH has been used. ARCH effect and stationarity of the series are conditions to be met for applying DCC-GARCH. We observe that there is ARCH effect in each series as it strongly rejects the null hypothesis of no arch effect. Augmented Dickey-Fuller (ADF) and PP test have been applied to check the order of integration or stationarity among series, both tests strongly reject the non-stationarity and confirms the stationarity of the series. Further, the Granger Causality test has been applied to check the direction of information transmission.

Descriptive	RNIFTY	RNIFTY BANK	RNIFTY FMCG	RNIFTY METAL	RNIFTY REALTY	RNIFTY ENERGY	RNIFTY AUTO	RNIFTY IT	RNIFTY
Nobs	2247	2247	2247	2247	2247	2247	2247	2247	2247
Minimum	-0.1390	-0.1831	-0.1120	-0.1233	-0.1233	-0.1022	-0.1491	-0.1249	-0.0935
Maximum	0.0840	0.1000	0.0799	0.0939	0.0809	0.0828	0.0990	0.0892	0.0987
Mean	0.0003	0.0003	0.0005	-0.0002	-0.0001	0.0003	0.0003	0.0005	0.0004
Median	0.0005	0.0006	0.0009	0.0000	0.0010	0.0006	0.0007	0.0005	0.0005
Sum	0.7045	0.6656	1.1004	-0.4669	-0.3137	0.5878	0.7101	1.0340	0.8674
Std. dev	0.0111	0.0157	0.0112	0.0177	0.0211	0.0134	0.0139	0.0134	0.0123
Skewness	-1.1428	-0.7485	-0.4301	-0.2665	-0.5104	-0.5278	-0.4431	-0.7704	-0.1851
Kurtosis	17.4459	12.7210	9.7168	3.1736	2.8035	6.1144	10.8038	10.8043	5.7816
Jarque-Bera Test	0.0000	0.0000	0.0000	0.0070	0.0000	0.0000	0.0001	0.0000	0.0000
ADF Test	0.0000	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PP Test	0.0000	0.0100	0.0008	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000
ARCH Test	0.0000	0.0100	0.0000	0.0030	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Author's own calculation

The table 2 presents the result of Granger Causality which helps to examine the direction of volatility transmission from one series to another (Gupta & Guidi, 2012; Huang et al., 2000). In order to employ causality test, optimal lag is required. As per Hannan Quinn (HQ) criterion, 3 lags are optimal lag at which the result of Granger causality is computed. We examine the volatility spillover from Nifty to selected sectors, therefore, we encompass on unidirectional causality. It is observed that Nifty Granger causes the Nifty Bank, Nifty FMCG, Nifty Metal, Nifty energy, Nifty Auto and Nifty Pharma while there is no causality to the Nifty realty and Nifty IT. It signifies that there is a possibility of information transmission from Nifty to the Nifty Bank, Nifty FMCG, Nifty Metal, Nifty energy, Nifty Auto and Nifty Pharma which does not provide an avenue for portfolio diversification but one can diversify their portfolio investing in Nifty realty and Nifty IT.

The result of Vector Auto-regression is depicted in table 3 which is based on optimal lag 3 computed through HQ. We employ multivariate VAR on these sectorial indices to check whether the log return of these indices can explain the log return of Nifty.

Considering the lag 1 of the return of each sectorial indices along with Nifty, return on Nifty metal does not affect the return on Nifty significantly; the rest of the indices affect it while return on Nifty Realty and Nifty Pharma does not affect significantly at lag 2. Further, at lag 3, Nifty Metal, Nifty Auto and Nifty Pharma are not significant in explaining the return of Nifty. It is clear from the VAR that overall, all the sectorial indices affect the return on Nifty except few lag of some indices which presents the relationship between Nifty and selected indices. Further, dynamic conditional correlation (DCC) has been applied to examine the volatility spillover from Nifty to eight different sectorial indices.

Table 2: Result of Granger Causality Test

Null Hypothesis	F-value	Probability
RNIFTY does not Granger cause RNIFTY BANK.	4.9194	0.0020**
RNIFTY does not Granger cause RNIFTY FMCG.	4.5824	0.0033 **
RNIFTY does not Granger cause RNIFTY METAL	3.4630	0.0156 *
RNIFTY does not Granger cause RNIFTY REALTY	0.8244	0.4803
RNIFTY does not Granger cause RNIFTY ENERGY	5.4972	0.0009 ***
RNIFTY does not Granger cause RNIFTY AUTO	2.6719	0.0459 *
RNIFTY does not Granger cause RNIFTY IT	2.0742	0.1016
RNIFTY does not Granger cause RNIFTY PHARMA	3.4267	0.0164 *

Source: Author's own calculation

Variables	Estimates	Std. Error	T-value	Pr(> t)
r_nifty.l1	-0.7899	0.0232	-33.9930	0.0000 ***
rnifty_bank.l1	0.3071	0.0161	19.1170	0.0000 ***
rnifty_FMCG.l1	0.1379	0.0162	8.5140	0.0000 ***
rnifty_metal.l1	0.0110	0.0127	0.8640	0.3879
rnifty_realty.l1	0.0305	0.0104	2.9500	0.00321 **
rnifty_energy.l1	0.1394	0.0164	8.5070	0.0000 ***
rnifty_auto.l1	0.0815	0.0173	4.7210	0.0000***
rnifty_IT.l1	0.1198	0.0124	9.6840	0.0000***
rnifty_pharma.l1	0.0557	0.0142	3.9130	0.0000 ***
r_nifty.l2	-0.4080	0.0245	-16.6420	0.0000 ***

rnifty_bank.l2	0.1620	0.0170	9.5240	0.0000 ***
rnifty_FMCG.l2	0.1066	0.0165	6.4640	0.0000 ***
rnifty_metal.l2	0.0418	0.0128	3.2730	0.0010**
rnifty_realty.l2	0.0155	0.0104	1.4890	0.1367
rnifty_energy.l2	0.1884	0.0167	11.2610	0.0000***
rnifty_auto.l2	0.0682	0.0173	3.9320	0.0000 ***
rnifty_IT.l2	0.1418	0.0126	11.2990	0.0000 ***
rnifty_pharma.l2	0.0092	0.0143	0.6390	0.5228
r_nifty.l3	-0.0756	0.0151	-4.9960	0.0000 ***
rnifty_bank.l3	0.0493	0.0166	2.9700	0.00301 **
rnifty_FMCG.l3	0.0981	0.0162	6.0550	0.0000 ***
rnifty_metal.l3	0.0128	0.0128	1.0000	0.3172
rnifty_realty.l3	0.0254	0.0104	2.4480	0.01443 *
rnifty_energy.l3	0.0985	0.0168	5.8500	0.0000***
rnifty_auto.l3	0.0244	0.0174	1.4040	0.1603
rnifty_IT.l3	0.0464	0.0124	3.7520	0.0001 ***
rnifty_pharma.l3	0.0199	0.0143	1.3950	0.1630
Const	0.0001	0.0001	0.4020	0.6877

Source: Author's own calculation

Table 4 presents the result of symmetrical and asymmetrical GARCH that includes standard GARCH, GJR-GARCH and exponential GARCH. In this table, “mu” is overall mean, and “omega” is constant or intercept of concerned series. Further, “alpha 1” and “beta 1” signify the autoregressive conditional heteroscedasticity (ARCH) and generalized autoregressive conditional heteroscedasticity (GARCH) respectively. The estimates of overall mean (mu) is positive and significant in symmetrical as well as asymmetrical GARCH. In this study, GARCH (1,1) has been applied due to which we derive ARCH 1 (alpha1), GARCH 1(beta1) and gamma 1. An alpha shows whether the new information is captured in the series, it can be also interpreted as whether there is volatility in short run or not. It considers previous disturbances or error term which is derived from mean equation. GARCH shows the previous variance which is associated with persistence of volatility and measures the impact of a shock on conditional correlation for the long run. All the ARCH and GARCH terms are positive and significant at 5% significance level except ARCH term of Nifty Realty which confirms the persistence of volatility in symmetrical GARCH. We also notice that the summation of alpha 1 and beta 1 is less than one which also indicates that there is stationarity and decay in volatility persistence over the time. Nifty Realty has fast decay in volatility persistence (sum of alpha and beta is 0.8782) while Nifty bank has slowest decay in volatility persistence (sum of alpha and beta is 0.9898). The reason for the volatility persistence could be due to the equity markets determinants and decrease in the variability of economic information.

For the Asymmetrical GARCH, the significance of ARCH and GARCH are similar like symmetrical GARCH whereas gamma signifies the leverage effect. Leverage effect may be defined as a condition when losses influence the future volatility higher than the profits. If gamma is negative and significant then it indicates that the magnitude of negative effect is high than positive news and vice-versa. In case of GJR and exponential GARCH in this paper, the volatility persistence occurs as ARCH and GARCH are significant while gamma is significant but positive. It signifies that positive shocks have higher influence than negative news. The sum of alpha and beta is less than 1 in both asymmetrical GARCH indicating the decay in volatility persistence. In GJR-GARCH, Nifty Pharma has slowest decay (sum of alpha and beta 0.9572) and Nifty IT has fast decay (0.8428) in volatility persistence. Similarly, there is slow decay in volatility persistence of Nifty Pharma (sum of alpha and beta is 0.9460) and quick decay in volatility persistence in case of Nifty (sum of alpha and beta 0.8669). We observe that symmetrical GARCH (standard GARCH) has larger volatility persistence which indicates the slow in decay compared to GJR-GARCH and exponential GARCH of asymmetrical model. Generally, investors want fast decay in volatility persistence so that it cannot linger for long lasting. From decay in persistence point of view, investors should invest in Nifty Realty, Nifty IT and Nifty as per this symmetrical and asymmetrical model.

After univariate analysis of sectorial indices along with Nifty with respect to volatility persistence, we analyze the volatility spillover effect from Nifty to various sectorial indices through dynamic conditional correlation GARCH (Symmetrical and Asymmetrical) which is presented in the table 5. DCC helps to examine whether there is transmission of information from one market to another market. The combined ARCH and GARCH coefficients are presented in form of dcc1 and dccb1. We observe that dcc1 and dccb1 are positive and significant in sGARCH, GJR-GARCH and eGARCH Models. It indicates that there is transmission of information or spillover of volatility from Nifty to eight different sectorial indices in short run and long run respectively. It also signifies that there is substantial time-varying co-movement in these indices. As the sum of dcc1 and dccb1 is less than one, it meets the overall stability condition of DCC. There may be some reasons for the information transmission like equity market determinants or herd behavior and decrease in the variability of information. Our outcome is in the congruence with the results of existing studies of Li, Y., & Giles, D. E. (2015); Kumar et.al. (2017); Teng et al., (2015). These findings suggest that an investor must be cautious while investing and diversifying their portfolio in Indian stock market especially with respect to National Stock Exchange. Nifty and sectorial indices are not providing any diversification opportunity to minimize an investor's risk.

Table 4: Results of Symmetrical and Asymmetrical GARCH

Variables	Symmetric sGARCH		Asymmetric -GJR GARCH		Asymmetric –eGARCH	
	Estimates	P-value	Estimates	P-value	Estimates	P-value
[rnifty].mu	0.0007	0.0003	0.0004	0.0392	0.0003	0.0190
[rnifty].omega	0.0000	0.0685	0.0000	0.0095	-0.2037	0.0000
[rnifty].alpha1	0.0903	0.0000	0.0008	0.9095	-0.1110	0.0000
[rnifty].beta1	0.8904	0.0000	0.9008	0.0000	0.9779	0.0000
[rnifty].gamma1	-		0.1462	0.0000	0.1174	0.0000
[rniftybank].mu	0.0008	0.0020	0.0005	0.0527	0.0003	0.1722

[rniftybank]. omega	0.0000	0.1421	0.0000	0.1367	-0.1204	0.0000
[rniftybank]. alpha1	0.0800	0.0000	0.0204	0.0478	-0.0692	0.0001
[rniftybank].beta1	0.9098	0.0000	0.9263	0.0000	0.9854	0.0000
[rniftybank]. gamma1	-		0.0849	0.0001	0.1211	0.0000
[rniftyFMCG].mu	0.0005	0.0125	0.0005	0.0251	0.0005	0.0392
[rniftyFMCG]. omega	0.0000	0.0000	0.0000	0.0000	-0.3218	0.1361
[rniftyFMCG]. alpha1	0.0788	0.0000	0.0620	0.0000	-0.0237	0.5433
[rniftyFMCG]. beta1	0.8635	0.0000	0.8647	0.0000	0.9637	0.0000
[rniftyFMCG]. gamma1	-		0.0277	0.3183	0.1594	0.2242
[rniftyMetal].mu	-0.0001	0.8378	-0.0003	0.3507	-0.0003	0.1113
[rniftyMetal]. omega	0.0000	0.0000	0.0000	0.0000	-0.1861	0.0000
[rniftyMetal]. alpha1	0.0626	0.0000	0.0194	0.0008	-0.0534	0.0000
[rniftyMetal]. beta1	0.9095	0.0000	0.9220	0.0000	0.9769	0.0000
[rniftyMetal]. gamma1	-		0.0654	0.0000	0.1144	0.0000
[rniftyRealty].mu	0.0001	0.7522	0.0001	0.8474	0.0001	0.7522
[rniftyRealty]. omega	-0.5555	0.0000	0.0000	0.1158	-0.5555	0.0039
[rniftyRealty]. alpha1	-0.0495	0.0065	0.0522	0.0409	-0.0495	0.0065
[rniftyRealty]. beta1	0.9277	0.0000	0.8522	0.0000	0.9277	0.0000
[rniftyRealty]. gamma1	-		0.0553	0.0761	0.1666	0.0000
[rniftyEnergy].mu	0.0005	0.0587	0.0002	0.3904	0.0003	0.4546
[rniftyEnergy]. omega	0.0000	0.0000	0.0000	0.0000	-0.3276	0.2823
[rniftyEnergy]. alpha1	0.0922	0.0000	0.0392	0.0000	-0.0731	0.0110
[rniftyEnergy]. beta1	0.8579	0.0000	0.8614	0.0000	0.9624	0.0000

[rniftyEnergy].gamma1	-		0.0947	0.0000	0.1551	0.2000
[rniftyAuto].mu	0.0007	0.0031	0.0004	0.0834	0.0003	0.7654
[rniftyAuto].omega	0.0000	0.2641	0.0000	0.0000	-0.1959	0.4979
[rniftyAuto].alpha1	0.1002	0.0000	0.0166	0.0267	-0.0798	0.0000
[rniftyAuto].beta1	0.8717	0.0000	0.8939	0.0000	0.9771	0.0000
[rniftyAuto].gamma1	-		0.1203	0.0000	0.1549	0.6762
[rniftyIT].mu	0.0007	0.0000	0.0006	0.0000	0.0007	0.0036
[rniftyIT].omega	0.0000	0.0000	0.0000	0.0000	-0.6090	0.7621
[rniftyIT].alpha1	0.1251	0.0000	0.0803	0.0000	-0.0605	0.2465
[rniftyIT].beta1	0.7600	0.0000	0.7625	0.0000	0.9290	0.0001
[rniftyIT].gamma1	-		0.0819	0.0000	0.2010	0.3557
[rniftyPharma].mu	0.0005	0.0694	0.0003	0.1636	0.0003	0.2580
[rniftyPharma].omega	0.0000	0.5777	0.0000	0.2784	-0.2309	0.0000
[rniftyPharma].alpha1	0.0686	0.0000	0.0466	0.0000	-0.0274	0.1501
[rniftyPharma].beta1	0.9066	0.0000	0.9106	0.0000	0.9734	0.0000
[rniftyPharma].gamma1	-		0.0359	0.1117	0.1465	0.0044

Source: Author's own calculation

Table 5: Parameters of Dynamic Conditional Correlation GARCH

Joint DCC	sGARCH		GJR-GARCH		Exponential GARCH	
	Estimates	P-value	Estimates	P-value	Estimates	P-value
dcca1[RNIFTY and RNIFTY BANK]	0.0379	0.0000	0.0393	0.0000	0.0329	0.0000
dccb1[RNIFTY and RNIFTY BANK]	0.9621	0.0000	0.9607	0.0000	0.9663	0.0000
dcca1[RNIFTY and RNIFTY FMCG]	0.0154	0.0030	0.0151	0.0014	0.0132	0.0041
dccb1[RNIFTY and RNIFTY FMCG]	0.9812	0.0000	0.9816	0.0000	0.9829	0.0000
dcca1[RNIFTY and RNIFTY METAL]	0.0319	0.0000	0.0362	0.0000	0.0321	0.0000

dccb1[RNIFTY and RNIFTY METAL]	0.9618	0.0000	0.9574	0.0000	0.9579	0.0000
dcca1[RNIFTY and RNIFTY ENERGY]	0.0240	0.0000	0.0248	0.0002	0.0240	0.0000
dccb1[RNIFTY and RNIFTY ENERGY]	0.9686	0.0000	0.9691	0.0000	0.9686	0.0000
dcca1[RNIFTY and RNIFTY REALTY]	0.0254	0.0000	0.0256	0.0000	0.0226	0.0000
dccb1[RNIFTY and RNIFTY REALTY]	0.9729	0.0000	0.9719	0.0000	0.9742	0.0000
dcca1[RNIFTY and RNIFTY AUTO]	0.0283	0.0000	0.0303	0.0000	0.0273	0.0000
dccb1[RNIFTY and RNIFTY AUTO]	0.9683	0.0000	0.9651	0.0000	0.9663	0.0000
dcca1 [RNIFTY and RNIFTY IT]	0.0281	0.0000	0.0260	0.0000	0.0270	0.0000
dccb1[RNIFTY and RNIFTY IT]	0.9578	0.0000	0.9609	0.0000	0.9579	0.0000
dcca1[RNIFTY and RNIFTY PHARMA]	0.0269	0.0000	0.0285	0.0000	0.0293	0.0000
dccb1[RNIFTY and RNIFTY PHARMA]	0.9475	0.0000	0.9439	0.0000	0.9311	0.0000

Source: Author's own calculation

Table 6 presents the conditional correlation of nine different series. It has been noticed that there is positive dynamic correlation among these series. The pairwise highest correlation is witnessed between RNIFTY AUTO and RNIFTY METAL (0.6459) while lowest correlation is found between RNIFTY and RNIFTY PHARMA (0.1067). It signifies that RNIFTY AUTO and RNIFTY METAL are more influenced by each other in terms of information provided in stock prices while the changes in RNIFTY does not change more in RNIFTY PHARMA as it has less correlation. These dynamic correlations have been supported by graphical representation which has been presented in figure 1 to figure 8. These figures depict the dynamic correlation estimates among RNIFTY, RNIFTY BANK, RNIFTY FMCG, RNIFTY METAL, RNIFTY REALITY, RNIFTY ENERGY, RNIFTY AUTO, RNIFTY IT and RNIFTY PHARMA. This helps to understand that how the conditional correlations have varied over the time.

Table 6: Conditional Correlation among RNIFTY and various sector indices return

	RNIFTY	RNIFTY BANK	RNIFTY FMCG	RNIFTY METAL	RNIFTY REALITY	RNIFTY ENERGY	RNIFTY AUTO	RNIFTYIT	RNIFTY PHARMA
RNIFTY	1.0000								
RNIFTY-BANK	0.3558	1.0000							
RNIFTY-FMCG	0.1930	0.4388	1.0000						
RNIFTY-METAL	0.2770	0.5885	0.3898	1.0000					
RNIFTY-REALITY	0.3172	0.6471	0.3794	0.5564	1.0000				
RNIFTY-ENERGY	0.3594	0.6095	0.3686	0.5425	0.5605	1.0000			
RNIFTY-AUTO	0.3504	0.6317	0.4057	0.6459	0.5926	0.5637	1.0000		
RNIFTYIT	0.1850	0.2042	0.2163	0.2420	0.1948	0.2152	0.2941	1.0000	
RNIFTY-PHARMA	0.1067	0.2799	0.3435	0.3035	0.3801	0.2264	0.2744	0.1886	1.0000

Source: Author's own calculation

Figure 1: Conditional correlation between RNIFTY and RNIFTY BANK

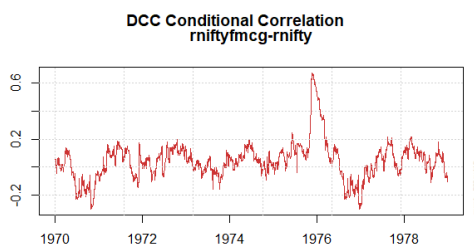


Figure 2: Conditional correlation between RNIFTY and RNIFTY FMCG

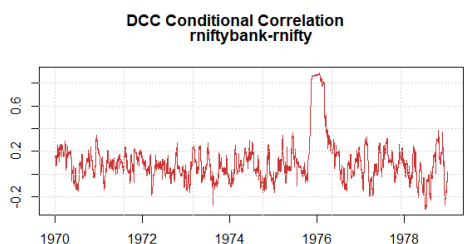


Figure 3: Conditional correlation between
RNIFTY and RNIFTY Metal

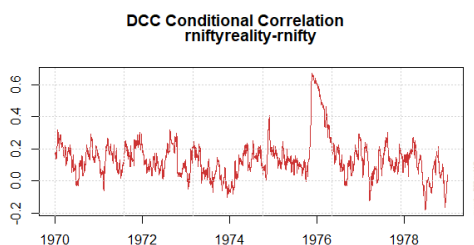


Figure 4: Conditional correlation between
RNIFTY and RNIFTY REALITY

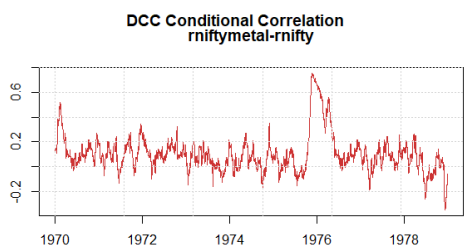


Figure 5: Conditional correlation between
RNIFTY and RNIFTY ENERGY

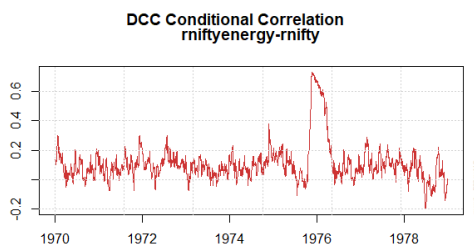


Figure 6: Conditional correlation between
RNIFTY and RNIFTY AUTO

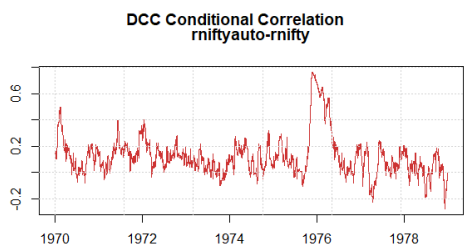


Figure 7: Conditional correlation between
RNIFTY and RNIFTY AUTO

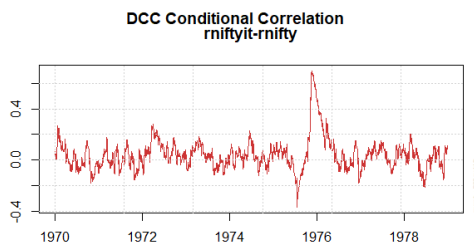


Figure 8: Conditional correlation between
RNIFTY and RNIFTY PHARMA

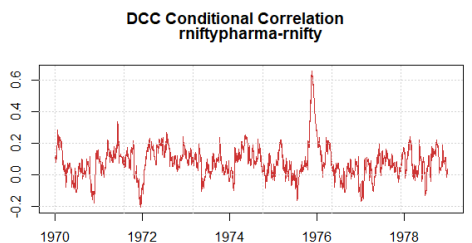


Table 7: Volatility Spillover among Nifty and Its sectoral indices using Diebold-Yilmaz (2012)

	Nifty	Nifty Bank	NIFTY FMCG	Nifty Metal	Nifty Realty	Nifty Energy	Nifty Auto	Nifty IT	Nifty Pharma	FROM
Nifty	9.27	22.51	8.53	9.89	9.7	11.83	15.47	7.62	5.19	10.08
Nifty. Bank	3.98	29.13	7.37	11.42	12.21	11.97	16.14	3.57	4.21	7.87
NIFTY-FMCG	4.06	16.38	27.78	7.28	7.43	10.62	13.8	5.36	7.28	8.02
Nifty. Metal	3.09	13.04	4.19	33.86	14.08	13.41	13.18	2.23	2.93	7.35
Nifty. Realty	1.69	15.21	4.43	15.19	36.54	12.29	10.53	1.74	2.37	7.05
Nifty. Energy	4.74	18.98	7.49	12.42	11.53	24.04	12.89	4.2	3.71	8.44
Nifty. Auto	4.84	15.65	8.59	11.45	8.48	9.83	29.42	4.39	7.36	7.84
Nifty.IT	7.28	9.33	8.15	4.64	3.78	8.34	9.33	42.11	7.05	6.43
Nifty. Pharma	4.34	6.65	10.25	4.14	3.1	4.95	11.97	6.74	47.86	5.79
TO	3.78	13.08	6.55	8.49	7.81	9.25	11.48	3.98	4.45	68.89
GROSS	13.86	20.95	14.57	15.84	14.86	17.69	19.32	10.41	10.24	
NET	6.3	-5.21	1.47	-1.14	-0.76	-0.81	-3.64	2.45	1.34	

Table 7 presents volatility spillovers among the Nifty and its sectoral indices derived from Diebold-Yilmaz (2012). Within the market spillovers and cross-market spillovers are represented by diagonal elements and off-diagonal elements of the matrix respectively. “From” the spillover refers to the spillover obtained from other indices while “To” the spillover depicts the spillover contributed to other indices. Referring the results of “From” spillover, we notice that Nifty has highest return spillover from other indices (10.08%) followed by Nifty energy (8.44%) and Nifty FMCG (8.02%). The most contributing sectoral index, with respect to return spillover, to others within the sample indices is Nifty Bank followed by Nifty Auto (11.48%). Further, market openness of sample indices has been measured by gross return spillover which is the sum of contribution received from others and made to others (Sehgal et al., 2019). High gross spillover indicates high openness of the indices. We find that Nifty Bank (20.95%) is most open indices followed by Nifty Auto (19.32%). As regards with net spillover (difference between contribution received from others and made to others), Nifty is witnessed with highest value (6.3%) followed by Nifty IT (2.45%) which indicates that Nifty is most dominant compared to its sectoral indices. Our findings corroborate with Sehgal et al., (2015) & Habiba et al., (2019).

Conclusion and Policy Implications

The domestic retail investors find the Indian market as a lucrative alternative to invest in; thus, the domestic household's portfolio is diverging from traditional investment avenues to capital market. The Indian market as an emerging and developing economy has featured as one of the fastest growing economy. It does not only attract the domestic investors but also foreign portfolio investors due to which participation of foreign investors in capital market increases its depth and breadth. Apart from this, the current slowdown in the Indian economy due to demand recession and later accentuated via pandemic provides huge volatility in the Indian stock market, therefore, it would be interesting to study diversification opportunities to hedge against the probability of loss. One way to test the integration is to apply correlation among various markets or indices (Gupta & Donleavy, 2009; Beakert et al., 2002) but it will lead to spurious outcome (Kasa, 1992), therefore, volatility spillover is one of the techniques which gives robust result in investigating the level of integration.

This paper aims to study the spillover effect from RNIFTY to its various sectoral indices like RNIFTY BANK, RNIFTY FMCG, RNIFTY METAL, RNIFTY REALITY, RNIFTY ENERGY, RNIFTY AUTO, RNIFTY IT and RNIFTY PHARAMA by investigating their conditional correlation using Dynamic Conditional Correlation Generalized Autoregressive Conditional Correlation (DCC–GARCH) to check either there is possibility of diversification opportunities among various Nifty sectoral indices or not. In any stock market (domestic or global), synchronized movements and volatility spillovers from one stock to another decreases the portfolio diversification opportunities. Portfolio managers or investors are looking at stock markets to derive diversification opportunity among various stocks; one of the methods is volatility spillover.

To check the spillover or linkages from RNIFTY to various stock indices, first, we applied Granger Causality test to identify the direction (Gupta & Guidi, 2012; Huang et al., 2000). The result reveals that Nifty Granger causes the Nifty Bank, Nifty FMCG, Nifty Metal, Nifty energy, Nifty Auto and Nifty Pharma while there is no causality to the Nifty realty and Nifty IT. It signifies that there is a possibility of information transmission from Nifty to the Nifty Bank, Nifty FMCG, Nifty Metal, Nifty energy, Nifty Auto and Nifty Pharma which does not provide an avenue for portfolio diversification but one can diversify their portfolio investing in Nifty realty and Nifty IT. Next, we employ multivariate vector auto regression (VAR) on these sectorial indices to check whether the log return of these indices can explain the log return of Nifty. It is clear from the VAR that overall, all the sectorial indices affect the return on Nifty except few lags of some indices which presents the relationship between Nifty and selected indices.

Further, dynamic conditional correlation (DCC) has been applied to examine the volatility spillover from Nifty to eight different sectorial indices. The combined ARCH and GARCH coefficients $dcca_1$ and $dcgb_1$ in sGARCH, GJR-GARCH and eGARCH Models are positive and significant which indicate that there is transmission of information or spillover of volatility from Nifty to eight different sectorial indices in short run and long run respectively. It also signifies that there is substantial time-varying co-movement in these indices. There may be some reasons for the information transmission like equity market determinants or herd behavior and decrease in the variability of information.

To corroborate the result obtained from DCC, Diebold Yilmaz (2012) spillover method reveals that the most contributing sectoral index, with respect to return spillover, to others within the sample indices is Nifty Bank followed by Nifty Auto (11.48%). As regards with net spillover (difference between contribution received from others and made to others), Nifty is witnessed with highest value (6.3%) followed by Nifty IT (2.45%) which indicates that Nifty is most dominant compared to its sectoral indices. These findings suggest that an investor must be cautious while investing and diversifying their portfolio in Indian stock market especially with respect to National Stock Exchange. Nifty and sectoral indices are not providing any diversification opportunity to minimize an investor's risk.

Our findings have implications for investors and portfolio managers. This study contributes to the spillover of volatility or transmission of information from RNIFTY to different eight stock indices. Investors and portfolio managers cannot diversify their portfolio. They need to explore other stocks for the perspective diversification destinations.

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Digitalisation of the Indian Economy: Role in Governance and Poverty Alleviation

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Abstract

Past analyses indicate that achieving the goal of growth with social justice and equality remained elusive following the erstwhile supply-oriented and top-down Five-Year Plans in India, primarily because local solutions were not offered, and disadvantaged sections of the society were not empowered to participate in the planning and implementation processes. Digital India is a potential alternative effective-demand based, bottom-up approach, to achieve inclusive growth, driven by a digitally empowered society and knowledge economy. Multidimensional digital programmes and systems have already been operationalised to connect every citizen to the mainstream and to provide easy and effective governance. In such programmes and systems, digital technology is the enabler and at the center of driving changes. Based on a review of digitalisation programmes in various sectors undertaken by the government of India, and using secondary data compiled by different national and international institutions, this paper assesses the extent and depth of digitalisation in India, whether digitalisation has improved governance and inclusiveness as also empowered people in changing their economic and living conditions. There are two impediments to the empirical estimation of the impact of digitalisation on the Indian economy. First, lack of data matching with the mission of Digital India, and second, absence of a conceptual framework regarding backward and forward linkages of digitalisation with the rest of the economy to fully capture the direct and indirect contributions of digitalisation on the economy.

Keywords: Digitalisation, Digital India, E-governance, Poverty Alleviation.

1. Introduction

1.1. India introduced Five-Year Plans in 1951 to achieve targeted economic growth. Each Five-Year Plan had specific goals. Following the Five-Year Plans, India remained a low-growth economy initially. Later, the growth rate improved, but achieving inclusive growth remained elusive. In the post-liberalisation era starting 1991, inequality widened. Geographically, socially, and economically disadvantaged population remained excluded from the growth benefits. Available analyses suggested that neither “Supply creates its own demand” nor the “trickle-down effect” worked in India. Besides, implementing the centralised plans created multilayered systems, many quarters of which were gradually inflicted by corruption and inefficiencies.

1.2. In 2014, the changed government voted to power, dissolved the Planning Commission, discarded Five-Year Plans, and replaced it with NITI Aayog tasked with catalysing economic development and fostering cooperative federalism by involving State Governments in the economic policy-making process using a bottom-up approach. Already unfolding digitalisation in the country was perceived as a powerful tool to achieve inclusive growth, and an effective means to reach intended target beneficiaries directly, counteract inefficiencies and corruption, enhance effectiveness,

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and bring about transparency. In July 2015, the “Digital India” programme was launched as a transformational agenda with 3 declared visions (MeitY, 2020): (a) Developing digital infrastructure as a utility to every citizen; (b) Making available governance and services on demand; and (c) Digital empowerment of citizens with universal digital literacy. Nine pillars were identified as thrust areas for “Digital India”: (i) Broadband Highways, for universal access to mobile connectivity; (ii) Public Internet Access Programme; (iii) e-Governance, to reform Government; (iv) eKranti, for electronic delivery of services; (v) Information for All; (vi) Electronics Manufacturing; (vii) Target Net Zero Imports; (viii) IT for Jobs, and (ix) Early Harvest Programmes. Thus, digitalisation was viewed as the potential effective-demand-based inclusive growth model driven by an empowered society and knowledge economy to act as the engine of transitions.

1.3. This paper reviews the extent of digitalisation in India, assesses the depth of digitalisation as revealed by the statistics reported by relevant national and international institutions, and attempts to analyse whether digitalisation has improved governance, resulted in inclusiveness, and empowered people in changing their economic and living conditions.

2. Extent of Digitalisation in India

2.1. Information and communication technology (ICT) gained momentum in India in the 1990s as the internet, smart hardware machines, and software, became available. IT Act 2000 enabled the introduction of e-Sign. To improve governance and smoothening the processes of delivering services, digitalisation initiatives like the Common Services Centres, National e-Governance Plan, Aadhaar, Aadhaar Enabled Payment System (AePS), e-District Mission Mode Project, Bharat Connect or Bharat Bill Payment System (BBPS) were introduced during the period 2006 to 2013. Building on some of these initiatives, and following the “Digital India” programme, spectacular digitalisation has occurred in India during the last decade. Sophisticated smartphones, electronic devices, cloud services, communication networks, websites, online platforms, apps, and of late, Artificial Intelligence and Machine Learning, have all been propelled by both the government and the private sector. Government Departments have been pushed to shift to e-governance and initiate digital solutions for achieving more efficiency, effectiveness, transparency in governance, and inclusiveness in all programmes.

2.2. The Financial Sector is the pioneer in digitalisation. A plethora of progressive digitalisation initiatives have been introduced in all the sub-sectors of the financial sector. Banks and non-banking financial companies (NBFCs) in collaboration with FinTechs and BigTechs have flooded innovations in providing banking and payment services. Some prominent ones include Unified Payment Interface (UPI), Bharat QR, Open Credit Enablement Network, Account Aggregator, Unified Presentment Management System, Digitalisation of the Insurance sector, and the Jeevan Pramaan for Life Certificate of Pensioners etc. have transformed the functioning of the financial services making these inclusive, user-friendly, frictionless and transparent. Digitalisation of tax governance is another revolutionary digital transformation, for both the direct and the indirect taxes. Digitalisation of the income-tax administration, digital customs clearance, the Indian Customs and Excise Gateway (ICEGATE), e-Sanchit, the Single Window Interface for Trade (SWIFT) program, and Digitalisation of GST deserve mention as game-changers. Digitalisation of Expenditure Management through PFMS since 2009, has emerged as a payment-cum-accounting network and has been playing a ground-breaking role in tracking funds and fiscal transfers, real-time reporting of expenditure, and making direct benefit transfers. PFMS has also been integrated with the Financial Management Systems of the States.

2.3. Digitalisation of Subsidy Schemes: Direct Benefit Transfer(DBT) Scheme was launched in January 2013 to reform the government welfare subsidy schemes for simpler and faster flow of funds to reach targeted beneficiaries, de-duplication of recorded beneficiaries, and reduction of leakages. As of November 2024, more than 350 Central Government Schemes have been brought under the Direct Benefit transfers .

2.4. Digitalisation of Governance to make it citizen-centric, efficient, and transparent: To make the government system and functionaries work efficiently, the government working system has been fully digitalised starting from biometric attendance, to secured nic mail as the medium of communications, and introduction of e-office for filing system and ease of monitoring of the file movements as also to diagnose the point of delay and reasons therefor. MyGov was introduced in 2014 to promote citizens' participation in governance and development. Registered users can discuss and contribute to various government policies and schemes. DigiLocker was launched in 2015 as a secure wallet for storage and sharing of personal documents. Every citizen holding an Aadhar number can register and use one GB of cloud storage to upload documents and give consent to share or revoke their consent as per requirements. The shared digital documents can also be securely verified. Government e-marketplace(GeM) introduced in August 2016 is an open and transparent procurement platform for government buyers and has been made mandatory for all Government purchases. Open Government Data Platform facilitates data sharing and promotes innovation over non-personal data. The platform provides open access to the data available with various ministries/departments/organizations of the Government of India. Unified Mobile Application for New-age Governance (UMANG) introduced in November 2017, provides access to central and state government services to the citizens online and round the clock through mobile. FASTag rolled out in April 2016 is a Radio Frequency Identification based system that allows vehicles to pay tolls automatically on national highways and eliminate the delay on toll roads. MeriPehchaan launched in July 2022 is a National Single Sign-on (NSSO) platform for user authentication service in which a single set of credentials enables access to multiple applications and government portals for different services saving time, effort, and cost. DigiYatra launched in December 2022 is a facial recognition system that verifies passenger identities at Indian airports without physical documents. It identifies passengers at various checkpoints, such as check-in, security, and boarding gates, without the need for physical documents.

2.5. Digitalisation of healthcare – eHospital introduced in July 2015 provides an online patient portal to deliver citizen-centric services like appointment booking, access to lab reports, and blood availability status. Ayushman Bharat Pradhan Mantri Jan Arogya Yojana (PM-JAY) launched in September 2018 is a Government scheme to provide free access to health insurance coverage for low income earners. Approximately 50 percent of Indian population is eligible for the scheme. In addition to primary care services, it provides hospitalisation assistance, if needed. Aarogya Setu, a mobile app launched in 2020 during COVID-19 for contact tracing, syndromic mapping, and self-assessment. The app enabled connecting health services and people in the fight against COVID-19. It provided risk alerts, best practices, and medical advisories in 11 languages. CO-WIN is another open platform introduced in 2020 for managing registration, appointment scheduling, and vaccination certificates for COVID-19. Ayushman Bharat Digital Mission was introduced in 2021 to create an integrated healthcare system that will link practitioners and patients digitally by giving them access to real-time health records.

2.6. Digitalisation to transform rural areas: Digital Village was conceptualised as a pilot project in October, 2018 to transform living in rural areas by making available necessary services. 700 Gram Panchayats/Village, with at least one Gram Panchayat/Village per District per State/UT are being

covered under the project. The digital services being offered include Health Services, Education Services, Financial Services, Skill Development, Solar panel powered street lights, including Government to Citizens Services (G2C), and Business to Citizen (B2C) Services. Pradhan Mantri Gramin Digital Saksharta Abhiyaan (PMGDISHA) has been introduced to usher-in digital literacy in rural India by covering 6 Crore rural households (one person per household).

2.7. Digitalisation of education - The Government is committed to ensuring equal access to online education for all sections of society. Online resources are provided through various initiatives like SWAYAM, SwayamPrabha, DIKSHA, e-Pathshala, e-PGPathshala, Virtual Labs, National Digital Library (NDL) and National Repository of Open Educational Resources (NROER). A comprehensive initiative called PM eVIDYA has been initiated which unifies all efforts related to digital/online/on-air education to enable multi-mode access to education

2.8. Digitalisation of Agriculture includes initiatives like Digital Crop Survey; Unified Portal for Agricultural Statistics (UPAg) to generate crop estimates and integrate with other systems generating Agriculture Statistics such as Price, Trade, Procurement, Stock etc.; Krishi Mapper, a geospatial web and mobile application platform aimed at efficiently managing a range of land-intervention based schemes such as CroPIC, Natural Farming, Seed Production and Distribution, NFSM Horticulture; MKisan, a portal through which experts/scientists of different departments like IMD, ICAR, send information to farmers in local languages; Kisan Suvidha, a mobile app to provide information on different parameters - weather, input dealers, market price, plant protection, expert advisories; Soil Health Card; Cold Store and Godown; Crop Insurance; Fertilizers KVK; PM-KISAN; Seeds, Organic Farming etc.

2.9. Digitalisation of Retail Businesses: Large foreign companies like Amazon and Flipkart have monopolised online retail businesses in India. Open Network for Digital Commerce (ONDC) was introduced in 2022 to set up connections between shoppers, technology platforms, and small retailers to create an inclusive e-commerce ecosystem. ONDC aims to achieve population-scale penetration and inclusion of all types of sellers.

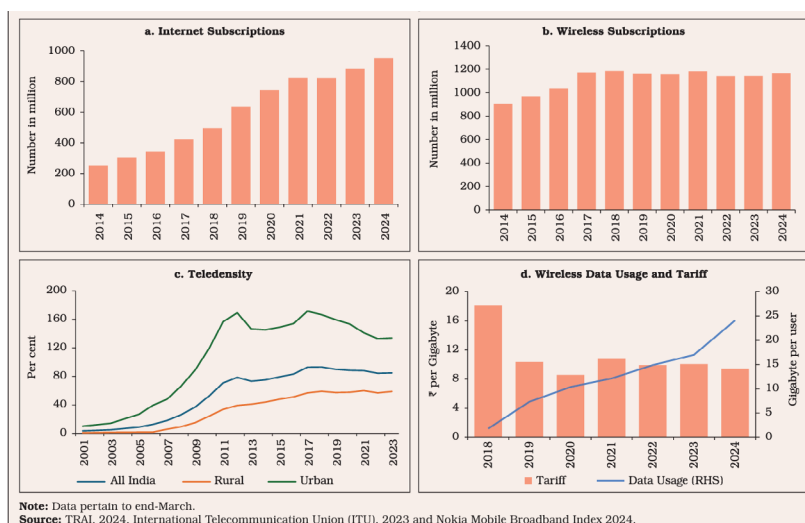
2.10. Digitalisation to support Innovation: Emerging technologies like 5G, IoTs, Advance Data Analytics, AI, Cloud computing, Augmented and Virtual Reality, 3D printing, robotics and blockchain etc. are shaping innovation and disruption in Industry and the operating business models. These will redefine the excellence and the future of technology-led transformation. Portals and platforms like e-manthan, National Knowledge Network, National Centre of Geo-informatics (NCoG) Applications project, FutureSkills Prime, etc. have been designed and implemented to support innovations and to promote learning from other's innovative ideas and applications, to promote collaboration and information sharing.

2.11. The above are some examples to inform the extent of digitalisation, and do not capture many more initiatives which have either been implemented or are still evolving.

3. Depth of Digitalisation in India

3.1. The depth of digitalisation in India can be gauged from some available statistics put together by RBI (Exhibit 1 and 2).

Exhibit 2: Trends of Digital Enablers in India



Source: RBI, Report on Currency & Finance 2023-24

Exhibit 1: Digitally Connected Population in India

	Number In Million*	Percentage of Population#
No. of Aadhar Issued	1380	97.9
Wireless subscription	1165	
Internet subscriptions	954	
Smartphone users	750	53.2
Social Media users	467	33.1
UPI unique users	424	30.1
Total Population	1410	

*Source: RBI, Report on Currency and Finance 2023-24

Calculated by author

Though there may be some overlapping in counting numbers since one individual may use more than one smartphone and hold multiple subscriptions, the numbers above broadly capture the status. Almost 98 percent of the Indian population has an electronic identity number called Aadhar. Internet subscriptions have consistently increased since 2014 and the number of wireless subscriptions is more or less stable. Teledensity in both rural and urban areas shows an increasing trend. A fall in tariff seems to have facilitated increased wireless data usage.

3.2. On the supply side, digitalisation is being taken forward speedily. Over 1668 e-services and over 20197 bill payment services are made available at UMANG. A total of 11890 services of various Ministries/States have been integrated with National Single Sign-on platform. 753 Hospitals have been on-boarded on e-Hospital and ORS (Online Registration System) has been adopted by 557 hospitals across the country with over 68 lakh appointments booked from ORS. More than

5.93 lakh datasets across 12,940+ catalogues are published on Open Govt Data Platform. The platform has facilitated 94.8 lakh downloads. Over 8.75 crore Digital Life certificates have been processed by using the Jeevan Pramaan app since 2014. So far, 659 applications across various domains are operational under the National Centre of Geo-informatics (NCoG) for project sharing, collaboration, location-based analytics, and decision support systems for Departments. 1752 links to institutions have been commissioned and made operational under the National Knowledge Network(NKN) of which 522 links have been connected to NIC district centers across India. India has the world's third largest startup ecosystem with over 1.4 lakh startups and over 100 unicorns. India's digital readiness immensely helped the government and the citizens during COVID-19. 78% of the population registered on Aarogya Setu app and used it for tracking cases. It also facilitated administration of 220 crore doses of vaccinations.

3.3. Despite such expansion of the facilities, digitalisation in India is yet to take deep root on the demand side for improving the lives of citizens. The larger proportion of people remains outside the purview of digitalised facilities and services. Approximately 30% of the Indian population (42.4 crore people) are users of UPI. Over 4.84 crore users (around 3.5% of the Indian population) are registered with MyGov which is meant for people's participation in governance. 35.99 crore users (approximately 25.5% of population) have registered under MeriPehchaan. 32.95 crore users (23.4% of population) and 1577 document issuers have registered with DigiLocker. The Ayushman Bharat Digital Mission (ABDM), provided Health ID to over 50 crore people (35.5% of population). Pradhan Mantri Gramin Digital Saksharta Abhiyaan (PMGDISHA) has 6.63 crore registered candidates and out of this, 5.69 crore candidates have been trained and 4.22 crore (3% of Indian population) have been certified. There are 19.47 lakh registered users under the FutureSkills Prime.

3.4. The government has introduced Production Linked Incentive schemes for Phones, IT Hardware and Electronic Components to promote electronics manufacturing in India. This has attracted global companies and also provided a fillip to domestic companies. Production of electronic items has increased from Rs.3.88 Lakh Crore (US\$60 Billion) in 2017-18 to Rs. 8.22 Lakh Crore in 2022-23 (US\$101 Billion), growing at a Compound Annual Growth Rate(CAGR) of 16.19%. Electronics production in India is expected to reach US\$300 Billion by 2026 (MeitY, 2024). However, India has yet to enter the list of the 10 largest electronic manufacturing countries. Emerging domains of AI, ML, and IOT are expected to be the new driving forces to push the growth of the ICT hardware segment. To give a further boost, there are plans to attract global semiconductor majors to open their fabrication units in India, and to set up Electronic Manufacturing Clusters, and Common Facility Centres in states.

4. Role and Impact of Digitalisation on Governance

4.1. The UNESCAP attaches 8 major characteristics to good governance : Participation, Transparency, Rule of Law, Responsiveness, Consensus oriented, Equity and inclusiveness, Effectiveness and efficiency, and Accountability. The Council of Europe adds 4 more characteristics to good democratic governance: (a) ethical conduct; (b) Competence and Capacity, (c) Innovation and Openness to Change, (d) Sustainability and Long-Term Orientation. NITI Aayog has identified 7 pillars of effective governance : Pro-people, proactive, participatory, empowering women, inclusion of all (SC, ST, OBC, Minorities, Gareeb, Gaon, and Kissan), equality of opportunity, and transparency (to make government visible and responsive).

4.2. Various e-Governance initiatives of the Government of India subsume almost all of these characteristics. Aadhar ID and e-KYC are powerful enablers for digital adoption. Platforms like MyGov and MeriPehchaan are designed for people to participate in governance and to make the government more pro-people and responsive to people's needs and suggestions. Introduction of Broadband Highways, trying to achieve universal access to phones, providing public internet access at common services centres, data.gov.in, Unified Portal for Agricultural Statistics, etc. are all aimed at empowering citizens to access information and bring about transparency. Revolutionary UPI for money transfer is an ideal example of consensus-oriented governance. Several initiatives, schemes and programmes like Direct Benefit transfers, Open Network for Digital Commerce, Arogya Setu, Co-Win, Ayushman Bharat, digitalisation of education projects, Open Credit Enablement Network, Account Aggregator etc. are all aimed at bringing about more equality and inclusivity in governance. Digitalisation of tax administration for income tax, GST, customs clearance, etc., digitalisation of expenditure management through PFMS, making Government e-marketplace mandatory for all government procurement, FASTag, Jeevan Pramaan, DigiYatra, Krishi Mapper and many such apps and platforms have brought about efficiency and effectiveness. Initiatives like Future Skills Prime, Pradhan Mantri Gramin Digital Saksharta Abhiyaan, MKisan, aim at capacity development for sustainability as well as empowering people to build their own future. Objectives of National Centre of Geo-informatics, National Knowledge Network, Open Gov Data Platform, Direct Benefit transferer Platform, e-manthan etc. are to promote innovation and reflect the government's openness to change. All such digitalisation covertly force the system to follow rule of Law, ethical conduct and to remain accountable to the stakeholders.

4.3. E-Governance has facilitated reaching out to the unreached, thereby inclusion of more and more thus far excluded people in the formal organised sector on the one hand, and reduced the scope of corruption and fake entries in various registers and accounts of the Government, on the other hand. Digital India has considerably reduced the gap between government and citizens. Increased use of digital payments including fiscal transfers are taking place instantly in real time and have brought about transparency and accountability. The Aadhar-enabled E-sign saves time and money by eliminating printing, scanning and mailing signed physical documents. It expedites transactions and improves customer experience. It is easy to use and secure as also tamper-proof and more difficult to forge.

4.4. Direct Benefit transfers eliminated leakages and middlemen, by honouring rights of people to deliver directly to them, and bringing in deprived and deserving under the Government subsidy net. As per the dashboard of the Government of India, cumulative DBT amounted to ₹ 40,26,529 Cr as on 25th November, 2024. DBTs have resulted in

- elimination of **4.15 crore** duplicate, fake/ non-existent, inactive subsidised LPG connections and **2.45 crore** non-subsidised LPG consumers. These include 1.13 crore consumers who have voluntarily given up subsidy.
- Deletion of **5.0358 crore** duplicate and fake/ non-existent Ration Cards.
- Deletion of **7.10 lakh** fake Job Cards under MGNREGS (FY 2022-23)
- Deletion of **11.05 lakh** duplicate, fake/ non-existent, ineligible beneficiaries under NSAP (National Social Assistance Programme) Scheme
- Deletion of **30.92 lakh** duplicate, fake/ non-existent beneficiaries under Scholarship Scheme of Ministry of Minority Affairs
- Deletion of **12.28 lakh** duplicate, fake/non-existent beneficiaries under the Scholarship Scheme of the Ministry of Social Justice and Empowerment
- Reduction of **98.8 lakh** duplicate, fake/non-existent beneficiaries under the schemes of Ministry

of Women and Child Development

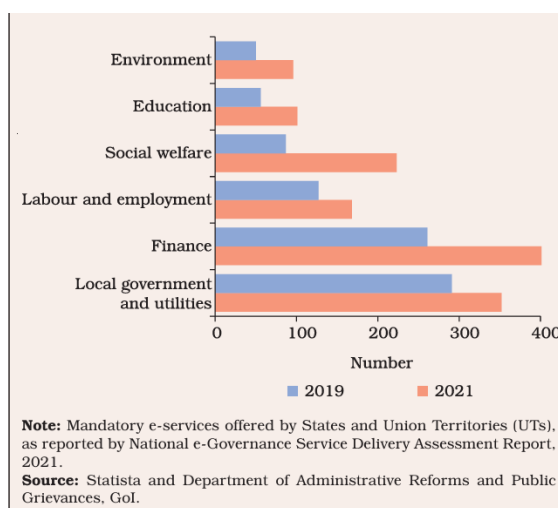
- Reduction of **158.06 Lakh** Metric Tonnes of fertilizer sale to retailers under the Department of Fertilisers
- Deletion of **2.1174 crore** ineligible beneficiaries under the PM-Kisan Scheme of the Department of Agriculture and Farmers' Welfare.

All the above deletions and elimination of duplicate records have resulted in cumulative subsidy savings of ₹ 3,48,564 Cr upto March 2023 (PIB, 2023).

4.5. Common Services Centres (CSCs) are bringing e-Services to the doorsteps of people in rural areas in an affordable manner. There are around 5.9 lakh CSCs across the country providing over 350 services ranging across sectors like education, health, agriculture etc. On average, 4 persons are engaged in each CSC, indicating the impact on employment generation. CSCs have become centres of digital empowerment being actively involved in providing digital literacy. Under Pradhan Mantri Gramin Digital Saksharta Abhiyan, 1.96 crore people in rural areas have already been imparted training to bridge the digital divide.

4.6. Sector-wise e-delivery of government services is indicated in Exhibit 3.

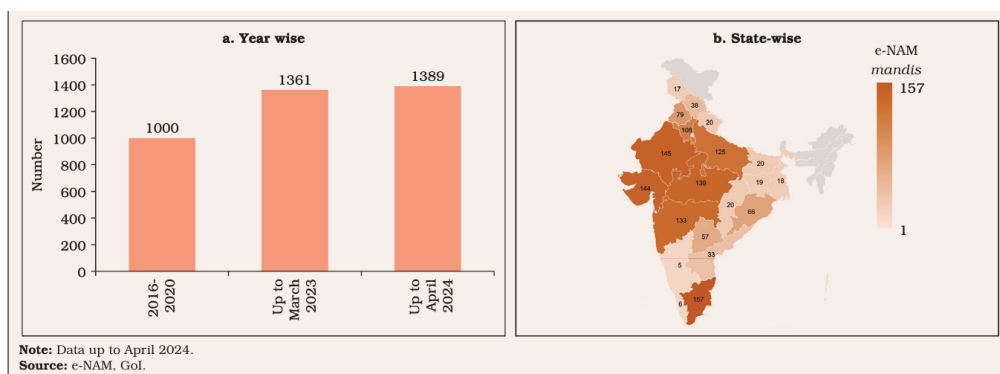
Exhibit 3: e-Delivery of Government Services in India by Sector



(Source: RBI's Report on Currency and Finance 2023-24)

4.7. Central government is providing funds to the states through the National e-Governance Plan in Agriculture for initiatives involving AI, Machine Learning, robotics, data analytics and blockchain. This is enabling IT-based solutions for crop planning and health, farm credit and insurance, crop estimation, and market intelligence. The three core registries are farmer registry; village map registry; and crop sown registry (PIB, 2023a). The Digital India Land Records Modernisation Programme is aiding the digitisation of land records to minimise discrepancies, enhance accessibility, and facilitate seamless land transactions. The programme is reducing the time taken to disburse crop loans and will accelerate the formalisation of land leasing within the farm sector, seamless land acquisition, and forest clearance for infrastructure planning. The National Agricultural Market programme (e-NAM) is integrating agricultural mandis with e-NAM platform (Exhibit 4, reproduced from RBI's Report on Currency and Finance 2024).

Exhibit 4: Integration of Mandis with the e-NAM platform

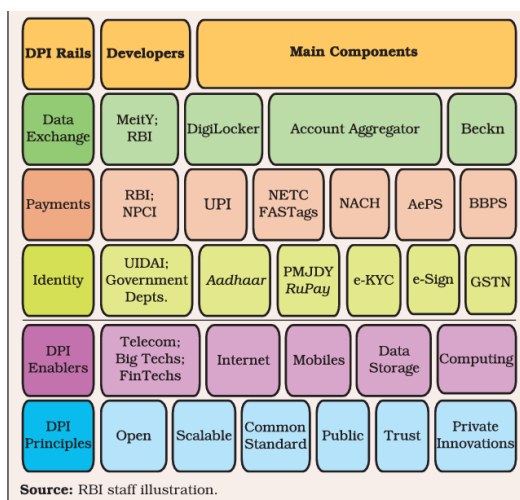


4.8. Digitalisation has empowered citizens replacing the multi-layered and offline cash-based delivery structures. Digital identity system has ensured that government benefits reach the intended beneficiaries, thereby reducing corruption, leakages, and inefficiencies. E-Governance in taxation has enabled the government to effectively leverage robust data analytics and artificial intelligence to detect instances of tax evasion, identify risky, and fake taxpayers. Introduction of biometric-based digital payments in employment, pension, and social programs reduced leakages by 41 percent (Muralidharan, Niehaus, and Sukhtankar 2016). Overall, digitalisation has been successfully used in India to improve governance in multiple sectors and levels to eliminate corruption, increase efficiency and transparency, provide instant and convenient services, improve speed and timely delivery, enhance credit access, and enhance safety and security.

5. Infrastructure to support Digitalisation

5.1. Digital Public Infrastructure(DPI) has facilitated large scale and speedy digitalisation of governance and expansion of service delivery. The most important DPI is the India Stack which is a set of Application Programming Interface(APIs) that allows governments, businesses, startups, developers, and consumers of services to utilise a unique digital infrastructure. India Stack consists of three layers of open APIs: identity, payments and data (Exhibit 5). There are four technology layers: (i) Presenceless layer, where a universal biometric identity (Aadhar) allows people to participate in any service from anywhere in the country; (ii) paperless layer, where digital records (Aadhar e-KYC, e-Sign, DigiLocker) move with an individual's digital identity, eliminating the need for massive amount of paper collection and storage; (iii) Cashless layer, where a single interface to all country's bank accounts and wallets (UPI, AePS, Aadhar Payment Bridge) to democratise payments; and (iv) Consent layer (Data empowerment and Data protection architecture) which allows data to move freely and securely to democratise the market for data.

Exhibit 5: India Stack



5.2. India Stack has cost-effectively facilitated population-scale service delivery, particularly benefitting marginalised segments (D'Silva et al., 2019; Alonso et al., 2023). Aadhaar, UPI, DigiLocker, UMANG, Digital Infrastructure for Knowledge Sharing (DIKSHA), Co-Win, Poshan Tracker, GeM, Application Programming Interface (API) Setu, etc., have demonstrated the transformational potential of DPI. Digital BHASHINI is resulting in AI-based text-to-text, text-to-speech, and speech-to-speech language technologies and solutions. The Government is working on key sector Healthcare, Education, Agriculture, Logistics, Women and Child Development, etc., and proposes to develop nationwide sectoral DPI weaving together multiple existing and new projects with central support in key sectors of the economy.

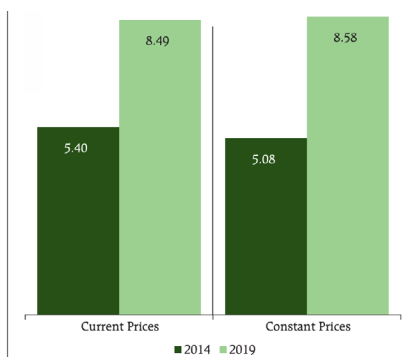
5.3. The India Stack has caught the attention of the World. Under the Indian Presidency, the G20 in 2023 reached the first multilateral consensus on a description of DPI and suggestive guiding principles and a framework for future international cooperation. The G20 recognizes digital ID, digital payments, and data sharing as basic DPI, and acknowledges that countries will have their own ways and architectures of implementing them. The Global Partnership for Financial Inclusion has developed policy recommendations on how DPI can promote financial inclusion and productivity gains. The World Bank has incorporated DPI in its global priority program on accelerating Digitalisation. The UN has launched a high-impact initiative on DPI to spur progress across all 17 Sustainable Development Goals (SDGs).

6. Forward and backward linkages of digitalisation with macroeconomic, financial, and social sectors, and their role in improving the economic and living conditions of people.

6.1. Attempts have been made by international agencies and in India to measure the size of digital economy and its contribution to the GDP by using the available information regarding digital industries and products. The OECD, IMF, ADB, and US Bureau of Economic Analysis (USBEA) have developed a digital economy measurement framework based on national accounts data. By using the approach followed by ADB, and ADB's National Input-Output tables, an RBI study has estimated that India's digital economy is growing at a much faster rate than overall economic growth and that the share of India's core digital economy at current prices increased from 5.4% of

GVA in 2014 to 8.5% in 2019 (Exhibit 6), recording a growth rate of 15.6%, which was 2.4 times the growth of the Indian economy during this period (Gajbhiye, Arora, Nahar, Yangdol, and Thakur, 2022).

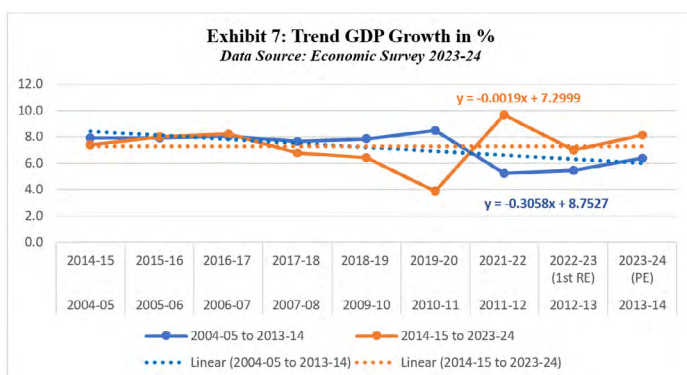
Exhibit 6: Size of India's Digital Economy (%) of GVA



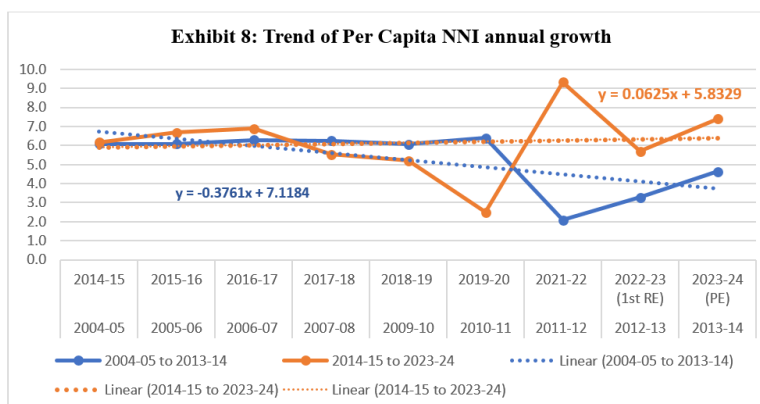
Source: RBI Bulletin, December 2022

6.2. RBI's Report on Currency and Finance 2023-24 has stated that the digital economy currently accounts for a tenth of India's GDP. Going by growth rates observed over the past decade, it is poised to constitute a fifth (or 20%) of GDP by 2026 (Chandrasekhar, 2023). MeitY (2019) has estimated that digital economy is expected to rise to US\$500 billion by 2025 in their 'business as usual' scenario, having the potential to reach up to US\$1 trillion by following a set of policy initiatives covering 30 digital themes under 9 national goals.

6.3. An ADB study (Nguyen and Nguyen, 2024) has found that in the period 2017–2021, countries with higher digital competitiveness had a stronger positive impact on real economic growth, or they reduced the negative impact of the COVID-19 pandemic on real GDP growth rates. Digitalisation is one of the factors which facilitated the faster post-COVID recovery of economic activities in India ((Gajbhiye, et al., 2022). A comparison of the trend GDP growth at constant prices (2011-12=100) between 2004-05 to 2014-15, and 2014-15 to 2023-24 in India shows significant differences (Exhibit 7).



6.4. Since per capita income is regarded as a single measure of wellbeing, an attempt has been made to compare the trend annual growth rate of per-capita income pre and post-digitalisation period. The average annual trend growth rates of per capita net national income between 2004-05 to 2014-15, and 2014-15 to 2023-24 also shows significant differences (Exhibit 8), though some portion of the improvement in the per capita income growth may be ascribed to the decline in population growth during 2014-15 to 2023-24, compared to 2004-05 to 2014-15.



However, it is difficult to establish from these facts that the improvement in trend growth rates of GDP and per capita NNI is entirely due to digitalisation as several other factors have changed during this period.

Has digitalisation facilitated inclusive growth?

6.5. In their attempts to develop a measurement of inclusive growth, the World Economic Forum and UNCTAD have come up with the Inclusive Development Index (IDI), and the Inclusive Growth Index (IGI). While IDI is outdated, IGI does not reflect the targeted inclusiveness indicators in India. In India, financial inclusion is considered the most powerful indicator of inclusiveness as it is the major factor of empowerment and a key driver of economic growth and poverty alleviation. Use of JanDhan, Aadhar, and Mobile(JAM trinity) has improved the proportion of the adult population holding bank accounts from 35% in 2011, to 53% in 2014, and 78% in 2021(Exhibit 9). What is more important to observe is that gender gap, and rural-urban gap have been filled in so far as bank account opening is concerned implying achievement of inclusivity. The Aadhar identification, the Universal Payment Interface, and the Digital Public Infrastructure have emerged as game-changers for achieving financial inclusion.

6.6. A more comprehensive measurement beyond “access” has been introduced by RBI in the form of Financial Inclusion Index (FI-Index) which, in addition to “access”, subsumes 2 more sub-indices of “usage” and “quality” of financial services. RBI’s FI-index value (covering access, usage, and quality) has improved from 53.9 in March 2021 to 64.2 in March 2024 as against the theoretically defined maximum of 100 for universal financial inclusion (RBI, 2024). A National Strategy for Financial Inclusion and another National Strategy for Financial Education is under implementation to further improve financial inclusion.

Exhibit 9: Improvement in Financial Inclusion

	% of 15+age population Holding Account in a financial institution						
	Total	Female	Male	Rural	Urban	Received wage payment or from Government in Account	Owns a debit card (% age 15+)
2011	35%	26%	44%				8%
2014	53%	43%	63%				22%
2017	80%	77%	83%				33%
2021	78%	78%	78%	77%	78%	54%	27%

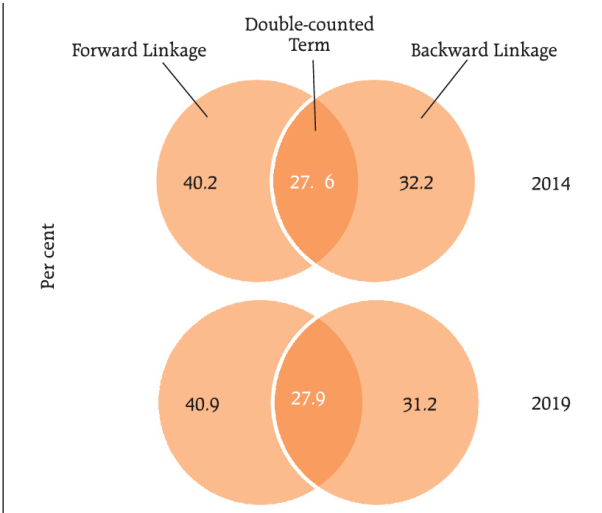
Source: World Bank, Global Findex Database

Backward and Forward Linkages of Digitalisation

6.7. Digitalisation is progressing in multidimensional directions creating intricate backward and forward linkages with other sectors of the economy. Backward linkage captures the inputs that a particular sector (digital sector in the instant case) draws from other sectors. The forward linkage refers to the output of the sector used as inputs in other sectors. The stronger the linkages, the deeper the impact on growth and welfare. To understand the role of the digital economy as a supplier and a user of goods and services, RBI's study has analysed the forward and backward linkages of the digital economy (Gajbhiye, et al., 2022). It finds that a major proportion of the digital GVA for India is attributed to forward linkages (around 40%) both in 2014 and 2019 (Exhibit 10), implying that the digital economy majorly acts as a supplier of value-added to the non-digital sectors, whereas 31-32 percent is attributed to backward linkages. The digital sector contributes around 28 per cent of its own value added (the double-counted term).

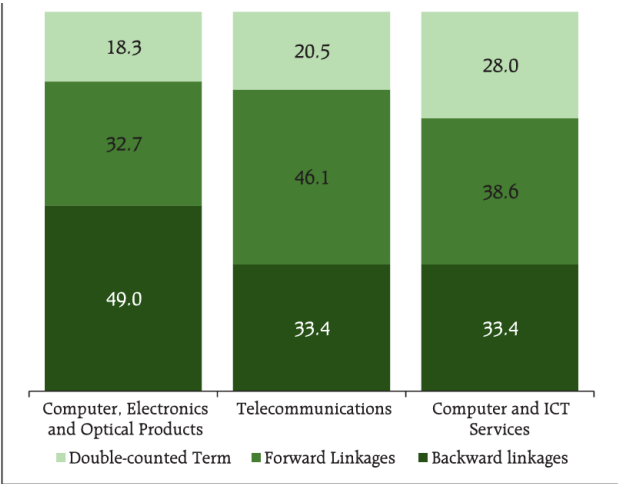
6.8. The RBI's study considers the digital economy comprising three subsectors – (i) computer, electronics, and optical products; (ii) telecommunications; (iii) computer and ICT services. Of these 3 sub-sectors, backward linkage is stronger than forward linkage in case of computer, electronics, and optical products. For the other two subsectors, forward linkages are stronger than the backward linkages (Exhibit 11). However, the study has indicated that it is difficult to capture the digital economy from traditional data within the System of National Accounts because of the numerous interactions of digital technology across various activities in the economy.

Exhibit 10: Forward and Backward linkages of Digital Economy



Source: RBI Bulletin, December 2022

Exhibit 11: Forward and Backward linkages at the sub-sectoral level



Source: RBI Bulletin, December 2022

6.9. Available national accounts statistics used in the Supply and Use Framework by the OECD and the USBEA do not capture the goods and services delivered using digital technology because although such goods and services are linked to the welfare of the people, these are either not priced separately or are non-marketable. This calls for moving beyond national accounts statistics and GDP to include non-market production enabled by digitalisation on the one hand, and to capture the indirect multiplier and accelerator effects of digitalisation on the economy.

Brynjolfsson et al. (2019) have attempted to supplement the national account statistics by proposing a welfare-based measurement called GDP-B, which quantifies the benefits of digitalisation rather than the costs. Applying this framework to several empirical examples like Facebook and smartphone cameras, they estimated their valuations through incentive compatible choice experiments. It finds that including the welfare gains from Facebook would have added between 0.05 to 0.11 percentage points to GDP-B growth per year in the US. Recently, ICRIER has suggested a methodology called CHIPS (Connect, Harness, Innovate, Protect, Sustain) to measure digitalisation (ICRIER, 2024). CHIPS measurement reflected the enormous scaling up that India has achieved in connecting millions to the internet and enabling the use of digital services at a population scale. However, it has not attempted to establish the linkages of such scaling up with the economic and welfare performances of India.

Has digitalisation impacted employment generation?

6.10. MeitY has stated that IT sector is the biggest employment generator and has spawned the mushrooming of several ancillary industries such as transportation, real estate and catering, Security, Housekeeping etc. Direct employment in the IT services and BPO/ITeS segment is estimated at 5.43 million in FY 2023-2024(Exhibit 12).

Exhibit 12: Direct Impact on Employment Generation

Description	2019-20	2020-21	2021-22	2022-23	2023-24 (E)
Employment (In Millions)	4.36	4.47	5.1	5.37	5.43
Net Addition	205000	138000	445000	290000	60000

Source: Employment Generation Ministry of Electronics and Information Technology

The RBI report points out that employment in the digital sectors of the Indian economy is still quite limited (RBI, 2024a). Among the digital sectors, the highest share of employment at 59.8% is for computer programming consultancy and related activities followed by telecommunication services at 15.2%.

Has Digitalisation contributed to poverty alleviation?

6.11. Global Multidimensional Poverty Index reveals that 41.5 crore poor people in India moved out of poverty from 2005/2006 to 2019/2021 (UNDP, 2024). During this period, the incidence of poverty in India fell from 55.1 percent to 16.4 percent, and deprivation in all multidimensional poverty indicators declined. The poorest states and groups, including children and people in disadvantaged caste groups, had the fastest absolute progress. The National Multidimensional Poverty Index has been prepared by NITI Aayog following the same global formula, but in addition to the 10 indicators used for global index, two more indicators (namely Maternal Health and Bank Accounts) have been added in line with India's national priorities. National Index shows that multidimensional poverty in India has declined from 29.17% in 2013-14 to 11.28% in 2022-23, with about 24.82 crore people moving out of poverty during this period (NITI Aayog, 2024). However, it cannot be concluded that the entire fall in poverty is due to digitalisation. Besides, it

is expected that there is a lead and lag relationship between digitalisation and its impact on various sectors. Hence, optimal benefits to get reflected will also involve a time lag.

7. Conclusions

7.1. A knowledgeable, empowered, and digitally connected society is expected to avail of various benefits offered by different government programmes and optimally utilise these for their wellbeing and live a good life. Alternatively, a more empowered and knowledgeable society is capable of demanding programmes and resources for creating better living conditions and ease of living, ease of doing business, and so on, for themselves. This paper reviews digitalisation programmes introduced and implemented in India. It finds that the extent of digitalisation spreads to various sectors including the financial sector, the economic and social sector subsidy schemes, governance, education, healthcare, rural sector, agriculture, retail businesses, and to support innovation, to name a few. Looking at secondary data obtained from relevant national and international sources reveals that on the supply side, digitalisation is being taken forward speedily. However, on the demand side, digitalisation is yet to take deep root in India. E-governance has yielded many positive results in bringing about efficiency, in reducing the scope of corruption and fake entries in government schemes and accounts. Direct benefit transfers have ensured transferring the entire subsidy to the targeted beneficiaries and also led to subsidy savings for the government. India's Digital Public Infrastructure has attracted global attention for potential adoption in other countries.

7.2. The digital economy in India is growing at a much faster rate than overall economic growth. However, the impact of the digital economy on the overall economic growth in general and inclusive growth in particular remains a grey area of research. Further, digitalisation is progressing in multidimensional directions creating intricate backward and forward linkages with other sectors of the economy resulting in alteration and transformation of the growth and development processes. On a priori consideration, there must be a lead-lag relationship between digitalisation and its impact on various sectors. The lack of data matching the mission of Digital India, and the absence of a sectoral level conceptual framework comes in the way of empirical estimation of the forward and backward linkages of digitalisation with various sectors and quantifying direct and indirect contributions to productivity and growth. Academics and researchers must work with the government on these two fronts based on which India's journey to move from poverty to empowerment and from macroeconomic growth to inclusive growth by using ways and means of digitalisation can be meaningfully analysed and established.

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Alternative Method Of The Time Series Modelling

Prof. Shri Prakash¹, Amit Sharma², Rebecca Donald³

Abstract

Shri Prakash, Amit Sharma and Rebecca Donald have examined an alternative method of modelling the time series. They explained the concepts, types and properties of the cross section, time series and panel data including the strength and weaknesses of these data sets. Specific method and modelling is appropriate for each type of data set. Cross section data is affected adversely by extreme values which may make variances of residuals heteroscedastic. The assumption of zero Mean of each residual is also violated.

The time series data are extremely sophisticated, highly specialised and greatly complex which require special method of modelling. Testing of the stationary nature of the series is mandatory. In case, of non – stationary Time Series included in the regression equation makes application of Engel Ganger test of co- integration necessary. The authors prefer the concept of stationary time series enunciated by J.K. Mehta over Hicksian concept. In view of the complexity, greatly specialized and highly sophisticated nature of the econometric modelling based on time series data, the authors come out with alternative methods of time series. They have enunciated the principle of elasticity as the base of modelling time series. The estimation of elasticities of the two variables between which the relationship is to be examine is estimated in terms of growth rates.

The averaging of the values moderates the extreme values which reduces non stationarity. Therefore, the use of rates of growth controls non-stationarity of the series greatly. The Authors proposed the use of the principle of elasticity as the alternative method of modelling time series. They used semi log linear and linear equations on the one hand, and the principle of compounding to determine rates of growth and the elasticity coefficients. They advocate use of principle of compounding as the relatively more reliable method for estimation of growth rates for the estimating the elasticity coefficients. The application of this method of modelling time series is empirically illustrated by the modelling of GDP and Capital stock accumulated during 24 yrs. from 2000 to 2023.

Introduction

Empirical research proceeds on figures relating to observed facts. These figures are defined as data, which is the plural of datum. The data may be classified into the following three categories:

- (1) Cross Section data set;
- (2) Time Series Set; and
- (3) Panel Data Set

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Cross section data refer to the set of such values of the given variable, each of which relates to a different entity. Entity may refer to place or person. Such data sets may comprise the values of a variable each of which may either be highly depend, or marginally different. Marginally different values may relate to such entities which belong to the group, each member of which has reached a similar level of attainment.

For example, if we consider Gross State Domestic Product (GSDP) of different states of India, it may be observed that per capita GSDP of developed states like Punjab, Haryana, Gujarat, Maharashtra, Karnataka and Tamil Nadu do not differ very highly. Similarly per capita GSDP of states like Bihar, U.P., Rajasthan, Orissa and M.P. may also not be highly different, since these states are at a much lower level of development than the states of the first group. However, these five states are more or less at a similar level of development. Generally, the set of Cross Section data comprises values of highly diversified entities. Consequently, variance and the coefficients of variation are not only high but the variation may also differ significantly among the sub sets of the entities covered by the data. For example, the following set of Cross Section data of GSDP of 32 states and UT's are examined for discerning some important properties of cross section data. The following table contains the results:

Table 1
Mean, Standard Error, Variances and Co- Efficient of Variations of GSDP of three sub groups of States, UTs and India

	Mean	St. Error	Variance	Co-efficient of Variation
Least	4.329167361	0.072536	0.057876	5.557077
Moderate	5.419354423	0.068813	0.052088	4.2113603
Highest	5.929163738	0.059038	0.034855	3.1487475
Total	5.203918031	0.125406	0.503251	13.632068

Source: Author's calculation

Table 2
Corresponding t and F statistics of the Significance of three sub groups

	lest with Moderate	Least with highest	Mod with Highest	Total with Least	Total with Moderate	Total with Highest
t	72.34	111.38	36.52	57.891	59.001	50.959
F	5.21	7.6	6.84	56.953	63.282	93.561

Source: Author's calculation

The above table shows that:

Differences among the paired means of three different groups of least, moderately and highly developed units are greatly differ significantly at 0 probability, and the paired variances of different

subgroups of the units differ significantly from each other at 0.05 and 0.00 probability.

The regression coefficients based on Cross Section data may be estimated by:

Ordinary Least Squares Regression (OLS)

Generalized Least Squares (GLS)

Indirect Least Squares (ILS) - Two stage or three stage, depending upon the nature of the regression model under consideration. But OLS is the most popular method of estimation of regression coefficients.

Assumptions of OLS

Following are the assumptions of OLS:

Estimates of parameter determine the relationship between the dependent/ endogenous and independent/ exogenous variables.

In case of multiple regression having two or more exogenous variables, exogenous variable are assumed to be independent of each other that is, their correlation coefficient is zero. Violation of this assumption results in multicollinearity which directly affects adversely the reliability of the estimates.

Total variation = Explained Variation + Unexplained Variation/ residual.

The Means of the residuals do not differ significantly from each other and have zero value;

$$E(U_i) = E(U_j) = 0,$$

E before U represents expected value which represents mean in probability theory.

All the variances of the residuals are equal to each other and remain constant:

$$E(U_i^2) = E(U_j^2)$$

If U_i and U_j are not related to each other, the correlation between these two is zero. If the assumption is violated, then the problem of the significance arises which compromises the validity of the empirical estimate of the coefficients. Durbin Watson d and t test have been proposed as the diagnostic test (Prof. Shri Prakash. Sonia Dhir and Amit Sharma)

Set of Time Series Data:

Whereas the values of the variable under consideration varies among the entities of cross section data, values in the set of Time Series data vary between different units of time. Time may refer to day, week, month, quarter or year. One single variable is under observation and its values relate to different points and time. Thus, time is the co -variable along with values of the variable under consideration. But each value of the Time Series is assumed to be an average. This aspect of the time series data may be illustrated as follows:

Let X be the variable under consideration and X_t be its value at time t . $t: 1, 2, 3, \dots, t$. thus, the data series comprise t periods. Let, P_t be the probability of X having the value X_t . Then, Expected value/ Mean of the entire series of the data shall be given by the following equation:

$$E(X_t) = P_1 X_1 + P_2 X_2 + \dots + P_i X_i + \dots + P_t X_t) \dots\dots\dots 1$$

$E X_t$ is defined as the expected value/mean of the entire series of the value of X . $E X_t$ is the expected or the average value of the X variable at time t . This may be elaborated by the example of the stock prices in the exchange market. The prices of each share tend to change with the lapse of time even within a day. Generally, four prices are reported everyday: opening price, closing price, highest price and lowest price. The fifth price of the day is an average of all the prices that have prevailed in the market during the day. The decisions of the investors are guided by the expectation they entertain about the change in price of the script during the period of time. Expectations are formed on the basis the changes that have occurred recently and the scaffolding of the market forces operating at the given pointing time. So the equation 1 may represent the expectations of the investors about the price of the given share in the exchange market during the day.

This aspect may also be illustrated by the budgetary growth rate which the Finance Minister of the country expects to realize during the financial year. The period of one year is quiet long in view of the fact that large number of factor continuously operate in the economy during the year. Consequently several rates of growth of GDP may be probable to materialize with certain probability. So, equation 1 may represent the expected rate of growth of GDP during the period of one year. We can either consider 12 months as the sub periods of the financial year or alternatively 4 quarters of the year may be taken into consideration each quarter of the year is associated with the operation of different economic factors and the configuration of the operating factors of each quarters shall be the basis of the expected growth rate of GDP of during that quarter.

Besides the above facet, the set of Time Series data may be the part of any of the following three economic states (J.K. Mehta 1959 and J.R. Hicks) Value and capital

- (1) Stationary State,
- (2) Static State,
- (3) Dynamic State

Mehta has classified the states of an economy in to above three states, while Hicks considers only static and dynamic state. Stationary state is that condition of the economy in which the economy remains change less through time. Consequently, economy reproduces itself year after year without change. Static refers to the condition of the economy in which the rate of change remains constant. Thus, the economy changes time to time but the rate of change does not change. But in a dynamic state the rate of change itself changes. However, Hicks define economic dynamics as that states in which every value of the variable has to be dated, since no two values are equal. But the values of the variable are not dated in a static state. This concept virtually coincides with the stationary state of Mehta.

On the basis of the above categorization of the states of economy, time series data has been classified into two categories: Stationary Time Series and Non Time series. Stationary time series has the following characteristics:

- (i) Mean of the series remains constant throughout the period of study;
- (ii) The variance of the Time Series also remains constant and
- (iii) The covariance is not affected by the time at which it is calculated.

Another property is that it comprises four components:

(i) Seasonal, (ii) business cycle, (iii) trend and (iv) the residual. First three components inference are the residual both directly and indirectly. These components are associated with Time Series data irrespective of whether it is stationary or Non Stationary. The stationary time series falls in the J.K. Mehta category of Stationary Series, while it falls in the category of static series according to Hicksian classification. According to Hicks, static time series may also include historical, periodically repeating and once for all changes. However the above changes will directly affect the constancy of the mean and the variance. So, we consider Mehta classification more appropriate for stationary time series data.

Y.A. Yule (1927) in an article published in the Journal of Royal Society of Statistics opined that Econometric modelling will not yield valid and acceptable results if the time series is non-stationary. Subsequent developments during 1980s related to the evolution of three tests of stationarity of the time series: (i) Dickey Fuller Test which considers current value of the variable as the function of its preceding value. It is thus auto regression modelling without any theoretical support; (ii) augmented Dickey Fuller test as the function of a large number of the preceding values. This poses the problem of the determination of the number of past values of the variable as the exogenous variable. Besides, it does not conform to the distributed lag model. It is also interesting to note that Shri Prakash and Chitra Bhatia Arora (2015) examined daily prices of the stocks of five companies for a period of 5yrs. Thus the study covers 30,000 observations. They included 60 lag values of the stock of each company. They found that the use of regression modelling is directly and significantly by multicollinearity to make the results unacceptable. They also used Q and Q* diagnostic Test of the evaluation the joint hypothesis. They found that it is not desirable to include one, two, three lag values of the variable under consideration as the exogenous variables. It may, therefore, be concluded that 2 to 3 lag values of the variable may be used as the determinants of the current value. It eliminates the need for the determination of the length of the lagged values of the variable of the analysis. (iii) the third test of Stationarity has been developed by Johansson. Another development of 80s suggested that even if the time series of one or more than one variable included in the regression are non-stationary, Engle Ganger test of co-integration may be used to validate the empirical result. Engle Ganger test uses the residuals of the regression equation as the variables of the system.

Besides, Auto correlation also adversely affects the results of regression based on time series data. Durbin – Watson test is very popular for the evaluation of the significance of the autocorrelation coefficient. Shri Prakash and Sonia Dhir (2014) have evolved alternative tests of auto correlation coefficient.

Interestingly, Shri Prakash and Mrs Rebecca Donald have evolved alternative method of the Time Series modelling which avoids the need for examining the stationary nature of time series data even if interrelation between two or more variables is involved in the system. This method uses the elasticity derived in terms of the rate of growth of the variable.

Panel Data

The panel data is the third category of the data typology. Panel data comprises group of cross section and the time series data of the variable under consideration. Therefore, econometric modelling based on panel data poses the problem relating both to cross section and time series data. Three alternative method of modelling have been evolved for the analysis of the panel data:

1. General Regression modelling, the results of which may be examined for the significance of the auto correlation coefficient, hetroscladity and multicollinearity;
2. Multicollinearity may be examined only if the model includes more than one exogenous variable;
3. Fixed variable effect modelling;
4. Modelling based Exponential system of the variables.

The above discussion shows that each type of data base requires econometric modelling of a specific category.

Regression Equations to estimate the Growth rate of GDP and Capital Formation

Semi Log

$$\ln Y_t = \alpha + \beta T \dots\dots (i)$$

Linear

$$Y_t = \alpha + \beta T \dots\dots\dots (ii)$$

Compound rate of Growth

$$Y_t = (1 + Gr)^t * Y_0 \dots\dots\dots (iii)$$

Y_t is Capital Formation/ GDP, T is Time period, Gr is Growth and Y_0 is first value of variable

Estimation of Growth Rate of Capital Formation (CF)

Semi Log

$$\ln Y_t = \alpha + \beta T$$

$$\ln CF = 5.787943 + 0.049989 T, R^2 = 0.97, F = 790.9, P = 3.75E-18$$

$t(223.3) \quad t(28.12)$

$$SG_{CF} = \beta * 100 \dots\dots E2$$

$$= 4.98 \%$$

Where CF is Capital Formation, T is time; SGCF is Semi Log Growth rate of Capital Formation

Linear Equation of CF

$$Y_t = \alpha + \beta T$$

$$CF = -737360 + 333985.8T, R^2 = 0.93, F = 283.86, P = 4.63936E-14$$

$t(-2.6) \quad t(16.84)$

$$LG CF = \beta / (\alpha + \beta * T)$$

$$\text{Linear Growth Rate} = 9.7\%$$

Where CF is Capital Formation, T is time; LGCF is Linear Growth rate of Capital Formation

Compound rate of Growth

$$Y_t = (1 + Gr)^t * Y_0$$

$$CG_{CF} = 12\%$$

CG_{CF} = Compound Growth Rate of Capital Formation, $Y_t / Y_0 = (1 + G)^t$, Y_t is Last value of the variable and Y_0 is initial value, $(1 + Gr)^t * Y_0 = Y_t$, $\ln Y_t / Y_0 = t \ln(1 + G) = 1/t * \ln Y_t / Y_0 = \ln(1 + G)$

Estimation of Growth Rate of GDP

Semi Log Linear

$$\ln GDP = 6.27 + 0.052T, R^2 = 0.99, F = 2454.98, P = 3.75E-18, 4.58E-24$$

$$t: (421.15) \quad t: (49.54)$$

$$SGDP = \beta * 100$$

$$= 5.2\%$$

Linear Equation of GDP

$$Y_t = \alpha + \beta T$$

$$GDP = -29084.626 + 11420.187T, R^2 = 0.93, F = 316.074, P = 1.54E-14$$

$$t(3.168) \quad t(17.77)$$

$$LGgdp = \beta / (\alpha + \beta * \bar{T})$$

$$= 6.65\%$$

Compound rate of Growth

$$Y_t = (1 + Gr)^t * Y_0$$

$$CG_{gdp} = 11.98\%$$

SWAT Analysis of Different Methods of estimating growth rates with respect to the type of data set:

In the ensuing paragraphs strength and weaknesses of different methods of estimating growth rate are analysed;

1. Growth rate derived from semi log linear equation: the coefficient of time t in this equation is the compound rate of growth which is an average of rate of changes, observation by observation/ year by year.

2. Log transformation of the observed values reduces the dimensions of the original values and it smoothen the differences among the observed values. Consequently the average and the variance are reduced. This takes care of the inter sub – groups differences of the observed values of the cross section data.

It also smoothen the high degree of inter-temporal variations in case of time series and panel data. It, therefore, takes care of the important assumptions of the constancy of the means and the variances of the stationary time series.

3. It takes all the observation into account irrespective of whether the dataset is cross section, time series or panel.

Weaknesses of estimating the growth rate: The following weaknesses are associated with this method of the estimation of the growth rate:

1. Longer the time series or larger is the number of observation in the cross section that is larger is the sample size, smaller are the correlation and regression coefficients. It implies the automatic reduction in the rate of growth. In other words as the sample size increases average/ growth rate tends to decrease.
2. It may, however, may also be considered as the strength of this method. According to the law of large numbers. According to this law, as the sample size increases, average/ growth rate emerges towards its true value. Since the over or under estimation is eliminated.
3. Log transformation of the observed values leads to an underestimation of the actual growth rate.

SWAT analysis of growth rate based on linear equation: The following are the strengths of this method of estimation of growth rate:

1. Like the semi log linear method this method also takes all observation into account irrespective of whether the data set is cross section, time series and panel.
2. The estimated rate of growth derived from this method is an average of averages, since the coefficient of time (numerator of the growth rate is an average and the denominator of the growth rate $(\alpha + \beta \cdot \bar{T})$ is also an average. So the ratio of an average to another average is the average of averages. This property is associated with growth rate derived from cross section, time series or panel data;
3. This method is free from artificial Mode of reducing the values of the observations by log transformation. So, it is free from underestimation of the actual growth rate to the large extent. This strength is independent of the nature of data set used in the derivation of the growth rate.

Weaknesses: the following are the weaknesses of this method of estimating growth rate:

1. Extreme values of the variables adversely affect the average and the variance. Extremely high values result in over estimation and extremely low values lead to underestimation of the average and the variance. Such extreme values are defined as out-liers. This weakness is commonly present in estimating the growth rate by this method cross section, time series and panel. However, it is noteworthy that the averages and the variance of the sub groups constituting the cross section data set are generally characteristics by high differentials. Consequently, over or under estimation of the actual growth rate may be much more effective in case of cross section data. In case of time series degree of inter - temporal variations will affect the over/ under estimation of the true growth rate. But panel data may further accentuate the degree of over/ under estimation of the true growth rate by this method.
2. In both the above two methods in estimating the growth are relevant only for time series data, since time itself is variable.

SWAT Analysis of Growth rate based on the principle of compounding: the following are the strength and weaknesses of this method:

1. The method requires least information/ data for the estimation of the growth rate – Terminal value, initial value and the duration of the time period are the necessary ingredients of the

- growth rate based on this method. Thus, the method avoids the necessity of knowing all the values of the time series data; it economises the database;
2. The difference between the terminal and the initial values/ ratio of the terminal to the initial value is averaged out over the entire period under study. Thus this method equalises the rate of change in the initial value over the entire period. Thus, this conforms to the basic assumptions of Time Series that each observation is an average which remains constant over the period.
 3. This method is totally independent of regression analysis.

The following are the weaknesses of this method:

1. This method over looks all values of the time series except the initial and the terminal values. Thus, all the fluctuations in the values of the variables between the terminal and the initial values are neglected in the calculation;
2. Averages are highly sensitive to the presence of extremely high or extremely low values. So if either the initial or the terminal value or both these values are extremely high or low the growth rate based on these two values shall be adversely affected greatly.

Derivation of the elasticity from these three methods:

All the three methods involved the growth rates of time and the growth rate of the variable(s) of observations. As the purpose of the study is the derivation of the relationship between two or more variables, rates of growth of each variable has to be consider in relation to time.

The average of the periods covered by the time series of the variable under consideration is the same, the average number of years/ months etc. is to be taken into account. The average of time is given by the following:

Average of time = $\text{Summation } t_i / N = \bar{T}$

Where t_i is equal to $t_1, t_2, \dots, t_n$

So far as

Average of all three growth rates of Capital Formation= $(5 + 8 + 12/3) = 8.33$

Average of all three Growth rates of GDP = $(5.2 + 6.65 + 11.98/3) = 7.94$

Elasticity Co-efficient

Elasticity Co- efficient measures the change in the independent variable in response to the change that takes place in the independent variable. Thus, the elasticity coefficient measures the degree and direction of the relationship between the two variables. Therefore elasticity may be defined as the change in one variable related to the change that occurs in the other variable with which the first variable is related. In other words, elasticity coefficient is the ratio of the rate of change to the change in one variable with respect the rate of change in the other variable:

$(d_Y / Y) (d_X / X)$ this ratio defines the elasticity coefficient of the variable Y with respect to Variable X.

The elasticity coefficients of Capital Formation with respect to the GDP of India have been estimated in terms of rates of growth of capital formation by three different methods with respect to the growth rate of GDP estimated by the same three methods of estimation of growth rate. These methods and their strength and weaknesses have already been discussed. The fourth elasticity coefficient has been estimated in terms of the ratio of the averages of three growth rates of capital formation and three growth rate of GDP. These coefficients are reported in the same sequence in which the rates of growth have been listed above.

$$EC_1 = SG_{cf}/SG_{gdp} = 4.98/5.2 = 0.95$$

Thus corresponding to 1% increase in GDP, capital formation increases by 0.95%. This expresses almost the full potential growth rate of Capital Formation with respect to GDP

$$EC_2 = LG_{cf}/LG_{gdp} = 8/6.65 = 1.20\%$$

Thus, corresponding to 1 % increase in GDP, capital formation increases by 1.2%. Consequently, capital formation seems to have already crossed its potential growth. Therefore there appears to be some overestimation of the growth of Capital Formation

$$EC_3 = CG_{cf}/CG_{gdp} = 12.00/11.98 = 1.001\%$$

So corresponding to 1% increase in GDP capital Accumulation increases by 1.001. Consequently Capital Formation more and less matches the growth rate of GDP.

$$EC_4 = AVG_{cf}/AVG_{gdp} = 8.33/7.94 = 1.04$$

This elasticity coefficient indicates that 1% increase in GDP leads to 1.04% increase in capital formation. The averaging of the sets of three growth rates moderates and modulates the over or under estimation of the growth rates which is embodied in the method of estimation.

Interestingly elasticity coefficient based on the averages of sets of three growth rates of the two variables furnishes the estimate of elasticity which is more and less equal to the elasticity coefficient derived from the principle of compounding. This suggests that the method of compounding the estimating the elasticity coefficient for measuring the relationship between the two variables may be relied upon as the analytical tool of time series data without any attempt to examine whether the time series is stationary or non - stationary.

However this may need more empirical research with different data set for conclusively validating this as the method of time series modelling.

Conclusion

The following are the important conclusions of the study:

1. The paper hypothesises that inter – subgroups means and variances significantly differ from each other. This hypothesis has been validated empirically on the basis of data relating to GSDP 32

States/ UT of India;

2. The paper highlights that the problem of heteroscedasticity in regression modelling arises because (i) residuals depend on inter temporal/inter unit behaviour of the dependent variable. So, the residuals and their variances are the mirror images of the dependent variable and (ii) precision of estimates directly affects the residuals and their variances. Therefore, the low precision of estimates may also account for heteroscedasticity;

3. The paper highlights that the averages and the growth rates moderate and modulate the inter unit as well as inter temporal differentials among the observations. Therefore, the estimated growth rates, irrespective of the method of estimation may, by and large, not be substantially affected by the departure of time series data from stationarity. This aspect has been empirically validated by the estimates of growth rates of Capital Formation and GDP of India over a period of 24 years by three different methods two of which use semi log linear and linear regression model and the third method is based on the principle of compounding the rate of changes;

4. The paper has proposed the use of principle of elasticity as an alternative to regression method of Modelling Time series;

5. 4 Elasticity coefficients are estimated from the alternative growth rates of capital Formation and GDP;

6. Empirical estimates of growth rates based on different methods show that the growth rate derived from linear regression model and the principle of compounding differ from each other by the least amount; and

7. The elasticity coefficient based on the averages of 4 growth rate of capital formation and GDP also approximately equals the elasticity coefficients derived from the linear regression.

This is suggested that more research may be required for validating principle of elasticity empirically as an alternative method of regression modelling on the basis of Time Series.

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Productivity: Investment and growth of Indian Economy

Ruchi Tyagi ¹

Abstract

The paper focuses on relationship between the labor productivity and GDP of India. The study covers the period of 13 years from 2013-2023. The following methods are used for analyzing the data: 1) summary statistics the objective of use of summary statistics is to mainly examine the nature of distribution of core variables :(i) GDP (ii) employment (iii) capital stock (iv) labor productivity and (v) capital productivity, 2) growth curves are used to estimate the growth of core variables, 3) Random walk model is used to highlight the stationary, 4) Engel Granger unit root test. Besides the study has used the regression for evaluating the inter relations between employment, capital and GDP. The study also examines the intertemporal behavior of average and marginal productivity of labor and capital through graphical presentation.

The empirical findings show that GDP of India grows 5 times more rapidly than employment and capital stock grows 7 times more rapidly than employment and 1.3 times more rapidly than GDP. Therefore, the growth of Indian economy has been dominated by capital intensive and labor displacing techniques of production.

Key words

GDP, Employment, Capital stock, average productivity, marginal productivity

Introduction

Post second world –war era has witnessed unprecedented growth of the global economy. Erstwhile colonies launched their ambitious programme of development while war devastated economies like European ones, especially Japan, Germany, France, U.K, Poland Hungary and others got engaged in reconstructing their economies during this period. Incidentally, successive a couple of industrial revolutions revolving around technology radically transformed the form structure of the economies of the globe. IT revolution succeeded by the digitalization, revolutionized the economies across the globe. This period witnessed the reemergence of the economy of Japan, Germany and the U.S and the leading economies of the world during first and a half decade after second world –war. Then emerged the Asian tigers succeeded by the members countries of the BRICS. These earth shaking changes transformed the global economy totally. This period has witnessed the emergence of the Chinese economy, challenging the economy of the U.S as the leader of the world while Indian economy has left the economies of U.K and some other developed economy far behind. The above is the backdrop of the present study. Needless to say that the present century is mainly the century of economic growth and the economies of Asia, especially Indian and Chinese economies may emerged as the leading lights of the future economic scenario. However, the theory of growth has also gone through several incarnations. Adam Smith postulated that the capital is store of labor of the past capital stock at the same time happens to be the carrier of the technology. We may postulate

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that the machinery, equipment, tools and instrument are not simply lifeless objects which contain the graveyard of labor. Capital stock is the container of the physical health which is associated with physical strength and mental power but it is also the embodiment of the knowledge, skills, experience and expertise of the workforce. As the physical technology is only an expression of the human technology, human capital has emerged as the leading factor of the modern economies (Shultz, T.W 1962, Vakil, and C.N. N Brahmanada, P.R, 1953-54, Shri Prakash, 1977/1994, Amit Sharma, 2000-2013). It is obvious that the labor productivity is an indicator of the productive capacity of human capital whereas capital productivity is the reflection of the productive capacity of physical capital and the technology embodied within it.

This paper attempts to quantify the relative contributions of labor productivity and the capital productivity to the growth of GDP of India.

Research Questions

The paper seeks to answers to the following questions:

1) What is the impact of employment / labor productivity on the growth of GDP? 2) What is the impact of the capital / productivity of capital on the growth of GDP of India? ; 3) What is the law of returns under which the production takes place? ; 4) What has been the rate of growth of population during the period of study?

Sources of Data

The data related to 1) GDP, 2) employment, 3) Capital stock have been taken from the Economic Survey of India 2024-25, ministry of finance Govt. of India. The Data relating to employment have been given only for the period from 2011-2023. Besides, the economic survey reports labor force participation rate year on year, the workers population Ratio. These rate and ratios have been converted into absolute numbers by the process of multiplication by population. This process has furnished the estimates of 1) total labor force, 2) total workforce, 3) employment during the period covered by the study. The figures relating to employment and total capital stock are used to derive the values of year on year labor productivity and capital productivity.

Methods / Models

The following models of data analysis are used for data analysis: 1) summary statistics, 2) growth curves and multiple regression model 3) Dickey Fuller test to evaluate whether the data series under consideration are stationary, 4) Engel Granger test of co-integration. Marginal and average productivities of labor and capital are estimated separately and their relation is traced graphically. Shri Prakash and Brinda Malakrishnan (2010) also evolved Input –output model to examine the growth effect of labor productivity on Indian economy. The author has chosen the econometric modelling for the following reasons: 1) I-O model cannot evaluate the joint growth effect of both labor and capital productivity. I-O model will require separate calculation of the impact of labor productivity and the impact of capital productivity on growth. Econometric modelling facilitates the separation of the impact of labor productivity and the impact of capital productivity on growth.

Their joint effect on growth may be embodied in intercept along with the impact of the technology on growth, 2) I-O model facilitates computation of growth effect for the year for which I-O table is available, though the growth effect of productivity may be calculated on the basis of I-O tables available for different years. However, I-O tables are generally available only at an interval of five years on the assumption that the technology remains constant for five years. As against this, econometric model allows the computation of growth effect on much longer period in a continual. Whatever the periodicity of the change in technology it is captured by the data analysis.

Discussion on empirical results

Empirical results are discussed in the sequence listed below: 1) Nature of distribution of the variables: t statistics is used to examine the statistical significance of the difference between the mean and the median of the variables (Shri Prakash et.al vol.No.1, April-June 2023). It is assumed that the distribution is normal and therefore the mean and the median of all the variables under consideration are equal. This is treated as the null hypothesis. The results are reported in the table given below:

Table 1: Summary Statistics

Variables	Mean	median	Standard Error	T statistic
GDP	7.08	7.10	0.0274	2.31
Employment	8.84	8.836	0.0076	4.51
Capital stock	6.71	6.67	0.0364	0.0049
Average labor productivity	0.018294	0.01914	0.000903	2.96
Average capital productivity	2.447	2.5292	0.07299	3.55

Source: author's calculation

Perusal of the above table reveals that the null hypothesis that the distribution is normal is rejected in case of GDP, employment, capital stock, average productivity and marginal productivity. Analysis of other aspects of distribution. The following table shows the results:

Table: 2

Variables	Skewness	kurtosis	Co .of variance
GDP	-0.222	-1.198	1.4414
Employment	1.0184	0.7325	0.311
Capital stock	0.4102	-0.4634	1.959
Average labor productivity	-0.3764	-1.34445	17.79
Average capital productivity	-0.964	-0.0187	10.75

Source: author's calculation

The perusal of the above table reveals that GDP has negative Kurtosis which implies that the distribution is bit concentrated. The inter-temporal distribution is also negatively skewed. However, the co-efficient of variation is only 1.44% which implies that the intertemporal variation are not extremely high. On the whole, it may be inferred that the intertemporal distribution of GDP is neither highly concentrated nor is it greatly skewed.

The positive coefficient of kurtosis of employment is much lower than unit and the positive coefficient of skewness is only one which implies that the distribution is marginally positively skewed, though the high employment does not appear to be concentrated in the narrow space and around the mode. It may therefore be inferred that the employment is approximately uniformly distributed between the years. This inference is also supported by the extremely low value of the coefficient of variance.

The negative co efficient of kurtosis is slightly greater than -1 which implies bit of high degree of concentration of capital accumulation has occurred in some selected years while the positive co-efficient of skewness is extremely low. This also suggest smooth intertemporal flow of capital into the Indian economy. This is supported by low value of co-efficient of variation.

Both the coefficient of kurtosis and skewness of labor productivity are negative which implies that the distribution is bit concentrated. The year on year variations in the rates of growth of labor productivity are not very high since the value of co-efficient of variation is high.

Both the coefficient of kurtosis and skewness of capital productivity are negative and greater than -1. This implies that the high values of capital productivity are concentrated in and around the narrow space of mode over few years and the distribution is negatively skewed significantly at 0.01 probability. This may be accounted by either by the slower flow of capital into the economy without affecting the trend growth rate or by spurt in the growth of GDP above the trend rate. However, the year on year variations in the rates of growth of capital productivity are not very high since the value of coefficient of variation is high.

Analysis of growth curves

Results of estimated growth curves are reported in the table below:

Table 3

variables	Intercept	Co-efficient (T)	R2	F	Sig f
GDP	6.901	0.0242	0.9671	323.6515	1.66E-09
Employment	8.807	0.0047	0.4610	9.408	0.0107
Capital stock	6.482	0.0326	0.935	159.0413	6.97E-08
labour productivity	-1.877	0.01903	0.8353	55.8037	1.24544E-05
Capital productivity	0.044768	-0.0087	0.4818	10.2296	0.00847

Source: Author's own calculations

The above table reveals that the growth curves fit the data well since: 1) the coefficient of determination of the three core variables have very high values and are statistically significant at 0.05 probability, 2) the co-efficient of determination vary from 0.46 for employment to 0.96 for GDP, 3) the co-efficient of time of all three variables are statistically significant at 0.05 probability, 4) GDP grows at an annual compound rate of 2.4% per annum, employment grows only at an annual compound rate of 0.47%. Thus, the growth of employment is highly sluggish and its growth is even less than one-fourth of the growth of GDP. It implies that the growth of GDP is given more by productivity and technology than employment, it implies that the labor productivity has been relatively high during the period of study. Rapid growth of labor productivity implies that the process of growth is labor displacing but it is at the same time productive capacity expanded. So, either capital accumulation or the induction of greatly advance technology has been playing dominant role in the process of growth. This finding is similar to the findings of Shri Prakash for the decade of 1990. The stock of capital has grown at an annual compound rate of 3.2 % which is roughly 1.5 times greater than the growth of GDP. It implies that the Indian economy has been moving towards greatly capital intensive technology modes of production. Therefore, the productivity of capital is likely to be relatively low.

The growth of labor and capital productivity

First we discuss the intertemporal behavior of average and marginal labor productivity. The following is the graphical presentation of average and marginal labor productivity

Figure :1

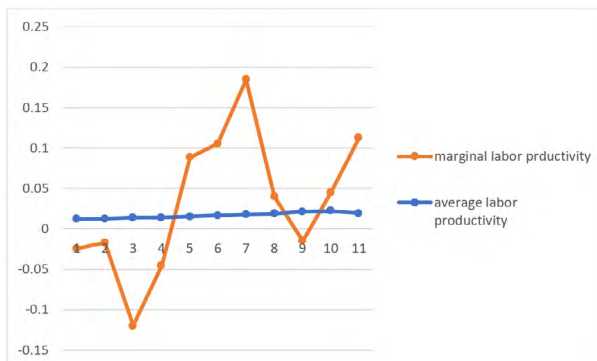


Figure: 2



Initially grows rapidly after the laps of couple of periods the growth rate of average labor productivity is accelerated a hump. it is created because of the deflation of the growth rate. Thereafter average continues to rise till the growth rate reaches 0.32%. Subsequently the average labor productivity continues declines till it reaches the minimum growth rate. The marginal productivity of labor, the rate of growth of marginal productivity of labor. However remains constant for first two years. It declines from 2 to 3 years but it continuously rises more rapidly than the average labor productivity till it reaches its peak around 2020. Thereafter the marginal labor productivity declines in three subsequent years.

Thus, the behavior of both marginal and average labor productivity approximates the theoretically predicted behavioral relationship.

The inter-temporal behavior of average capital productivity diverges from the theoretical expectation. It continuously traces slightly downward bending straight line almost throughout the period of study. The intertemporal behavior of marginal capital productivity is zigzag since it increases, than falls and increases again than falls.

The growth of productivity both of labor and capital has been estimated by semi-log linear equation / growth curves. The OLS estimates of the growth curve of average labor productivity and capital productivity is given in table 3 shows that: 1) the equation explains 83.53% of total of intertemporal variation in the average labor productivity, 2) the co-efficient of correlation is statistically significant, 3) the negative intercept is statistically significant which implies that the variable excluded from the equation (other than time) exercise negative influence on labor productivity. Policies pursued by employers, overall environment, work culture and the nature of technology may be include such negative influences on average negative productivity. The co-efficient of time is statistically significant and the average annual productivity at an annual compound rate of 1.9 / 2 %. This is only slightly less than the growth rate of GDP. The positive intercept of average labor productivity is highly significant statistically. It means that the variables excluded from the regression influence capital productivity positively.

The negative co-efficient of time is statistically significant and the average capital productivity tends to decline at an annual compound rate of 0.87%. This decline in average capital productivity may either be explained by the over capitalization of the production process or some investment in unproductive activities or the underutilization of the installed capacity of production.

The marginal productivity of labor increases at annual rate of 15.16 % which is approximately 8 times more than the rate of growth of average labor productivity. However, the marginal productivity of capital grows at 15.91% per annum which is in contrast to the decline in the average productivity of capital.

Interrelations between employment, capital and GDP

The following is the OLS estimates of the regression:

$$GDP_t = 6.5550 + (-0.529) \ln LAB_t + 0.775 \ln KAP_t, R^2 = 0.933, F 70.59, \text{Sig } f = 1.27E-06, t = 2.138, (-11.37), 9.610$$

The above results shows that the equation fits the data well since: 1) co-efficient of determination has a very high value and it is statistically significant at almost 0 probability, the equation explains 93.3% of total variation in GDP over the period of study, 2) the positive intercept is statistically significant at 0.05 probability. As the intercept captures the influence of the variables excluded from the equation, it may be inferred that the technology and the public policy influence the growth of GDP immensely, the negative elasticity co-efficient of labor is not significant statistically. So the influence of employment as such may be 0, the co-efficient of capital is highly significant statistically corresponding to 1 % change in capital/stock, GDP increases by 77.5 %. Thus the growth of Indian economy is given greatly by capital and technology.

Dicky fuller test

The OLS estimates of the regression are reported below:

Table: 4

GDP	Co-efficients	T stat
Intercept	0.1210	0.4358
Yt-1	0.9868	25.01
Employment		
Intercept	0.9610	0.3953
Yt-1	0.8913	3.236
Capital stock		
Intercept	1.2039	1.8094
Yt-1	0.8205	8.276

Source: own calculations

The results of applications of Dickey-fuller test to the core variables show that the time series of 1) GDP, 2) employment and 3) capital stock is non stationary because the coefficients of the lagged values in the regression of these variables are positive and statistically significant. Therefore, the validation of the results of the regression equation containing these variables requires application of Engel Granger test of co-integration.

Engel Granger test

The OLS estimates of Engel Granger test of co-integration is reported below:

$$U_t = -0.00233 - 2.22187U_{t-1}, R^2 = 0.9381, F = 15.1595, \text{sig } f = 0.1600$$

$$(t = -0.98763) (t = -3.89353)$$

The above equation shows that the negative co-efficient of lagged residual is statistically significant.

Therefore it may be inferred that regression of GDP on employment and capital stock is yields valid and acceptable results.

The table shows the OLS estimates of the regression of $MP_l = f(MP_k)$

Table: 5

	Coefficient	T stat	R2	F	Sig f
Intercept	0.021416	0.9490	0.245	3.239	0.10
MPk	0.007389	1.799			

Source: own calculations

The OLS estimates of the labor productivity and capital productivity show that 1) co-efficient of determination is statistically significant only at 0.10 probability. The regression explains 24.5% variations in labor productivity limited to no of observations may account for the acceptance of statistically significant at 0.10 probability.

The rationale of treating labor productivity as a function of capital productivity is that greater capital intensity based technology enhances the productive capacity of labor. More advance the technology, greater is its labor displacing and productivity enhancing effects.

Findings and conclusions

The following are the main conclusion and findings:

1) The intertemporal distribution of GDP diverges from normal distribution but the distribution is neither highly concentrated around the mode nor is it highly skewed; 2) the intertemporal distribution of employment is also diverges from normal distribution but the distribution is not greatly concentrated and it is not highly skewed; 3) the distribution of capital stock between the years is not normal but the distribution is slightly concentrated in few years around the narrow space of mode which represents clustering of high values of capital stock in couple of years. It may be explained by great spurt in domestic savings and high inflow of foreign investment but the distribution shows positive skewness; 4) the values of the co-efficient of variation of GDP, employment and capital stock are low. The GDP of India grows 5 times more rapidly than employment and capital stock grows 7 times more rapidly than employment and 1.3 times more rapidly than GDP. It may, therefore be concluded that the growth of Indian economy has been dominated by capital intensive and labor displacing techniques of production. The use of capital intensive technology must have resulted in rapid growth of average productivity of labor; 5) the time series of GDP, employment and capital stock are non-stationary. Therefore the corresponding regression equation has been subjected to Engel granger test; the regression of GDP on employment and capital shows co-efficient of employment to be negative and non-significant. This is primarily explained by very relative low increase in employment and consequent low intertemporal variation in the values. It is also partially explained by a bit of over capitalization in the initial years due to time lag in the fortification of the productive capacity of machinery and equipment.

But GDP has been positively and significantly affected by capital during the period of study;6) the labor productivity is not found to be a positively significant function of average capital productivity, but the average labor productivity has been found to be positive and statistically significant for capital stock per unit of labor. this finding lends support to the thesis that the growth of Indian economy has been dominated by capital intensive technology of production;7) the marginal labor productivity has grown more rapidly than average labor productivity while marginal capital productivity has increased more rapidly than average capital productivity.

The above findings and conclusions imply that India should either enhance the rate of growth of the economy to around 7-7.5% per annum or it should be facilitate the more rapid growth of micro and small production units to generate employment relatively more rapidly. This will require some tilt in public policies towards smaller production units.

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Econometric Modeling of Relationship between Tertiary Output and GDP Net of Tertiary Output

Anju Agrawal¹

Abstract

This paper investigates the relationship between tertiary output and GVA net of tertiary output. Time series data covers the period of 25 years from 1999-00 to 2023-24. Summary statistics of the time series of both the variables is used to examine the nature of distribution. The result show that the distribution of both tertiary output and net GVA diverges from normal distribution though the distributions are neither significantly skewed nor are these highly concentrated. Dickey- Fuller Test reveals the time series of both the variables to be non- normal. Initial regression function of tertiary output on net GVA is found to be unacceptable, due to want of satisfaction of Engel Granger Test. But the regression of the first order differences of the tertiary output on first order differences of net GVA is found be satisfactory and acceptable on all counts. The equation also shows that first order differences of the tertiary output are not affected by any variable other than first order differences of net GVA. Besides, corresponding to one unit increase in first order differences of net GVA, first order differences of tertiary output increases by 1.14 units.

Key words

Tertiary, output, GVA, first-order differences, regression, summary-statistics, Dickey-Fuller Test

Introduction

The Indian Economy has been dominated by the primary sector especially agriculture for times immemorial. India used to be self- sufficient and self-reliant in the matter of food grains. Approximately, 90 to 95% area were used to be under food crops. But the advent of British rule brought drastic changes in the Indian economy. In large number, small and cottage industries were closed down as these could not compete with mill-machine made products imported from U.K. Besides, the Britishers introduced Zamindari / Jagirdari System of Land Management and area from food crops was transferred to non- food crops for making the raw materials requirements of British industries. India was thus made the hewer of water and cutter of wood.

Attempts were made to rectify the gaps and imbalances in the structure of Indian economy under the Five Year Plans of development. India gave high priority to the development of basic and heavy goods industries on the one end and decided to trace the socialist path of development. Consequently, successive Congress government adopted the selectivity approach to development. This resulted in the:

- (1) accentuation of the inequalities of regional development,
- (2) accentuation of the inter- sectoral inequalities of development,

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(3) inadequacy of infrastructure development, and
(4) the inter- sectoral inequalities led to the creation of blocks and bottlenecks in the economy and its structure. For example, mountains were being accumulated of coal at the mine pits while thermal plants were starved of coal due to short supply. This is explained by the inadequate development of the railway wagon industry. So, the coal could not be moved in adequate quantity from coal mines to the thermal plants. The short supply of coal resulted in the under - utilization of generation capacity of power. This, in turn, resulted in sub-optimal utilization of productive capacity of other sectors, especially industries, (Sriprakash and A.C. Mahapatra,(1981)¹ and Sriprakash (1994)²). The problems of under capacity utilization emerged in the Indian economy for the first time in mid-sixties.

Indian planners were greatly influenced by the spectacular success of U.S.S.R. under the communist regime. The status achieved by U.S. in four centuries was attained by U.S.S.R. in few decades after the Bolshevik Revolution of 1917. The U.S.S.R. opted for basic and heavy goods industries. So India emulated U.S.S.R. by giving first priority to the development of basic and heavy goods industries. High priority to the development of secondary sector for the achievement of the rapid growth has also been highlighted by Arthur Lewis in 1962³. Lewis postulated that the developing economies remained less developed due to their heavy dependence on primary sector, especially agriculture while their agriculture is characterized by zero labour productivity due to disguised employment. So he emphasized transfer of labour from low productive agriculture to high productive industrial sector for rapid growth. This aspect has also been stressed by Gunnar Myrdal⁴ in 1966, who observed that one third of the total global population living in developed economies has had more than two third of global income. This may probably be accounted by the fact that developed economies were highly organized while developing economies were highly dependent on primary production. (A. H. Singer, (1966-68), Raul Prebisch ()⁵ also emphasized the development of industries for rapid growth. However, this growth theory is associated with the unbalanced growth. Hirschman,(1958)⁶ developed fully blown up and grown up theory of unbalanced growth. He emphasized that the developing economies face critical shortage of capital and complementary human resources to operate advanced technology. So, he advocates the focus of developing countries to develop selected few (one or two) leading sectors of the economy with both high forward and backward linkages. The operation of the linkages will automatically impart momentum to the growth of other related sectors. This has been challenged by the proponents of the balanced growth theory. Nurkse (1958)⁷ is among the leading economist in this group.

Even though India opted for the strategy of the unbalanced growth under which basic and heavy goods industries were given prime Importance. Industries like Iron and Steel, heavy electrical, machine building industries, Cement and such other industries occupied the central place in the programs of planned economic development. As it is obvious, most of the heavy and basic goods industries have been located in vicinity of availability of abundance raw materials like iron- ore, zinc, coal etc. and abundance supply of water in near river beds. Consequently, these industries have to be established in such areas which possessed above type of resources but were backwaters of Indian economy. So these areas were grossly under-developed; these areas did not have infrastructure, both physical and economic, facilities to support the upcoming industries. Tata Steel Plant in Jamshedpur, Steel plant in Bhilai, Durgapur and Rourkela are examples of this. Consequently, all the physical infrastructure like roads, railways, airports, and socio-economic infrastructure like banking, insurance, health, education, post- offices etc. have to be created. Obviously most of these

infrastructure facilities are both directly and indirectly related to the tertiary sector. Consequently, the growth story of Indian economy has been that of tertiary domination. On an average, around 40% of GDP has been contributed to the GDP by the tertiary sector. Tertiary domination was further strengthened by the opening of the services sector to foreign direct investment. Therefore, this paper focuses on the primacy of tertiary sector in the Indian economy and its relation with the GVA net of the tertiary output.

Research Questions:

The following are the main research questions considered in this study.

- (1) is the distribution of tertiary output normal?
- (2) Does the distribution appear to be concentrated and skewed?
- (3)) is the distribution of net GVA normal?
- (4) Does the distribution appear to be concentrated and skewed?
- (5) What is the degree and direction of relationship of tertiary output with net GVA?

Empirical analysis focuses on finding answers the above research questions.

Sources of Data:

Data have been taken from Economic Survey, Ministry of Finance, Government of India, (2023-24), New Delhi.

Models and methods of Data Analysis:

The study does not depend on one single method/ model of data analysis. This is to ensure that the acceptance of Otiose results is avoided.

The following method/models are used in analysing the data:

- (1) Summary Statistics, results of which will furnish answers to the first four questions;
- (2) Two versions of Random walk model, associated with Dickey Fuller Test, are used to evaluate whether the time series of two co - variables are stationary or not;
- (3) Durbin Watson d Statistics as the diagnostics test of significance of auto – correlation;
- (4) Engel-Granger Test of co- integration are validating the results of regression equation; and
- (5) Regression of tertiary output on The models and methods net GVA .

The models and methods are selected with reference to the nature and expanse of the data and objectives of the research along with the strength and weaknesses of each chosen method.

Discussions of Empirical Results

The empirical results are analyzed and discussed in the same sequence in which method/ modules are listed.

Discussion of the results of summary statistics of tertiary sector:

Table: 1

Descriptive Statistics	Tertiary Sector	Net GVA *
Mean	4476352.08	4254213.2
Median	3969975	4136971
Standard Error	435158.4	311451.1255
t - statistics	5.58	1.80
Standard Deviation	2175792.456	1557255.627
Coefficient of Variation	48.6%	36.6%
Kurtosis	-1.16	-1.09
Skewness	0.41	0.3
Number of Observations	25	25

**Net GVA = Gross GVA- Tertiary output*

First of all, the nature of distribution is analyzed. The distribution of the output of tertiary sector is assumed to be normal. This is treated as null hypothesis. An important feature of normal distribution is that mean, median and mode are equal and these lie at the top of the curve and divide the distribution into two equal halves. Therefore the statistical significance of difference of mean and median is tested by small t-statistics. The calculated value of t is as high as 5.58 which is much greater than the critical value of at 0.01 probability. Consequently, the null hypothesis that the distribution of output of tertiary sector is normal stands rejected on basis of the empirical evidence.

The coefficient of variation is as high as 48.67% This high degree of variation of the observed value of tertiary output explains the divergence of the observed distribution from the normal distribution (i.e. null hypo. is rejected)

The negative coefficient of Kurtosis is less than -1 (i.e. $-1.16 < -1$) in absolute terms and hence, is statistically, not significant at 0.01 probability. Therefore high observed values may not be concentrated in and around the narrow space of Mode.

However the coefficient of Skewness is positive but less than one. Therefore, it may be inferred that distribution of output of the tertiary sector is not skewed.

The above results may suggest that the time series of output of tertiary sector may not be stationary. Therefore, it required the testing of whether time series is stationary or not.

Discussion of the results of summary statistics of Net GDP:

The calculated value of t statistics of the difference between mean and median of net GDP is 1.80 which is less than the critical value at 0.05 probability. Therefore, it may be inferred that null hypothesis that the distribution of net GDP between the years is normal stands accepted. The alternative hypothesis that the distribution of net GDP diverges from normal distribution is rejected.

The calculated values of the coefficient of Kurtosis is less than -1. So, it means that high values of net GDP are not concentrated in and around the narrow space of the mode. The coefficient of variation is at the moderate high value of 36.6.%. The calculated value of coefficient of Skewness is positive and statistically not significant. Since it is much less than one.

Application of econometric modeling:

The paper focuses on the relationship between the output of the tertiary sector and its determinants. As tertiary sector is one of the contributors to GDP, the relationship between GDP and output of the tertiary sector is bi-directional, the production of the commodity output precedes the production and operations of the services. Therefore, the relationship between the output of tertiary sector and output of the commodities is characterized by lead and lag structure. The commodity output relates to the primary and secondary sector of the economy. Therefore, GDP net of tertiary output represents commodity production. In view of the above, the following regression equation is specified:

$$O_{st} = a + b \cdot O_{ct-1} + U_t$$

Where O_{st} shows output of tertiary sector during t year (i.e. current period output),

O_{ct-1} shows commodity output during t-1 year (i.e. previous period),

U_t shows error (random/estimate),

a is an intercept and **b** is the regression coefficient.

Intercept captures the influence of such variables as are not included in the regression equations while b measures the amount of change in O_{st} which corresponds to one unit change in O_{ct-1} .

Discussion of the results of regression of current tertiary output on lagged GDP:

The OLS estimate of the regression of current tertiary output on lagged net GDP is reported here under-

$$O_{st} = -1439573.002 + 1.46 O_{ct-1}, R^2 = 98.99, F = 2161.29, P = 1.83757E-23$$

$$t: (-10.49) \quad (46.49)$$

The above equation shows that:

1. The equation fits the data well since it explains 98.99% of total variation of tertiary output during the period of study. The coefficient of determination R^2 (degree of determination of variation) is statistically significant at zero probability;
2. The negative intercept is highly significant statistically. It may imply that some variable (s), excluded from the equations, may influence the tertiary output adversely;
3. The co-efficient of lagged GDP net of tertiary output is positive and statistically significant virtually at zero probability;

4 Corresponding to one unit increase in lagged net GDP, tertiary output increases by rupees 1.46. Thus tertiary output increases 1.5 times more with the increase in net GDP.

Random Walk Model for testing stationarity of tertiary output:

Dicky - Fuller test, associated with RWM, is used too . Here only two versions of RWM are being used.

First one of two versions is:

$$Y_t = a + bY_{t-1} + U_t$$

Y_t is the current tertiary output and Y_{t-1} is the lagged tertiary output. A is defined as the coefficient of drift while b is defined as usual the coefficient of Y_{t-1} and U_t shows random errors.

If b is positive and statistically significant, then the above equation is entrapped in unit root circle. and the series is shown to be known as stationary. It implies that the above equation can be inferred to be stationary only if b is negative and statistically significant.

The following is the other version of RWM:

$$Y_t = a + bY_{t-1} + cT + U_t$$

where T = time and the significance of c will depict the random errors to contain the stochastic trend.

Discussion of the output results of RWM of Tertiary Output:

First Version:

$$Y_t = -1092.59 + 0.93Y_{t-1} + U_t, R^2 = 0.99, F = 14266.62, P = 4.1505E-15$$

$$t: \quad (-0.03) \quad (0.008)$$

Second Version:

$$Y_t = -30583.2 + 0.976389Y_{t-1} - 30019.4T + U_t, R^2 = 0.99, F = 7118.269, P = 4.0044E-15$$

$$t: \quad (-0.61) \quad (20.19) \quad (-0.99)$$

The equation shows that:

The coefficient of Drift is negative but it is not statistically significant at 0.05 probability. Therefore, it may be inferred that expected values do not significantly drift away from the observed values. But the positive coefficient of the lagged tertiary output is highly significant even at zero probability. It may thus be concluded on this evidence that the above equation is entrapped in unit root circle. So the time series of the tertiary output is not stationary.

The negative coefficient of drift in this case also is not significant. Like the coefficient of drift, the negative coefficient of time is not statistically significant. So, the random error of OLS estimate of this regression equation are free from stochastic trend. But the coefficient of lagged tertiary output is highly significant at zero probability. Therefore, this equation also shows the time series of the tertiary output being contained in unit root circle. This suggests that the regression equation containing tertiary output as either dependent or independent variable needs to be validated by Engel-Granger Test of co-integration.

Discussion of the results of RWM of Net GVA:

1. The OLS estimates of the first versions of RWM of net GVA are reported here as under-

$$Y_t = 90892.5 + 1.02Y_{t-1} + U_t, R^2 = 0.99, F = 2281.224, P = 0.34$$

$$t: (0.99) \quad (47.8)$$

The above equation shows that the positive coefficient of drift is not statistically significant. Hence, the expected observation are shown not to drift away significantly from the observed values. But the coefficient of the lagged net GDP is positive and highly significant at zero probability. So the time series of net GVA is shown to be contained in unit root circle and hence, this time series is also non- stationary.

2. The OLS estimate of second version of RWM of net GVA is given below:

$$Y_t = 456905.3 + 0.75Y_{t-1} + 110407.44T + U_t, R^2 = 0.99, F = 1337.79, P = 7.31E-12$$

$$t: (1.92) \quad (4.59) \quad (1.65)$$

The equation shows that

1. The positive coefficient of drift is significant at 0.08 probability. So the expected values of net GDP may drift away from the observed values significantly. This value of probability may be accepted because the sample size is only 12;
2. The positive coefficient of time is not statistically significant. Hence, the random error of this equation do not contain stochastic trend. But the coefficient of lagged GDP is highly significant at 0.0013 probability. It may, therefore, be concluded that the time series of net GVA is not stationary.

Results of Engel-Granger Test

The regression of current value of the random error on its lagged value is reported below:

Table: 1

U_t	=	-81200.04 + .49 U_{t-1} ; $R = 0.43$, $d = 1.14$	
t	=	(-1.14)	(1.36)

The above equation shows that:

1. d statistics of auto-correlation coefficient reveals that the test is inconclusive because the calculated value of d is greater than its lower value but less than upper value of the statistics at 0.05 probability for two variables and 9 degrees of freedom,
2. The coefficient of lagged errors is positive but the calculated value of Tau reveals that the coefficient is not statistically significant.
3. But the positive sign of the coefficient of the lagged error suggest that this equation lies in the unit root circle. Therefore, the results of regression equations, with which these errors are associated, are not acceptable.

The inconclusive result of d test implies that the data requires to be adjusted for autocorrelation coefficient.

It may also imply that the first order difference should be taken into account for existing data in order to take cognizance of non- stationary nature of the time series of both the variables.

Analysis of the results based on first order difference of tertiary output and net GVA :

The following is the estimate of the regression equation based on first order differences of both the variables:

$$\Delta O_{st} = 46957.828 + 1.1468128 \Delta NGVA_t, \quad R^2 = 0.329, \quad F 10.79, \quad P=0.003,$$

$$t: \quad (0.55), \quad (3.3)$$

The above equation reveals:

- (1) The equation fits the data well since the coefficient of correlation, 0.57 is statistically significant at practically zero probability;
- (2) The equation explains 33% of total variations in the first order differences of tertiary output;
- (3) The intercept is positive but it is not significant statistically. Therefore, the variables excluded from the regression do not influence the first order difference of the tertiary output;
- (4) The coefficient of first order differences of net GVA is highly significant at zero probability;
- (5) Corresponding to one unit increase in first order differences of net GDP, first order differences of the tertiary output increase by 1.14 units.

The OLS estimates of the residuals (Engel Granger Test) is reported below:

$$U_t = -5793.7298 - 0.202 U_{t-1}; \quad \text{Rho} = -0.47, \quad \text{Rho}^2 = 0.22$$

$$d = 2(1 - 0.47) = 2(0.53) = 1.06$$

The calculated value of Durbin Watson statistics, d is 1.06 which is not statistically significant. Besides, the value of Tau, 1.69 is also not statistically significant. Therefore, the equation of the first order differences of tertiary output on first order differences of net GVA is shown to be valid

by the Engel-Granger Test. The variables included in the regression of first order differences are acceptable and valid.

Findings and Conclusions:

The following are the main findings of study from which the following conclusions may be drawn:

- (1) The distribution of the tertiary output and the distribution of net GVA diverge from normal distribution significantly;
- (2) But the coefficient of Kurtosis and Skewness are not statistically significant, both in case of tertiary output and net GVA;
- (3) The time series of the tertiary output is found to be non-stationary by Dickey - Fuller Test;
- (4) The time series of the net GVA is found to be non-stationary by Dickey - Fuller Test
- (5) The regression of tertiary output is found to be satisfactory on all Counts. But Durbin Watson statistics reveals the auto-correlation test to be inconclusive;
- (6) The regression of the first order differences of tertiary output on first order differences of net GVA emerges satisfactory on all counts;
- (7) Auto-correlation coefficient of this equation is not significant statistically and the Engel Granger Test shows the equation to be acceptable;
- (8) The first order differences of the tertiary output is not significantly affected by any variable other than the first order differences of net GVA; and
- (9) Corresponding to one unit increase in the first order differences of net GVA , the first order differences of the tertiary output increase by 1.14 units.

The findings of this research suggest that similar research may be undertaken to find out the relation of other constituents of GVA with the corresponding to net GVA.

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End Notes

1. DBT Schemes | (DBT) Direct Benefit Transfer
2. <https://www.mygov.in/>
3. <https://www.digilocker.gov.in/>
4. <https://gem.gov.in/>
5. <https://www.data.gov.in/>
6. <https://nceg.gov.in/public/assets/pdf/Umang.pdf>
7. <https://fastagworld.in/index.php/About/fastag>
8. <https://meripehchaan.gov.in/welcome/faq>
9. <https://www.india.gov.in/spotlight/digi-yatra-new-digital-experience-air-travellers>
10. <https://ehospital.gov.in/ehospitalssso/>
11. <https://www.cowin.gov.in/>
12. <https://abdm.gov.in/>
13. <https://www.meity.gov.in/technical-specifications-under-pilot-project-digital-village>
14. <https://www.pmgdisha.in/>
15. <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1655698>
16. <https://www.ondc.org/>
17. <https://nkn.gov.in/en/>
18. <https://ncog.gov.in/about-us.html>
19. <https://futureskillsprime.in/>
20. Unicorn is a term used in the venture capital industry to describe a privately held startup company with a value of over \$1 billion. See <https://www.investindia.gov.in/indian-unicorn-landscape> for data and details.
21. <https://www.pmgdisha.in/>
22. <https://www.unescap.org/sites/default/files/good-governance.pdf#:~:text=Good%20governance%20has%208%20major%20characteristics.%20It%20is,and%20inclusive%20and%20follows%20the%20rule%20of%20law.>
23. <https://rm.coe.int/12-principles-brochure-final/1680741931>
24. <https://pib.gov.in/newsite/PrintRelease.aspx?relid=114273>
25. <https://csc.gov.in/>
26. The identified 9 national goals are (1) 21st-century IT infrastructure and software capabilities, (2) E-governance of the future, (3) Healthcare for all, (4) Quality education for all, (5) Energy for all, (6) Next-generation financial services, (7) Doubling farmers' income, (8) Make in digital India, make for India, make for the world and (9) Jobs and skills of the future.
27. Global MPI uses ten indicators covering three areas namely health, education and standard of living. Health dimension includes Nutrition and Child & Adolescent Mortality indicators, education dimension includes Years of Schooling and School Attendance indicators and standard of living dimension includes 6 household specific indicators namely, housing, household assets, type of Cooking Fuel, access to Sanitation, Drinking water and Electricity

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