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Unraveling Labour Productivity Growth and Economic Growth Nexus in India: A Toda-Yamamoto Dynamic Granger Causality Approach

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Abstract: In a thickly populated country like India where there are abundant skilled and unkilled labour forces, economic growth along the path of GDP growth can be augmented when the number of workers increases in production process providing opportunity for employment or when each worker produces more. Competitiveness, standard of living and also economic growth of a country are connected with labour productivity growth. That is why, labour productivity growth is construed as one of the essential instruments of economic growth in general and industrial progress in particular. In view of this, the article explores the direction of causal link between labour productivity growth and economic growth via GDP growth in India. By adopting the techniques of unit–root tests (ADF, PP and KPSS), and Toda and Yamamoto long–run dynamic Granger causality test, the causal connection between the above two variables has been investigated using annual data for the period 1990 to 2018. The findings suggests that there exist bidirectional causality between labor productivity and economic growth indicating that labour productivity is a vital cause of economic growth and economic growth via GDP growth enhances labour productivity in India. The study concludes with a note of optimism that the policy makers in India should be cautious enough in implementing its economic policies towards healthy sustainable economic development and strengthening labour productivity as well as employment generation.

Keywords: Labor Productivity, Economic Growth, Toda Yamamoto, Causality Analysis, India

1. Introduction

Economic performance of a country can be measured through labour productivity growth because competitiveness, standard of living and also economic growth are connected with labour productivity growth. It is construed as one of the essential instruments of economic growth in general and industrial progress in particular. Labour productivity characterizes aggregate quantity of output (calculated with respect to GDP) manufactured per unit of labour (measured with respect to the number of employed persons) during a given time period. In other words, it can be articulated as the amount of production obtained by taking into consideration the number of workers employed. It has been argued that "[improving] a country's ability to [raise]… its standard of living over time depends almost entirely on its ability to raise its output per worker" [18]. Countries can boost production either through additional labour effort or through boost in labour productivity. When growth of labour force is sluggish and unemployment remains at somewhat low levels, countries must increasingly look into productivity enhancement to uphold high rates of output and income growth [12]. From this particular perspective, it can be emphatically advocated that labor productivity plays vital role for the production potential. The major reason for this is that labor force is one of the most effective factors in economic development [6]. This has been extensively accepted that the boost in labour productivity considerably influences the process of production dropping the cost of production steadily. It turns essential due to its steady decrease in cost of production which is a vital determinant of competition in the worldwide marketplace.

In a densely populated country like India, economy can grow when the number of workers increases (i.e. opportunity for employment increases) or when each worker produces more. Labour productivity measures the second effect. Consequently, the economic growth of a country like India can be attributed either to increased employment or to more effective work by those who are employed. The driving force behind labour productivity which is a key indicator of economic performance is human capital. Since human capital is generated from gathered knowledge (education and experience), talent and expertise of an average employee in the economic process, labour productivity is frequently connected with high levels or particular types of human capital which invoke priorities for specific education and training policies. Employment policies incorporate some issues such as training programs, promotion of entrepreneurship and identification of areas. These are the main drivers of labor productivity. Additionally, the wages and premiums paid to the workers are also considered to have an important impact on labor productivity. The fact that workers have work safety at the place of work also contributes to labor productivity. In addition, the high level of communication between people in the workplace will increase their motivation and this will have a positive effect on labor productivity [19]. As workers' efficiency through skill enhancement plays a crucial role in augmenting labour productivity, workers unwillingness to work competently will lead to a reduction in the country's output adversely affecting the profitability, enhances reluctance to make new investments and to employ more workers on the part of the government thereby resulting decrease in the amount of investment in the country as well as increase in unemployment rate. Technological change due to institutional inventions and innovations, governments motivate the development of new products and services, which, in turn, increase the productivity. Economies of scale which reduce manufacturing costs is also an important indicator of labour productivity [31].

The study aspires to make out the contribution of labor productivity to the economic growth in India. The most significant reason of selecting India within the domain of our discussion is that it is one of the rapidly developing economies in Asia as well as in global perspective having potentially skilled abundant labour resources and it targets to be a developed economy. In this study, annual data between 1990 and 2018 period is tested with Toda Yamamoto causality analysis. The main hypothesis of this study is that labor productivity in India causes economic growth or vice versa in India. Therefore, causality analysis is preferred to determine whether the relationship between variables is well-built or not.

Consequently, the main impetus of this study is to be aware of the main contribution of labor productivity to the economic growth in India. In other words, labor productivity is thought to affect economic growth. However, it is desirable to test whether the effect is causal or not for India. Therefore, in case of the fact that this hypothesis is not true, for India's economic growth, different strategies will be recommended except for the provision of labor productivity. However, if the study proved that the hypothesis is correct, in order to ensure India's economic growth, labor productivity-oriented development strategies will be recommended. Thus, it is intended that this study will be guiding for the development of India's economy.

2. Review of Existing Literature

There are many studies which investigate the affiliation between economic growth and labor productivity. Jorgenson [15] observed that an increase in labor and capital contribution within the time frame of 1947 and 1985 was witnessed in United States. It had also been found that the increase in capital input and labour input are the first and second source of output growth respectively and productivity is not so important in enhancing output growth. Therefore, the country should concentrate on the mobilization of the output sources with respect to the capital and labor rather enhancing productivity. Baily, M. N., Bartelsman, E. J., & Haltiwanger, J. [4] observed that during recession, average labour productivity turns down and boosts up during boom. Nachega and Fontaine [20] assessed that in Nigeria, the decline in the output per person during 1963 -2003 is owing to the pessimistic adverse growth in the TFP as well as to the pessimistic growth per person in physical capital. Yıldırım, K., Koyuncu, C., & Koyuncu, J. [34] found out a statistically significant negative connection between hotness and growth in labor productivity using OLS technique on 111 countries. Rudolf and Zurlinden [22] noticed that capital and labor inputs collectively enhanced the economic growth on an average 1.28 percent per annum in Switzerland for the period, 1991-2005 which was less than the observations attained from earlier studies. Jajri and Ismail [13] observed that capital-labor ratio and capital stock had a crucial bearing upon labor productivity growth and economic growth of Malaysia's economy for the period, 1981 - 2007. Inspite of the effective labor having favourable effect upon economic growth, its contribution and involvement with economic growth is not as much of physical capital. Ahmed [2] investigated the consequence of total factor productivity, labour productivity and capital deepening in ASEAN5 (Philippines, Malaysia, Thailand Indonesia and Singapore) plus 3 (China, South Korea and Japan) and found that there was a negligible contribution of total factor productivity growth (TFPG) intensity to economic growth and found that capital intensity had a well-built considerable impact on labour productivity in countries under consideration. Su and Heshmati [25] observed that labor productivity is having significant effect upon economic growth applying Least Square Dummies Variables (LSDV) technique for China for the period, 2000-2009. Alani [1] put emphasis that the turn down in economic growth in Uganda for the period, 1972-2008 might have been because of the boost in productivity and, sequentially, unemployment and decline in capital stock could have been owing to the boost in productivity. Tabari and Reza [28] investigated the possible effects of the education and technology on labor productivity in agriculture sector of Iran for the period, 1961-2007 by using ARDL method. The results recommend that the education and technology in agriculture sector have favourable effects on labor productivity. Wu [36] adopted output and employment indicators for 33 industries in China for a period of 21 years and found that the Chinese economy achieved almost a fourfold growth in labour productivity averaging 6.6 percent per annum. Auzina-Emsina [3] investigated the association between productivity growth and economic growth of European Union countries in the pre-crisis and post-crisis period and observed a weak link between productivity growth and economic growth before the crisis and no relationship in the first stage of the post-crisis period. Szirmai and Verspagen [26] emphasized on the affiliation between these two variables on the basis of both developed and developing countries and they concluded that labor productivity optimistically affects economic development in both countries. Following the similar spirit, Haraguchi et al. [37] investigated low-income countries and found that labor productivity is assumed to favourably affect economic growth but there is no agreement on the degree of this impact. several researchers believe that this effect is only instrumental in the long-term relationship dimension [6], while others argue that it is at the level of causality [17].

Yao [35] observed that the impact of education on labor productivity in China is negative which affects human resources as well as human resource allocation across sectors. Wagner [33] investigated the impact on firms' productivity based on 7000 firms for the period 1989-2009 and found that new exporters achieve quick productivity gains after starting the venture compared to non-exporters. Tejaniand Milberg [29] suggested that the manufacturing industry concentrating on more capital is having a bias towards women in labor demand in developing countries. Similarly, Saraçoğlu et al. [24], who examined women's employment trends in the manufacturing sector in 30 countries between 1995 and 2011, observed that the share of women's employment in production has a tendency to decline as countries shifted from low-skilled, labor-intensive production to higher-tech production.

The brief review of literature depicts that there are a lot of studies on both the factors affecting labor productivity and the impact of labor productivity on economic growth in different countries and groups of countries. Most of the studies applied regression and co- integration to establish the relationship. Consequently, the literature and empirical evidence robustly advocates that labour productivity plays an important role in finding out economic growth across countries and is worth investigating further. The novelty of this research article involves determination of the strength of the impact of labor productivity on economic growth. In order to attain our objective, Toda Yamamoto causality analysis has been conducted under two variable framework- economic growth (GDP growth) and labour productivity growth (LPROD) to determine the relationship between these variables which will offer us an insight to judge how labor productivity is important in economic growth of India.

3. Methodology

In this section, causality analysis will be conducted for India in respect of GDP growth and labour productivity growth. In this context, the data set used in the analysis will be explained first. Subsequently, theoretical information about Toda Yamamoto causality analysis will be interpreted and finally, results of the analysis will be conducted.

3.1. Data Set, Scope and Variables

This study investigates the link between labor productivity growth (LPROD) and economic growth (GDP) in India. The data set covers 29 years from 1990 to 2018. The labour productivity is calculated as real output per unit of labor input. For GDP, the annual percentage growth rate was taken. Labour productivity is GDP per worker employed. Economic growth is measured by GDPgrowth. Two variables were taken from the World Bank electronic database and ILOSTAT, electronic database, 2019.

3.2. The Stationary Test (Unit Root Test)

Before empirical investigation on linkage between GDP growth and labour productivity growth by Toda Yamamoto method of Granger Causality, the paper determines the order of integration for each variable. There have been a multiplicity of unit root tests which can be used for deciding the order of integration [7, 21, 16] and each has been extensively used in the applied economics literature. The study applied Augmented Dickey-Fuller (ADF) Test, Phillips–Perron test (P-P) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test to identify the order of integration in each and every variable.

The reality that lies behind selecting these tests is that that ADF and PP generate approximately equivalent results for unit root and KPSS makes them cross checked by means of testing variables' stationarity. It must be remembered that the null hypothesis of KPSS opposes the null hypothesis of ADF and PP [5]. ADF and Phillips–Perron test (P-P) tests assume a null hypothesis of nonstationary data series against an alternative hypothesis of stationary data series. On the other hand, KPSS assumes stationery data series as null hypothesis and nonstationary data series in the alternative hypothesis. The basic reason for selecting this three methods is to ensure a cross check in estimating the order of integration in each variables.

In time series, particularly when we use OLS method, some econometric and statistical issues can influence the estimation of parameters. Regressing a time series variable on a further time series variable using the Ordinary Least Squares (OLS) estimation can attain a very high R^2, although there is no significant relationship between the variables. This circumstance reveals the problem of spurious regression between totally unrelated variables generated by a non-stationary process.

Consequently, before applying the T-Y Granger Causality test, econometric methodology is of the requirement to check up the stationarity. For each individual time series, most macro economic data are non stationary, i.e. they tend to exhibit a deterministic and/or stochastic trend. Therefore, it is recommended that a stationarity (unit root) test be carried out to test for the order of integration. To test the stationary of variables, we use the Augmented Dickey Fuller (ADF), commonly used to test for unit root. Following equation checks the stationarity of time series data used in the study:

$$\frac{n}{\Delta y_t} = \beta_1 + \beta_1 t + \alpha\, y_{t-1} + \gamma\, \Sigma \Delta y_{t-1} + \varepsilon_t$$

Where ε_t is white nose error term in the model of unit root test, with a null hypothesis that variable has unit root. If the ADF test-statistic (t-statistic) is less (in the absolute value) than the Mackinnon critical t-values, the null hypothesis of a unit root cannot be rejected for the time series and hence, one can conclude that the series is non-stationary at their levels. The unit root test tests for the existence of a unit root in two cases: with intercept only and with intercept and trend to take into the account the impact of the trend on the series.

The PP tests are non-parametric unit root tests that are modified so that serial correlation does not affect their asymptotic distribution. PP tests reveal that all variables are integrated of order one with and without linear trends, and with or without intercept terms. It is based upon the Dickey–Fuller test of the null hypothesis δ = 0 in $\Delta\ y_t = \delta y_{t-1} + \mu_t$, here Δ is the first difference operator. Like the ADF test, the Phillips–Perron test talks about the subject that the procedure generating data for y_t might have a higher order of autocorrelation than is admitted in the test equation - making y_{t-1} endogenous; Consequently, it invalidates the Dickey–Fuller t-test. Even as the ADF test deals with this issue by introducing lags of $\Delta\, y_t$ as regressors in the test equation, the Phillips–Perron test formulates a non-parametric correction to the t-test statistic. The test is robust in regard to unspecified autocorrelation and heteroscedasticity in the disturbance process of the test equation.

Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests are applied for testing a null hypothesis that an observable time series is stationary around a deterministic trend. The series is expressed as the sum of deterministic trend, random walk, and stationary error. KPSS tests are proposed to complement unit root tests, like Phillips–Perron test and the Dickey-Fuller tests. The KPPS [16] Test is based on the residuals (ε_t) from an ordinary least square regression of the variable of interest on the exogenous variable (s) as follows:

$$Y_t = X'_t\, \beta + \varepsilon_t$$

where Y_t is the variable of interest (real exchange rate) and X_t is a vector of exogenous variable (s). The Lagrange Multiplier (LM) statistic used in the test as follows:

$$LM = T^{-2} \sum_{i=1}^{T} S(t)^2 / f_0$$

where T is the sample size, S (t) is the partial sum of residuals which is computed as $S(t) = \sum_{i=1}^{t} S_r$. Here ε_t is the estimated residual. f_0 is an estimator of the residual spectrum at frequency zero. This statistic has to be compared with KPSS et al. (1992) critical values.

3.3. Toda Yamamoto Causality Analysis

Granger causality is one of the tests that can be utilized to establish a causal relationship among variables. Nevertheless, this experiment may dictate spurious results on functions with time lags on integrated variables [8]. Additionally, the standard granger causality tests suffer from inconvenience parameter dependency asymptotically [30, 32].

Granger Causality test consider only two variables to examine the causal relation between them. But it fails to judge the effects of further associated variables which are subject to possible specification bias. Causality is responsive to model specification and the number of lags [11]. It would reveal different results if any variable (s) was relevant and was not included in the model. Therefore, the empirical evidence of a two variable Granger-Causality is fragile because of this problem.

Time series data are often non-stationary. These circumstances could demonstrate the problem of spurious regression. In the context of stable VAR model, testing for granger non causality involves testing whether some parameters of the model are jointly zero. In the past, such testing has involved a standard F test in a regression context.

Toda and Phillips [30] have shown that when variables are integrated, the F-test procedure is not valid, as the test statistics don't have a standard distribution. Although researchers can still test the significance of individual coefficients with t-statistics, one may not able to use F-statistics to jointly test the Granger-Causality. Enders [10] established that in several special cases, using F-statistics to jointly test first differential VAR is permissible. First differential VAR also has its restrictions, which cannot be applied unanimously. To sum up, because of the plausible inadequacy of specification bias and spurious regression, this study does not carry out conventional Granger-Causality procedure to analyze the relationship between more than two variables.

Consequently, Toda and Yamamoto method is chosen over other causality test because of the following causes [27] (p. 478): "(a) the standard Granger (1969) causality test for inferring leads and lags among integrated variables is expected to provide spurious regression results and F-test becomes invalid unless the variables are cointegrated, (b) the error correction model [9] and the VAR error correction model [14] as alternatives for testing of non causality between time series are burdensome, (c) Toda and Phillips [30] asserted that the Granger causality tests in Error Correction Model (ECM) still have the chance of incorrect inference and may undergo nuisance parameter dependency asymptotically in some cases."Toda and Yamamoto [32] test does not necessitate acquaintance of the integration and cointegration properties of the system. Even, it can be used when there is no integration or stability, and when rank conditions are not satisfied 'so long as the order of integration of the process does not exceed the true lag length of the model' [32] (p. 225).

We have decided to use Toda- Yamamoto [32] procedure to examine the causal relation for our selected variables. The potency of Toda and Yamamoto's procedures in establishing causal relationship among variables lies in its ability to overcome numerous deficiencies of the standard Granger causality procedures. The Toda and Yamamoto test for granger non-causality is conducted from the modified Wald test [23], and, therefore, the Wald statistic is valid irrespective of variables' integration order, be it I (0), I (1) or I (2). Therefore, this technique has the advantage that it is applicable irrespective of the integration and cointegration properties of the system. For these reasons, the Toda and Yamamoto test for Granger non-causality test is applied to this study. Toda and Yamamoto [32] proposed a simple procedure requiring the estimation of an 'augmented' VAR, even when there is cointegration, which guarantees the asymptotic distribution of the MWald statistic. This method is applicable "whether the VAR's may be stationary (around a deterministic trend), integrated of an arbitrary order, or cointegrated of an arbitrary order" [32] (pp. 227). This procedure has two important advantages over the standard causality tests. First, it conducts Granger causality tests with allowance for the long-run information often ignored in systems that requires first differencing and pre-whitening. Therefore, the most vital advantage of this arrangement is that by differencing, the loss of long-run information which occurs in the series can be prevented. Secondly, this methodology is useful because it bypasses the need for potentially biased pre-tests for unit roots and cointegration, common to other formulations such as the vector error correction model (VECM).

Toda and Yamamoto [32] procedure involve a modified Wald (MWALD) test in an augmented VAR model, and do not require pretesting for cointegration properties of the system. The idea lying behind the Toda–Yamamoto (TY) test is to artificially augment the true lag length (say, p) of the VAR model by the maximal order of integration (dmax) that might occur in the process.

In order to analyze Granger causality (1961), Toda and Yamamoto [32] developed a model based on the estimation of augmented VAR model (k + dmax), where k denotes the optimal time lag and dmax the maximum integrated order of variables in the VAR model.

The process applies a modified Wald (MWald) test for restrictions on the parameters of a VAR (k), where k is the lag length in the model. The MWald statistic has an asymptotic χ^2 distribution when the augmented VAR (k+dmax) is estimated. Therefore, in the preliminary step of the Toda and Yamamoto causality test, the lag length of the variables (*k*) can be set according to the Akaike Information criterion (AIC) and then stationary tests are applied to identify the integration of variables (max *d*).

According to Toda and Yamamoto [32], for d = 1, any lag selection process is always effective, since $k \geq 1 = d$. However, if d = 2, the procedure is valid only if $k \neq 1$. Using the VAR model, the Toda–Yamamoto causality is expressed as follows:

$$y_t = \mu_0 + \left[\sum_{i=i}^{k} \alpha_{1t} y_{t-i} + \sum_{i=k+1}^{d_{\max}} \alpha_{2t} y_{t-i} \right] + \left[\sum_{i=i}^{k} \beta_{1t} x_{t-i} + \sum_{i=k+1}^{d_{\max}} \beta_{2t} x_{t-i} \right] + \varepsilon_{1t} \tag{1}$$

$$x_t = \theta_0 + \left[\sum_{i=i}^{k} \gamma_{1t} x_{t-i} + \sum_{i=k+1}^{d_{\max}} \gamma_{2t} x_{t-i} \right] + \left[\sum_{i=i}^{k} \partial_{1t} y_{t-i} + \sum_{i=k+1}^{d_{\max}} \partial_{2t} y_{t-i} \right] + \varepsilon_{2t} \tag{2}$$

Toda and Yamamoto [32] prove that the Wald statistic used in this setting converges in distribution to a χ^2 random variable, no matter whether the process is stationary or non-stationary. The preliminary unit root and cointegration tests are not necessary to implement the DL test, since the testing procedure is robust to the integration and co integration properties of the process.

Hence, Toda Yamamoto causality analysis is applied to find out the association between different variables. In the investigation process, the variables used do not require to be stationary at their level values. This is believed to be the most crucial advantage of Toda Yamamoto causality analysis. It is possible to talk about 2 diverse steps in the investigation process of this technique. First, the variables are subjected to testing of unit root and maximum degree of integration (d) is determined. On the other hand, in the second stage of the analysis, the ideal lag length (k) of the established VAR model is determined. As a result, the VAR model is re-established according to (k + d) level and the causality analysis is concluded.

4. Analysis of Results

Economic growth of India in the long-run has accelerated gradually over last three decades. It accelerated to 5.5 percent during entire 1990s and also during early 2000s. The buoyancy of growth trajectory of India, more particularly, growth rate falling below 7% between third quarter of 2016-17 and second quarter of 2017-18 was due to the dual impact of two main policy reforms like demonetization and the implementation of the Goods and Services Tax (GST) which is considered to be a crucial indirect tax reform.

During about last three decades of our study, 1990-2018, there have been three incidences of elevated growth which exceeded 8 percent, approximately once in each decade. Majority of such incidences lasted for one or two years, and corrected subsequently in the later years. The only long-lasting incidence of growth which upheld at above 8 %level for 5 uninterrupted years from 2004 to 2008was due to the combined outcome of some vital reforms undertaken in the 1990s and early 2000s. There may be other reasons for such stable growth rate which probably may be from an atypical resilience in the global economy and straightforward global liquidity, signifying high sustained growth over sectors as well as all components of GDP. During three decades of our study, 1990-2018, average labour productivity grew steadily over time. It accelerated from 3.59% in 1990-2000 to 5.1% in 2001-10 and 5.62% in 2011-18. During peak GDP growth period, 2004-2008, average labour productivity rises to 6.20%.

In the first stage of the analysis, stationary analysis is done for the variables. For this purpose, Augmented Dickey Fuller (ADF) unit root test is performed. Because of this analysis, it is defined that the variable of economic growth is stationary on its level value because its probability value is 0.00 which is lower than 0.05. On the other side, it is determined that the probability value of the variable of labor productivity is 0.7015. Because this value is greater than 0.05, it is concluded that this variable is not stationary on its level value. Due to this situation, the first difference of this variable is calculated, and unit root test is re-conducted. This new unit root test result is 0.00, so the first difference of labor productivity is taken into consideration in the analytical process. On the other side, the maximum degree of integration (d) is defined as "1".

Table 1&2 depict the results of the unit root test for the two variables for their levels and first differences using both augmented Dickey Fuller Test (ADF) and Phillips-Perron (P-P) Test (PP test). Results from table 1 and 2 revealed that the ADF and PP values [Absolute values] are greater than the critical t-value at 1% level of significance for the variable - GDP at its level, I (0). More precisely, at level, I (0), the ADF and PP values of variable-GDP is more negative than MacKinnon critical values at 1% level of significance. Based on these results, the null hypothesis that the series have unit roots at their levels is rejected, meaning that the GDP series are stationary at their levels. [they are integrated of the order zero i.e I (0)]. The AIC (Akaike Information criterion) and SBC (Schwartz Bayesian criterion) are shown in the tables to determine the number of lags that makes the error term a white noise, which is zero lag, as can be seen from table 1 and 2. Both AIC (Akaike Information criterion) and SBC (Schwartz Bayesian criterion) cannot be considered simultaneously to determine the optimum lag structure. Here, considering AIC as the determinants of optimum lag structure, we have found that the AIC (Akaike Information criterion- value 3.978 and 4.16 for ADF and PP test respectively) is minimum for variable-GDP at level, intercept & trend and lag-one (lag-1). Therefore, the result shows that first variables of our interest, namely Economic growth (GDP growth) attained stationary at level, I (0), using both ADF and PP test.

On the other hand, second variable-labour productivity growth (LPROD) attained stationary after first differencing, I (1), using both ADF and PP test. The results indicate that the null hypothesis of a unit root cannot be rejected for the given variable at level, I (0) as none of the ADF value and PP value is not smaller than the critical t-value at 1%, level of significance at level, I (0) for the variable-LPROD with optimum lag structure. ADF and PP values are smaller at first difference, intercept with minimum AIC (minimum Akaike Information criteria for LPROD is 4.056 and 4.075 for ADF and PP test at first difference respectively).

Table 1. *Unit Root Test: The Results of the Augmented Dickey Fuller (ADF) Test for Level &First differences with an Intercept and Linear Trend.*

ADF Test												
Economic growth and Labour productivity	**Levels**						**First Differences**					
	Intercept			**Intercept&Trend**			**Intercept**			**Intercept&Trend**		
	Lag 0	**Lag 1**	**Lag2**	**Lag0**	**Lag1**	**Lag2**	**Lag 0**	**Lag1**	**Lag2**	**Lag0**	**Lag1**	**Lag2**
GDP	-4.38	-4.36	-3.28	-4.98	-4.62	-3.72	-8.12	-5.70	-4.70	-8.05	-5.61	-4.65
AIC	4.234	3.999	4.116	4.169	3.978	4.078	4.509	4.438	4.477	4.560	4.507	4.543
SBC	4.329	4.142	4.309	4.312	4.170	4.32	4.605	4.583	4.673	4.704	4.701	4.786
LPROD	-3.87	-3.83	-2.74	-5.01	-4.64	-3.74	-8.11	-5.71	-4.71	-8.04	-5.62	-4.65
AIC	4.297	4.072	4.188	4.127	4.941	4.040	4.056	4.404	4.442	4.528	4.474	4.510
SBC	4.393	4.216	4.381	4.270	4.134	4.283	4.142	4.549	4.638	4.672	4.668	4.753
Critical Values												
1%	-3.6852			-4.3226			-3.6959			-4.3382		
5%	-2.9705			-3.5796			-2.9750			-3.5867		
10%	-2.6242			-3.2239			-2.6265			-3.2279		

Source: Author's own estimate

ADF tests specify the existence of a unit root to be the null hypothesis.

*MacKinnon critical values for rejection of hypothesis of a unit root.

AIC stands for Akaike info criterion.

SBC stands for Schwarz Bayesian criterion.

Ho: series has unit root; H_1: series is trend stationary

Table 2. *Unit Root Test: Phillips-Perron (PP) Test results for Level &First differences with an Intercept and Linear Trend.*

PP Test												
Economic growth and Labour productivity	**Levels**						**First Differences**					
	Intercept			**Intercept&Trend**			**Intercept**			**Intercept&Trend**		
	Lag0	**Lag1**	**Lag2**	**Lag0**	**Lag1**	**Lag2**	**Lag0**	**Lag1**	**Lag2**	**Lag 0**	**Lag1**	**Lag2**
GDP	-4.37	-4.36	-4.33	-4.98	-4.98	-4.96	-8.12	-8.25	-9.11	-8.05	-8.19	-9.13
AIC	4.234	4.231	4.232	4.169	4.16	4.169	4.509	4.509	4.408	4.560	4.560	4.560
SBC	4.332	4.321	4.325	4.311	4.31	4.312	4.605	4.604	4.60	4.704	4.704	4.704
LPROD	-3.87	-3.83	-3.80	-5.01	-5.02	-5.00	-8.11	-8.24	-9.12	-8.04	-8.18	-9.11
AIC	4.297	4.297	4.298	4.128	4.127	4.127	4.476	4.475	4.075	4.528	4.527	4.527
SBC	4.392	4.392	4.393	4.270	4.270	4.270	4.571	4.572	4.192	4.672	4.671	4.671
Critical Values												
1%	-3.6852			-4.3226			-3.6959			-4.3382		
5%	-2.9705			-3.5796			-2.9750			-3.5867		
10%	-2.6242			-3.2239			-2.6265			-3.2279		

Source: Author's own estimate

Ho: series has unit root; H_1: series is trend stationary

*MacKinnon critical values for rejection of hypothesis of a unit root.

PP tests specify the existence of a unit root to be the null hypothesis.

Table 3. *Unit root test through Kwiatkowski, Phillips, Schmidt and Shinn (KPSS) test.*

Variables	**KPSS level**		**KPSS First Difference**	
	Without Trend	**With trend**	**Without Trend**	**With trend**
	LM-Stat.	**LM Stat.**	**LM Stat.**	**LM Stat.**
GDP	0.391076	0.245089	0.500000	0.500000
Residual variance (no correction)	3.48800	2.957499	6.084168	6.083742
HAC corrected variance (Bartlett kernel)	4.02285	0.602505	0.229595	0.225014
LPROD	0.588175	0.195233	0.174231	0.174231

Source: Author's own estimate

In contrast, the null hypothesis under the KPSS test states that there exist a stationary series.

Ho: series is trend stationary; H_1: series is non stationary.

Note: 1) 1%, 5% and 10% critical values for KPSS are 0.739, 0.463 and 0.347 for *without trend.* 2) 1%, 5% and 10% critical values for KPSS *with trend* are 0.216, 0.146 and 0.1199. 3) *, **, *** denotes acceptance of the null hypothesis of trend stationarity at the 1%, 5%, and 10% significance levels, respectively. 4) The null hypothesis of stationarity is accepted if the value of the KPSS test statistics is less than it is critical value. 5) † the null of level stationary is tested.

In order to avoid the low power in the standard unit root tests as well as cross checking of ADF and PP test results, the newly developed KPSS test is applied to test the null of stationary real exchange against the alternative of non-stationary. The results of applying the KPSS test on variable-GDP show strong evidence of stationary at level since the null of stationary is accepted at the 1, 5 and 10 percent significance at level, I (0). An inspection of the figures reveals in table 3 that LPROD series is first difference stationary at 1%, 5% and 10% level using the KPSS test. However, the ADF and PP test result are cross checked through KPSS test. In a nutshell, ADF, PP and KPSS tests reveal that variable-GDP is integrated of order zero, I (0) with intercept terms and linear trends and variable-LPROD is integrated of order one, I (1).

Table 4. *Diagnostic test results.*

Test Statistics	**Parameters**	**Probability (p-Value)**	**Decision**
Heteroscedasticity (White Test)	Obs*R-squared (3.387166)	0.1839	Residuals are homoscedastic
Serial correlation (Breusch-Godfrey Serial Correlation LM Test)	Obs*R-squared (1.401611)	0.4962	Residuals are serially uncorrelated
Stability (Ramsey RESET Test)	Log likelihood ratio (0.389882)	0.5324	No functional misspecification in the series
Normality (Jarque Bera Test)	Jarque Bera Statistic (1.431359)	0.4889	Residuals are normally distributed

Source: Author's own estimate

When we adopt econometric modeling in studying a particular research theme, it is imperative to carry out a number of diagnostics for pinpointing the soundness and legitimacy of the model's results. This study initiates heteroscedasticity, serial autocorrelation, stability and normality tests. The results from these tests in Table 4 illustrate that probabilities for all these performed tests are more than 0.05 (5%), suggesting that the null hypotheses for normality, serial correlation and heteroscedasticity are rejected. Specifically, the model residuals are normally distributed, uncorrelated and homoscedastic. Additionally, using the Ramsey RESET test, results in Table 4 confirm the stability of the used model.

In the second stage of the analysis, VAR model is established. Based on this model, the ideal lag length (k) is defined. In this process, Akaike Information Criterion (AIC), Schwarz Criterion (SC), Hannan-Quinn Criterion (HQC) and Akaike's final prediction error criterion (FPE) are used. Table 5 gives information about the optimal lag length of the model.

Table 5. *Optimal Lag Length [VAR Lag Order Selection Criteria].*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1638.021	NA*	1.08e-55*	-120.8904*	-120.6025*	-120.8048*
1	1533.035	-171.0883	3.49e-52	-112.8174	-112.3374	-112.6747
2	1414.513	-175.5878	3.10e-48	-103.7417	-103.0698	-103.5419

Source: Author's own estimate
* indicates lag order selected by the criterion.
LR: Sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criteria
SC: Schwarz information criteria
HQ: Hannan – Quinn information criteria

The E-views software automatically selects the optimum number of lags. However, given that causal relationship in this study is determined using the Toda–Yamamoto for Granger causality, it is necessary to determine the lag selection using the VAR approach. In Table 5, the term "*" indicates lag order selected by the criterion. The results from the five information criteria are exhibited in Table 5, where four out of five criteria emphasize the use of "0" lag. Therefore, zero lag is employed to determine causal relationships among variables. Therefore, this situation explains that optimal lag length is "0" because most of these terms show this lag. Hence, the ideal lag length (k) can be calculated as '0'. As a result, the VAR model is re-established with 1 lags (k + d). In order to analyse Toda and Yamamoto Granger causality based on the estimation of augmented VAR model (k + dmax), here k denotes the optimal time lag which is "0"and dmax the maximum integrated order of variables in the VAR model which is 1, so (k + dmax) is (0+1)=1. Toda Yamamoto causality test results are given on Table 6.

Table 6. *Toda–Yamamoto causality test (Block Exogeneity Wald Tests).*

Dependent variable: Economic Growth (GDPG)				
Excluded	Chi-sq	df	Prob.	Direction of causality
Labor Productivity (LPROD)	23.00028	1	0.0000	LPROD → GDPG
All	23.00028	1	0.0000	
Dependent variable: Labor Productivity (LPROD)				
Excluded	Chi-sq	df	Prob.	Direction of causality
Economic Growth (GDPG)	22.93937	1	0.0000	GDPG → LPROD
All	22.93937	1	0.0000	
Final decision:	Bidirectional causality exists			LPROD ⇄ GDPG

Source: Authors' own estimate from tabulated data
→ denotes one - way causality, ⇄ denotes two -way causality.

The estimates of MWALD test shows that the test result follows the chi-square distribution with 1 degree of freedom in accordance with the appropriate lag length along with their associated probability. In this table, there are two different results. The first result is related to the causality analysis from labor productivity to the economic growth. On the other side, the second test indicates the causality analysis from economic growth to the labor productivity. In this test, the first part consists of the dependent variable which is economic growth whereas labor productivity is the explanatory variable. The second part consists of labour productivity as dependent variable and economic growth as explanatory variable. In Toda Yamamoto causality analysis, the probability value gives information about the results. If p value is lower than 0.05, we reject null hypothesis of no causality which means that there exists a causality between the variables. On the other hand, in case of the fact that this value is greater than 0.05, it is concluded that we accept null hypothesis of no causality between variables indicating that there does not exist any causal relationship. Table 6 states that the probability value of both the cases is 0.0000. Since this value is lower than 0.05, it can be concluded that there is a causal relationship between labour productivity growth and economic growth in both directions. Therefore, the result suggests that labor productivity is the major determinant of the economic growth in India and at the same footing, economic growth via GDP growth augments labour productivity in India. The indication of a two-way causality between labour productivity growth and economic growth, recommends that if Indian economy wants a sustainable economic growth, it should go on to increase its labour productivity growth.

5. Conclusion and Recommendation

This study tried to assess the impact of the labor productivity on economic growth in India and vice versa using for the period, 1990-2018 by Toda Yamamoto causality analysis. The hypothesis of the present study is that the labor productivity is considered as the crucial determinant of the economic growth in India. The findings suggests that there exist bidirectional causality between labor productivity and economic growth indicating that labour productivity is a vital cause of economic growth and economic growth via GDP growth enhances labour productivity in India.

Labor productivity is a notion that has gained popularity in the literature especially in present contemporary times. Since labor productivity is one of the vital causes of economic growth, the quality of education which is to be offered to the citizens living in the country comes to the forefront. Through training among potential human resources, it is likely for them to be indulged more prolifically in the workforce of India. Another vital issue in this process is the inevitability of preparing the details of the training to be provided according to the business need of the country. Otherwise, a large number of trainings will be provided to the persons, who will not be dynamically involved in the labor force of the country as these trainings do not meet the needs of the market.

Occupational safety is another issue that plays a vital role in this process. Employees want to feel protected in their work place. Otherwise, employees will experience discomfort unfavorably affecting labor productivity. Furthermore, the quality of communication in the workplace is another factor affecting employee motivation which will also be likely for highly skilled personnel to be productively involved in the workforce.

Labour market of India is portrayed by an issue where protections of workers' rights are deficient, inadequately-developed active labour market policies prevail and critically-low participation of women employees is found. Labour regulations of India are supposed to be inflexible, with multiplicity of laws at the national level as well as various state levels. This type of rigid existing labour laws persuade a low scale of manufacturing, because of the reason that there exists several laws that are adopted only when businesses have a certain number of workers, thereby dragging productivity down. It is suggested that India's intricate labour laws need urgent generalization.

The study concludes with a note of optimism that the policy makers in India should be cautious enough in implementing its economic policies towards healthy sustainable economic development and strengthening labour productivity as well as employment generation.

The most fundamental limitation of this study is that the research is limited to a single country like India. Therefore, in the new studies to be undertaken in forthcoming period, potential researchers may consider different countries or groups of countries to present a comparative study that will contribute to more realistic results.

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