DETERMINATION OF WHETHER UGANDA'TECHNOLOGICAL PROGRESS IS LABOR OR CAPITAL INTENSIVE

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Abstract

The paper determined whether technological progress was labor deepening in Uganda within the 1971–2009 period. Theoretical models were developed and transformed into econometric models before conducting statistical tests. Worldwide appropriate data on capital stock do not exist. As a result aggregate capital stock is usually estimated by proxy. To avoid estimation of capital stock by proxy, the capital stock series were estimated from annual disposable income, annual real GDP and annual investment expenditures based on the Cobb-Douglas production function. Labor force series may not give a true estimate of labor stock because in an economy labor exists both in the formal and informal sectors.

Yet, in economics labor stock is measured in terms of man-hours. Uganda's technological progress as found to be labor deepening because tests revealed that the rise in marginal product of labor was higher than that of marginal product of capital. By decomposing technology into output, capital productivity and labor productivity, Uganda's technical progress was confirmed to be labor deepening because labor productivity had a greater contribution to technological progress than capital productivity.

Also, the study found out that within the feasible region of production capital productivity as well as labor productivity had a negative influence on economic growth because (a) laborers could have worked less than required and enjoy more leisure and (b) firms could have used less capital to make profits, respectively than the required. Labor productivity growth could have influenced economic growth through the growth in labor. Capital productivity growth could have affected economic growth through growth in capital stock. Labor productivity growth could have been caused by growth in capital-labor ratio. Growth in capital productivity could have been caused by growth in labor-capital ratio. Therefore, technological progress through appropriate management of productivity and input ratios are important for rapid economic growth.

1. Introduction

The study aimed at examining the effects of technological progress and productivity on economic growth in Uganda from 1971 to 2009. The study analyzed the consequences of technological progress and productivity on output, and found that Uganda's technical progress was labor deepening. Uganda's technological progress was labor deepening because the marginal product of labor could raise output more than the marginal product of capital. The research work made used of the Neoclassical production function to build relevant models to be tested statistically or econometrically.

In the study level of technology (i.e. total factor productivity) was decomposed into output growth, capital productivity and labor productivity. Regression results revealed that output growth had the greatest contribution to technological progress, followed by labor productivity and then by capital productivity.

Furthermore, the research found out that increase in labor–capital ratio could have given rise to capital productivity growth. In turn the capital productivity growth could have led to decline in output growth. Similarly, it could have been the capital–labor ratio that gave rise to labor productivity growth. In turn the labor productivity growth could have caused the reduction in output growth in the country within the given period.

Lastly, increase in either capital–labor ratio or labor–capital ratio could have lead to technological progress and consequently output growth. Otherwise, growth in capital–labor ratio causes reduction in the amount of labor used in the production process and as a result the labor augumenting (i.e. embodied technology in labor) brings about technical progress.

Similarly, increase in labor–caital ratio causes reduction in the amount of capital used in the production process and as a result the capital augumenting (i.e. embodied technology in capital) brings about technical progress.

2. Objective

Chapter 6 aims at finding out whether from 1970 to 2009, Uganda's technological progress was labor deepening or not.

3. Literatrue review

The review of literature is composed of threoretical review of theoretical literature as well as review of empirical literature.

3.1. Reveiw of theoretical literature

Technological progress is capital-deepening (or capital using) if the marginal rate of substitution of capital for labor $(MRS_{K,L} = -MP_K / MP_L)$ increases in absolute terms as one moves down along a line that has constant capital–labor ratio (K/L). Implying that for a capital deepening technical progress, technological progress increases the marginal product of capital (MP_K) by more than the marginal product of labor (MP_L). Similarly, a technological progress is labor–deepening (or labor–using) if the marginal rate of substitution of labor for capital $(MRS_{L,K} = -MP_L / MP_K)$ increases in absolute terms as one moves down along a line that has constant capital–labor ratio (K/L). Implying that for a labor deepening technical progress, technological progress increases the marginal product of labor (MP_L) by more than the marginal product of labor (MP_K) (Kutsoyainnis, 1979, p.87). A less developed country may develop its technology in three stages, namely: acquisition and implementation, assimilation and improvement. From the early stages to the later stages of development, a country needs to change from labor intensive to capital intensive technology (Kim, 1990, pp.10-12).

Technology can determine the production function of the economy as a whole. The production function consists of all the technically efficient methods of production. The method of production is a combination of factor inputs needed for production of one unit of output. Therefore, the method of production or technology can be represented by the input ratios (Koutsoyainnis, 1979, p.71). The marginal rate of substitution MRS can be written only in terms of the input ratios. For example, MRS of labor for capital can be written in terms of K/L ratio only (Schooter, 2009, p.181). Consequently, it is this MRS that influences level of technology through the marginal product as well as average product of either labor or capital (i.e, capital or labor productivity), and eventually it influences output through the level of technology.

3.2. Reveiw of empirical literature

Dowrick and Nguyen (1989) contend that an empirical measure of of technology is total factor productivity (TFP). We take the measure of technology specified by Dowrick and Nguyen (1989), to be one way through which the contributions of output, capital productivity and labor productivity towards technonogy can be provided. For example, labor productivity has a positive contribution towards technology. Martinez–Garcia (2013) argues that labor productivity grows either through capital accumulation accumulation as capital-labor ratio increases in the economy, a process known as capital deepening or through technological progress. Acemoglu and Guerrieri (2005), believe that capital deepening tends to increase the relative output of the sector with greater capital share. Technological progress or labor productivity refers to the efficient use of inputs (i.e. capital and labor) in the production process (Martinez–Garcia, 2013).

However, it should be noted that capital accumulation (or growth in capital stock) has a direct negative influence on labor as well as capital productivity since productivity is defined as output per unit input.

This argument is in line with the law of diminishing returns to capital as noticed by Ricardo (1772–1823) that adding successive units of capital while keeping the number of workers unchanged results in persistent decline in labor productivity. That is because adding more and more capital to the production process while using the same amount of labor increases output less and less i.e. results in reduction in labor productivity (Martinez–Garcia, 2013). Also, from the Neoclassical production function it can be discerned that where the elasticity of production lies between 1 and 0, as the output is increasing both the average product and marginal product (i.e. labor productivity) must be falling (Debertin, 2012, p.35). As a result, we agree with Martinez–Garcia (2013), according to Solow-Swan model, that only technological progress and not capital deepening, can sustain labor productivity growth over time.

Crafts notes that the traditional Neoclassical methodology captures contribution to growth from exogenous technological change in the Solow residual estimate of total factor productivity (TFP) growth. The Solow residual estimate of total factor productivity (i.e. technology) is composed of growth in output, capital and labor. In our analysis technology shall be decomposed into output, capital productivity and labor productivity.

Technological progress has long been identified as one of the important sources of economic growth in Western economies (Solow, 1956, 1957; Abromovitz, 1956; Denison, 1962; Kim and Lawrence, 1994). Denison (1967) found that technological progress alone accounted for almost 60 to 90 percent of the growth in income per capita in Western countries. To them the factor inputs (capital, labor and land) could explain relatively a small percentage of overall economic growth. Denison (1967), concluded that the economies of the Western countries were affected more by TFP growth than growth in capital or labor.

Also Kim and Lawrence (1994), found that almost 45 to 70 percent of economic growth of the Organization for Economic Cooperation and Development (OECD) countries was contributed by technological progress (i.e. productivity growth).

On the contrary, it was found that in the Newly Industrialized East Asia countries, economic growth was being driven mainly by input growth through immense factor accumulation rather than being driven by technological progress. Japan was found to be the only county in East Asia having economic growth driven by technological progress (Young, 1992, 1995; Krugman, 1994; Kim and Lawrence, 1994; Ahmed, 2011).

Otherwise, we agree with other independent studies that technological progress had important contribution to the rapid and sustained economic growth in East Economies (World Bank, 1993; Sarel (1996), Thomas and Wang (1996), Klenew and Rodriguez-Clare (1997), Hsieh, 2002).

According to Craft (2008), many studies have pointed out that labor productivity growth comes from technological progress (Fabricant, 1954; Abramolitz, 1956; Kendrick, 1961). In a similar manner our study attempts to determine the contribution of technological progress as well as input ratios on capital productivity as well as labor productivity in the case of Uganda.

In empirical analyses of economic growth decomposition of technological progress into its major components can allow us find empirical evidence on some of the main sources of economic growth (Salami and Soltanzadeh, 2012).

The study in a similar way decomposes technological progress into capital productivity and labor productivity. It also goes ahead to decompose technological progress into input ratios and estimating the contributions of the input ratios towards technological progress in the case of Uganda. More importantly, we shall test the proposition that only technological progress and not capital deepening, can sustain labor productivity growth over time.

4. Theoretical Framework

In the threoretical framework linear relationships are developed that make it possible for conducting econometric (or statistical) tests to assist in testing whether within the study period Uganda's technological progess was labor or capital deepening.

4.1. Distinguishing between capital deepening and labor deepening technological progress from the rise in the marginal product of inputs

A capital deepening technical progress occurs when the marginal product of capital MP_K rises faster than the marginal product of labor MP_L. Whereas, a labor deepening technical progress occurs when the marginal product of labor MP_L rises faster than the marginal product of capital MP_K.

To estimate the marginal product of technology $MP_A = \frac{\partial Y}{\partial A}$, marginal product of capital $MP_K = \frac{\partial Y}{\partial K}$ and marginal product of labor $MP_L = \frac{\partial Y}{\partial L}$ we maximize output by choosing the level of technology, capital and labor as follows:

$$\underset{A,K,L}{Max} Y(A,K,L) \quad (1)$$

Taking the first total derivative of this function gives

$$dY = \frac{\partial Y}{\partial A} dA + \frac{\partial Y}{\partial K} dK + \frac{\partial Y}{\partial L} dL, \quad (2)$$

or $dY = MP_A dA + MP_K dK + MP_L dL.$ (3)

These marginal products could also be estimated from the expression

$$\frac{dY}{dA} = MP_A + MP_K \frac{dK}{dA} + MP_L \frac{dL}{dA} \quad (4)$$

4.2. Expressing the effects of marginal rate of substitution of an input on its marginal product of the given input

Given the linear homogeneous production function

$$Y = Y(K, L) \text{ .... (5)}$$

we maximize output as follows:

$$\underset{K,L}{Max}\, Y(K, L). \text{ .... (6)}$$

The first condition for output maximization requires that

$$\frac{\partial Y}{\partial K} dK + \frac{\partial Y}{\partial L} dL = 0. \text{ .... (7)}$$

Or $-\frac{dK}{dL} = \frac{\partial Y / \partial L}{\partial Y / \partial K} = \frac{MP_L}{MP_K} = MRS_{L,K}$. .... (8)

Otherwise $-\frac{dL}{dK} = \frac{\partial Y / \partial K}{\partial Y / \partial L} = \frac{MP_K}{MP_L} = MRS_{K,L}$. .... (9)

From these two functions we find that

$$MP_L = \frac{\partial Y}{\partial L} = MRS_{L,K} \left(\frac{\partial Y}{\partial K} \right). \text{ .... (10)}$$

Likewise, $MP_K = \frac{\partial Y}{\partial K} = MRS_{K,L} \left(\frac{\partial Y}{\partial L} \right)$. .... (11)

Therefore, the marginal rate of substitution MRS of a given input has positive influence on the marginal product MP of that input. In particular the marginal product of capital MP_K is a function of the marginal rate of substitution of capital for labor $MRS_{K,L}$ and is given by: $MP_K = f\left(MRS_{K,L}\right)$. .... 12)

Similarly the marginal product of labor is a function of marginal rate of substitution of labor for capital $MP_L = f\left(MRS_{L,K}\right)$. .... (13)

4.3. The capital productivity and labor productivity functions can be expressed as functions of capital-labor ratio alone

Given the linear homogeneous production function $Y = f(K, L)$ labor productivity (Lp) and capital productivity (Kp) can be expressed as a function of the capita-labor ratio $(k = K/L)$ alone. To prove this we multiply both sides of the function $Y = f(K, L)$ by a factor $t = 1/L$.

Thus $Lp = \frac{Y}{L} = f\left(\frac{K}{L}, \frac{L}{L}\right) = f\left(\frac{K}{L}, 1\right) = (k, 1)$.. (14)

The labor productivity therefore becomes a function of the capital-labor ratio k alone i.e.

$Lp = \frac{Y}{L} = \rho(k)$ .... (15)

The expression for (Kp) is given by

$Kp = \frac{Y}{K} = \frac{Y}{L}\frac{L}{K} = \frac{\rho(k)}{k}$ .... (16)

Similarly, the expression for (Lp) is given by

$Lp = \frac{Y}{L} = \frac{Y}{K}\frac{K}{L} = \frac{\rho(l)}{l}$ .... (17)

In other words growth in labor productivity can be expressed as growth in capital-labor ratio alone as follows: $\frac{dLp}{Lp} = \frac{d(K/L)}{K/L}$ .... (18)

Or $\frac{dKp}{Kp} = \frac{dLp}{Lp} + \frac{d(K/L)}{K/L}$ .... (19)

Likewise, capital productivity can be expressed as growth in labor-capital ratio alone as follows: $\frac{dKp}{Kp} = \frac{d(L/K)}{L/K}$ .... (20)

Or $\frac{dLp}{Lp} = \frac{dKp}{Kp} + \frac{d(L/K)}{L/K}$ .... (21)

4.4. The transmission mechanism of inputs ratios effects on to output growth

The growth in input ratios, seem to affect growth in capital in two ways:

$$\frac{dK}{K} = \alpha_1 \frac{d(K/L)}{K/L} \quad \text{...} \quad (22)$$

or $\frac{dK}{K} = \alpha_2 \frac{d(K/L)}{K/L}$, ... (23)

where α_1 is positive and α_2 is negative.

Similarly, growth in the input ratios could have two possible effects on growth in labor productivity:

$$\frac{dL}{L} = \beta_1 \frac{d(L/K)}{L/K} \quad \text{...} \quad (24)$$

or $\frac{dK}{K} = \beta_2 \frac{d(K/L)}{K/L}$, ... (25)

where β_1 is positive and β_2 is negative.

Although growth in these input ratios have the above influence on the respective input growth they seem to potentially affect the input growth through growth in productivity.

Therefore, growth in input ratios, seem to affect growth in capital productivity in two ways:

$$\frac{dKp}{Kp} = \alpha_1 \frac{d(K/L)}{K/L} \quad \text{...} \quad (26)$$

or $\frac{dKp}{Kp} = \alpha_2 \frac{d(K/L)}{K/L}$, ... (27)

where α_1 is negative and α_2 is positive.

Whereas, growth in the input ratios may have two possible effects on growth in labor productivity:

$$\frac{dLp}{Lp}=\beta_1\frac{d(L/K)}{L/K} \quad \text{(28)}$$

or $\frac{dL}{L}=\beta_2\frac{d(K/L)}{K/L}$, ………………………………………………… (29)

where β_1 is negative and β_2 is positive.

These eight possible effects can be set for tests by systematically substituting respective input ratios into the following equations:

$$\frac{dY}{Y}=\lambda\frac{dA}{A}+\alpha\frac{dK}{K}+\beta\frac{dL}{L} \text{ or } \frac{dY}{Y}=\frac{1}{1-\alpha-\beta}\left(\lambda\frac{dA}{A}-\alpha\frac{dKp}{Kp}-\beta\frac{dLp}{Lp}\right) \quad \text{(30)}$$

However, the influence of growth in input ratios on economic growth via input growth, may be expressed better by defining respective input values as:

$$K=\frac{K}{L}L,\; K=L\left(\frac{L}{K}\right)^{-1},\; L=\frac{L}{K}K \text{ or } L=K\left(\frac{K}{L}\right)^{-1} \quad \text{(31)}$$

The respective movements in inputs can be expressed in terms of growth rates as follows:

$$\frac{dK}{K}=\frac{dL}{L}+\frac{d(K/L)}{K/L},\; \frac{dK}{K}=\frac{dL}{L}-\frac{d(L/K)}{L/K},\; \frac{dL}{L}=\frac{dK}{K}+\frac{d(L/K)}{L/K}$$

or $\frac{dL}{L}=\frac{dK}{K}-\frac{d(K/L)}{K/L}$ ………………………………………………… (6.32)

By substituting each of the four expressions in the equation

$$\frac{dY}{Y}=\lambda\frac{dA}{A}+\alpha\frac{dK}{K}+\beta\frac{dL}{L} \quad \text{(33)}$$

we can then express the respective growth in the input ratios on economic growth as follows: $\frac{dY}{Y}=\lambda\frac{dA}{A}+(\alpha+\beta)\frac{dL}{L}+\alpha\frac{d(K/L)}{K/L}$, $\frac{dY}{Y}=\lambda\frac{dA}{A}+(\alpha+\beta)\frac{dL}{L}+\alpha\frac{d(L/K)}{L/K}$,

$$\frac{dY}{Y}=\lambda\frac{dA}{A}+(\alpha+\beta)\frac{dK}{K}+\beta\frac{d(L/K)}{L/K}\text{, or }\frac{dY}{Y}=\lambda\frac{dA}{A}+(\alpha+\beta)\frac{dK}{K}-\beta\frac{dL}{L}\text{.} \quad (34)$$

Similarly, the influence of growth in input ratios on economic growth via productivity growth may could be expressed better by defining respective productivity values as:

$$\frac{Y}{K}=\left(\frac{Y}{L}\right)\left(\frac{L}{K}\right),\ \frac{Y}{K}=\left(\frac{Y}{L}\right)\left(\frac{K}{L}\right)^{-1},\ \frac{Y}{L}=\left(\frac{Y}{K}\right)\left(\frac{K}{L}\right)$$

$$\text{or }\frac{Y}{L}=\left(\frac{Y}{K}\right)\left(\frac{L}{K}\right)^{-1} \quad (35)$$

The respective movements in inputs can be expressed in terms of growth rates as follows: $\frac{dKp}{Kp}=\frac{dLp}{Lp}+\frac{d(L/K)}{K/K}$, $\frac{dKp}{Kp}=\frac{dLp}{Lp}-\frac{d(K/L)}{K/L}$,

$$\frac{dLp}{Lp}=\frac{dKp}{Kp}+\frac{d(K/L)}{K/L}\text{ or }\frac{dLp}{Lp}=\frac{dKp}{Kp}-\frac{d(L/K)}{L/K} \quad (36)$$

By substituting each of the four expressions in the equation

$$\frac{dY}{Y}=\frac{1}{1-\alpha-\beta}\left(\lambda\frac{dA}{A}-\alpha\frac{dLp}{Lp}-\beta\frac{d(Lp)}{Lp}\right) \quad (37)$$

we can then express the respective growth in the input ratios on economic growth as follows:

$$\frac{dY}{Y}=\frac{1}{1-\alpha-\beta}\left(\lambda\frac{dA}{A}-(\alpha+\beta)\frac{dLp}{Lp}+\alpha\frac{d(K/L)}{K/L}\right), \quad (38)$$

$$\frac{dY}{Y}=\frac{1}{1-\alpha-\beta}\left(\lambda\frac{dA}{A}-(\alpha+\beta)\frac{dLp}{Lp}-\alpha\frac{d(L/K)}{L/K}\right), \quad (39)$$

$$\frac{dY}{Y}=\frac{1}{1-\alpha-\beta}\left(\lambda\frac{dA}{A}-(\alpha+\beta)\frac{dKp}{Kp}+\beta\frac{d(L/K)}{L/K}\right), \quad (40)$$

$$\frac{dY}{Y}=\frac{1}{1-\alpha-\beta}\left(\lambda\frac{dA}{A}-(\alpha+\beta)\frac{dKp}{Kp}-\alpha\frac{d(K/L)}{K/L}\right). \quad (41)$$

4.5 Influence of input ratios on technology via productuvity

To make it possible for trassing the transmission mechanism of input ratios on technology through productivity requries the decomposition of level of technology into the ouput and productivity levels. To do this we begin from the Neoclassical production function of the form:

$$Y = AK^{\alpha}L^{\beta} \text{ .... } (42)$$

Thus from the Neoclassical production function the the level of technology is discomposed in to output level, capital productivity and labor productivity as follows:

$$\log(A) = (1-\alpha-\beta)\log(Y) + \alpha\log(Kp) + \log(Lp) \text{ .... } (43)$$

As a result it can be demonstrated that the capital–labor productivity ratio contribute to level of technology as given by

$$\log(A) = (1-\alpha-\beta)\log(Y) + \alpha\log(Kp) + \rho\beta\log(K/L) \text{ .... } (44)$$

Implying that

$$\log(A) = (1-\alpha-\beta)\log(Y) + \alpha\log(Kp) - \rho\beta\log(L/K) \text{ .... } (45)$$

Thus, by considering the input ratios would imply that the economy is being looked at as if it was following the Cobb–Douglas production function with constant returns to scale.

Hence, by comparing Equations 6.43 and 6.44, indicates that $Lp = \rho(K/L)$ as expressed by Equation 6.15.

Similarly, substituting $\rho(L/K)$ by Kp in Equation 6.43 provides

$$\log(A) = (1-\alpha-\beta)\log(Y) + \alpha\log(L/K) + \log(Lp) \text{ .... } (46)$$

Indicating that

$$\log(A) = (1-\alpha-\beta)\log(Y) - \alpha\log(K/L) + \log(Lp) \text{ .... } (48)$$

More importantly it should be noted that the input ratios contribute towards technology via productivity. As a result there must be a direct effect of variations of input ratios on variations on productivity of either capital or labor.

Such arelationships are given by Equations 6.48 to 6.51 below.

$$\log(Kp) = \log(A) + \alpha \log(L/K) - (1-\alpha-\beta)\log(L) \quad (48)$$

$$\log(Kp) = \log(A) + \beta \log(L/K) - (1-\alpha-\beta)\log(K) \quad (49)$$

$$\log(Lp) = \log(A) + \beta \log(K/L) - (1-\alpha-\beta)\log(L) \quad (50)$$

$$\log(Lp) = \log(A) + \alpha \log(L/K) - (1-\alpha-\beta)\log(K) \quad (51)$$

The parameters given above were tested empirically using statistical and econometric method according to the methodology given below.

5. Methodology

The relevant econometric models were useful in (i) obtaining the coefficient of returns to scale on capital (ii) coefficient of return to scale on labor, and (iii) estimating technology, capital stock and labor stock series. Time was measured in years running from 1970 to 2009. We assumed that the aggregate output produced by the households each year depended on the amount of capital stock employed within a year.

In conducting tests of hypotheses we aimed at getting regression models that were free from serial correlation and heteroscedasticity. Also in the analyses most of the coefficients of determination R^2 and Adjusted R^2 were relatevly. The high R^2 was an indication that the sample regression line could explain almost all variations in the dependent variable in every case. All the regressions were tested for serial correlation against the critical Durbin Watson (D.W.) statistic. The regression results indicated that all the normal regressions obtained were free from serial correlation.

The t test conducted showed that all the coefficients of interest were significantly different from zero. Implying, keeping other variables constant, a particular independent variable bearing a given parameter, could have been the underlying cause of the dependent variable. While the test indicated that the all the independent variables present in a given normal model might have jointly been the cause of a given dependent variable.

The econometric models were estimated according to the equations the corresponding to the theoretical equations to produce the relevant regression equations.

Using data from Uganda from 1971 to 2008 consisting of 36 to 40 observations after adjusting endpoints we obtained the regression models relevant regression equations. In all the regression results the $F - Statistic = 0.000000$ and $p - value = 0.0000$. The $p - value$ is the probability of obtaining a value of and t test statistic as much as or grater than the computed t value. In other words the $p - value$ is the lowest significance at which the null hypothesis can be rejected. Therefore with a $p - value = 0.0000$ the null hypothesis can be rejected and the alternative hypothesis accepted with absolute confidence.

Also for 32 to 36 degrees of freedom at 0.001 level of significance the tabulated t values were less in absolute terms than all the computed t values obtained. Hence, under the null hypothesis that a given coefficient value was zero we, reject the null hypothesis. All the computed F values were greater than the respective tabulated critical F values and they followed F distribution with the corresponding degrees of freedom in the numerator and denominator respectively. (Note that there are 36 to 40 observations and one, two or three explanatory variables depending on the regression equation of interest). From the table we found that in all five regression cases the F was significant at 1 percent level of significance.

Therefore, form all the regressions results we rejected the null hypotheses that in each case the three independent variables jointly had no effect on the dependent variable. Also, in each of the five regression results, the $p - statistic$ of the respective F value was as much as or greater than the one from a given result was almost zero i.e. 0.000000 leading to the rejection of the hypothesis that together the three variables had no effect on the independent variable.

In each of the five regression results given, the coefficient of multiple determination, R^2 and adjusted R^2 (i.e. $\overline{R}^2$) is a measure of the proportion of variations in the independent variable explained by the regression line, showed that the independent variables together could explain over 93 percent of the variations in the dependent variable.

In all the regression results with 37 degrees of freedom the computed Durbin-Watson statistic $D.W.$ was greater than the table $D.W. = d_U = 1.66$ at 5 percent level of significance, confirming that there was no serial correlation (i.e. autocorrelation) problem. Other regressions with different degrees of freedom we tested in a similar manner for serial correlation.

Koenker – Bassett (KB) test for Heteroscedasticity was used to test whether the models used in making conclusions were homoscedastic (i.e. having constant variance). The KB test for heteroscedasticity is based on squared residuals $\hat{u}_t^2$. In the KB test the squared residuals are regressed on the squared estimated values of the regressand.

In the KB test the original model is usually specified as

$$Y_t = \beta_1 + \beta_2 X_{2t} + \beta_3 X_{3t} + ... + \beta_k X_{kt} + \hat{u}_t.$$

After estimating the model $\hat{u}_t$ is got and the estimate becomes

$$\hat{u}_t^2 = \alpha_0 + \alpha_1 (\hat{Y})^2 + v_t.$$

Where $\hat{Y}_t$ are estimated values of Y_t in form of the original model.

The null hypothesis is that $\alpha_2 = 0$. When the null hypothesis is accepted we conclude that there is no heteroscedasticity. Otherwise, when the null hypothesis is rejected we conclude that there is presence of heteroscedaticity in a model. The null hypothesis is tested by employing the usual t test or F test. If the model is double log then the residuals are regressed on $(\log \hat{Y})^2$.

One advantage of the KB test is that it is applicable even if the error term in the original model is not normally distributed (Gujarati 2003, p. 415). Finally the advantage of differencing, taking logarithms or using growth rates caused all the models used in making the empirical analyses to become homoscedastic.

6. Results on determining whether Uganda's technical progress has been labor deepening

Marginal product MP of an input depends on its marginal rate of substitution MRS and marginal product MP determines whether a technical progress is capital deepening or labor deepening.

As given in Table 1 the influence of marginal rate of substitution of capital for labor $MRS_{K,L}$ on the marginal product of labor MP_K is greater than the influence of marginal rate of substitution of labor for capital $MRS_{L,K}$ on the marginal product of capital MP_L. The explanation for this could be that production in Uganda is more labor intensive, but less capital intensive. In fact in the country capital is scarce but labor is abundant. Therefore, within the 1972-2008 period producers were finding it easier to substitute labor for capital, but more difficult to substitute capital for labor. The finding is in line with the law of diminishing returns.

From the result we see that a one unit change in $MRS_{K,L}$ could have given rise to 0.403264 unit of MP_K whereas one unit change in $MRS_{L,K}$ could have resulted in 0.194266 unit of MP_L within the 1972-2008 period in Uganda (see Table 1, Regressions 1 and 2).

In fact as more and more units of labor were employed in the production process each additional unit of labor could have been substituted for less and less units of capital.

At the same time as the producers, continued to give up more and capital for each additional unit of labor employed it might have become increasingly difficult for them to give up more of capital. Hence, as more and more units of labor were substituted for capital, fewer and fewer units of capital were given up for each additional unit of labor employed.

A technical progress is labor deepening when it raises the marginal product of labor MP_L by more than the marginal product of capital MP_K. From the results given in Table 1 Regression 3, we find that a unit change in technology could have made MP_L to rise by 0.439865 and MP_K to rise by 0.141839.

Similarly, from the results given in Table 1 Regression 4 we find that a unit change in technology could have made the MP_L to rise by 0.404734 and MP_K to rise by 0.184910. Implying that in the economy of Uganda, labor was being substituted for capital at a faster rate that capital was being substituted for labor. One reason for this is that in the country labor is in abundance, but capital is scarce. According to these findings, the MP_L rose more than MP_K during the 1972-2008 period, implying that in Uganda within the period technical progress was labor deepening.

From these two regressions we find the marginal product of technology were $32{,}334{,}504$ and $27{,}841{,}114$ respectively. Consequently, from this finding we see technological progress can immensely bring about economic growth more than either capital accumumulation or employment (i.e. labor) generation.

The finding also implies that for Uganda to develop rapidly may require a deliberate move to successfully implement sience, technology and innovation policy to enable the country adequately and lucratively access the global market.

Table 1: Influence of marginal rate of substitution and technical progress on marginal product and economic growth

	Reg. 1	Reg. 2	Reg. 3	Reg. 4
Dep.Variable	MPL	MPK	D(Y)/D(A)	D(Y)
Constant (C)			32,334,504	
MRS(L,K)	0.194266			
MRS(K,L)		0.403264		
D(K)/D(A)			0.141839	
D(L)/D(A)			0.439865	
D(A)				27,841,114
D(L)				0.404734
D(K)				0.184910
Sample Period	1972-2008	1973-2008	1972-2008	1972-2008
R-Squared R^2	0.801694	0.582575	0.985554	0.985944
Adjusted R^2	0.801694	0.582575	0.984705	0.985117
S.E. of Reg.	5.574316	0.334516	19236862	6.70E+10
Sum of e^2	1118.628	3.916535	1.26E+16	1.53E+23
DW Statistic	2.005097	1.731044	1.980841	1.690166
F or t-Statistic	12.10494	6.991407	1159.830	1192.467

Note: All t – values were above $|6.99|$, Prob. = 0.0000 and Prob. (F-statistic) = 0.000000. Since the p value of obtaining each of the t or F values above was close to zero, we rejected the null hypothesis that individually or together the independent variables had no effect on economic growth. In all Durbin-Watson tests revealed no serial autocorrelation.

7. Dicussion of results regarding transmissions to and from tehnological progress

7.1. Aims of section 7.

The discussion of results on the tramission mechanisms to and from technological progress involves the following objectives for empirical analyses of findings:

(a) Test the proposition that marginal product of labor depends on the marginal rate of substitution of labor for capital.

(b) Test the proposition that marginal product of capital depends on the marginal rate of substitution of capital for labor.

(c) Estimate the influence of marginal technology with respect to capital on the marginal product of labor in Uganda within the given period.

(d) Estimate the influence of marginal technology with respect to labor on the marginal product of capital in Uganda within the given period.

(e) Decompose technological progress into output and productivity.

(f) Estimate the influence of input ratios on tehnological progress.

(g) Estimate the effects of input ratios on productivity.

(h) Use results in (c) and (d) above to determine whether technological advancement in Uganda has been labor or capital deepening with the given period.

(i) Compare results in (a) with those in (b).

7.2. The influence of input ratios on input productivity

7.2.1. Aims of section 7.2

This present section attempts to provide the following empirical analyses and findings:

(a) Test the proposition that capital productivity can be written as a function of capital-labor ratio or labor capital ratio only.

(b) Test the proposition that labor productivity can be written as a function of capital-labor ratio or labor-capital ratio only.

7.2.2. Analyses of Effects of Input Ratios on Productivity

The null hypothesis of no relationship between $d(L/K)/(L/K)$ (growth in labor-capital ratio) and $d(Kp)/Kp$ (growth in capital productivity) tantamount to the claim that growth in capital productivity is not influenced by the growth in labor-capital ratio. We therefore, have $H_0 : \beta = 0.$ For the alternative hypothesis we take $H_\alpha : \beta \neq 0.$

Our aim is to test H_0 at 1 percent level of significance. With the number of observations being 37 the appropriate value of the t statistic for the two-tail test is the value corresponding to $t_{35,0.005}$.

The acceptance region for the test is $-2.7 \leq \frac{\hat{\beta}}{se(\hat{\beta})} \leq +2.7.$ From Table 2, Regressions 5, the calculated values are $\hat{\beta} = 0.437915$ and $se(\hat{\beta}) = 0.043237$ so that $\frac{\hat{\beta}}{se(\hat{\beta})} = 10.1,$ which clearly lies outside the acceptance region. Therefore, the hypothesis of no relationship between $d(L/K)/(L/K)$ and $d(Kp)/Kp$ is rejected.

Hence, we conclude that the case of Uganda shows that growth in capital productivity can be expressed as grow in the labor-capital ratio. Similarly, for the regressions 6, 7 and 8 in Table 2 we reject the null hypothesis because the calculated values $-9.98, -9.2, 12.56$ respectively fall outside the critical region of acceptance.

Likewise, we test the hypothesis that the rate at which growth in the capital-labor ratio causes growth in labor productivity is equal the rate at which growth in labor-capital ratio causes reduction in the labor productivity growth. Symbolically, we therefore, state that $H_0 : \beta = 0.588429.$ Our alternative can be state as $H_\alpha : \beta \neq 0.586429.$

In this case the calculated value of t is given by

$$t = \frac{\hat{\beta} - 0.586429}{se(\hat{\beta})} = \frac{0.586429 - 0.516014}{0.046685} = 1.51.$$

Since the computed t value (i.e. 1.51) is smaller than the critical t value (i.e. 2.7) at 1 percent level of significance, we therefore conclude that in Uganda within the given period growth in labor-capital ratio influenced growth in capital productivity as much as growth in the capital-labor ratio brought about reduction in the capital productivity.

Growth in the capital-labor ratio results in of labor productivity growth because reduction in the use of labor while keeping the use of captal constant causes labor productivity to increase. The same is true for growth in labor-capital ratio ans capital productivity productivity (see Regression Equations 5 and 8). Equations 6 and 7 reveal that it may be wrong to believe that labor or capital productivity grows either through capital or labor deepening alone because growth in capital leads to reduction in capital productivity and the same is true for labor growth.

Table 2: Influence of Input ratios on productivity growth

	Reg. 5	Reg. 6	Reg. 7	Reg. 8
Dep, Variable	D(Kp)/Kp	D(Kp)/Kp(-1)	D(Lp)/LP	D(Lp)/Lp(-1)
CONSTANT				1.014244
D(L/K)/(L/K)	0.437915			
D(K/L)/(K/L)(-1)		-0.392147		
D(L/K)/(L/K			-0.516014	
D(K/L)/(K/L)(-1)				0.586429
Sample Period	1972-2008	1972-2008	1972-2008	1972-2008
R-Squared R^2	0.574670	0.550924	0.691166	0.818551
Adjusted R^2	0.574670	0.55094	0.691166	0.813264
S.E. of Reg.	0.028174	0.025596	0.036522	0.026559
Sum of e^2	0.028577	0.023586	0.048019	0.024688
DW Statistic	1.622209	1.621360	1.722769	1.621581
t-Statistic	10.12834	-9.983404	-9.206855	F=157.7879

Note: All t – values were above $|2.85|$, Prob. = 0.0000. Since the p value of obtaining each of the t values above was close to zero, we rejected the null hypothesis that individually the independent variables had no effect on economic growth. In all Durbin-Watson tests revealed no serial autocorrelation.

7.3. The input ratios affect output growth through productivity growth

7.3.1. Aims of section 7.3

This present section attempts to provide the following empirical analyses and findings:

(a) Test the hypothesis that growth in labor-capital ratio caused decline in output growth via capital growth.

(b) Test the hypothesis that growth in capital-labor ratio resulted in output growth through capital growth.

(c) Test the hypothesis that growth in labor-capital ratio resulted in output growth through growth in labor.

(d) Test the hypothesis that growth in capital-labor ratio caused decline in output growth via growth in labor.

7.3.2. Analyses of Effects of Input Ratios on Economic Growth

From Table 3 we can deduce that technical progress gave rise to economic growth in Uganda within the 1972-2008 period. Within the same period growth in both labor and capital led to economic growth. Growth in the capital-labor ratio had a positive influence whereas growth in the labor-capital ratio had a negative influence on economic growth within the given period, as the influence was transmitted through growth in capital. Implying that it is the decrease not increase in the use of capital in production that leads to growth capital productivity.

Likewise, growth in labor-capital ratio had a positive influence whereas growth in capital labor-ratio had a negative influence on economic growth in the given period, because the effect was transmitted through growth in labor. The finding reveals that it is the reduction not the increase in the use of labor in production that leads to growth in labor productivity.

Table 3: Influence of technical progress, input growth and input ratio growth on economic growth

	Reg. 9	Reg. 10	Reg. 11	Reg. 12
Dep.Var.	D(Y)/Y	D(Y)/Y	D(Y)/Y	D(Y)/Y
D(A)/A	0.982926	0.855912	1.072295	0.980243
D(L)/L	0.607884	0.623383		
D(K)/K			0.549015	
D(K(-1))/K(-1)				0.585044
D(L/K)/(L/K)	-0.264196			0.315652
D(K/L)/(K/L)		0.299238	-0.321359	
Sample Period	1972-2008	1970-2008	1972-2008	1972-2008
R-Squared R^2	0.998429	0.978608	0.993807	0.973574
Adjusted R^2	0.998337	0.977350	0.993442	0.9971973
S.E. of Reg.	0.001982	0.007315	0.003936	0.971973
Sum of e^2	0.000134	0.001820	0.000527	0.002211
DW Statistic	2.225899	1.986434	2.240236	2.035322
F-Statistic	10807.48	777.6977	2727.913	607.8948

Note: All t – values were above $|13.14|$, Prob. < 0.0000, Prob. (F-statistic) = 0.000000. Since the p value of obtaining each of the t or F values above was close to zero, we rejected the null hypothesis that individually or together the independent variables had no effect on economic growth. In all Durbin-Watson tests revealed no serial autocorrelation.

7.4. The input ratios affect output growth through productivity growth and in turn productivity growth affect output growth through input growth

7.4.1. Aims of section 7.4

This present section attempts to provide the following empirical analyses and findings:

(a) Test the hypothesis that growth in labor-capital ratio caused decline in output growth via capital productivity growth.

(b) Test the hypothesis that growth in capita-labor ratio resulted in output growth through capital productivitygrowth.

(c) Test the hypothesis that growth in labor-capital ratio resulted in output growth through growth in labor productivity.

(d) Test the hypothesis that growth in capital-labor ratio caused decline in output growth via growth in labor productivity.

7.4.2 Analyses of Effects of Input Ratios and Productivity on Economic Growth

As mentioned before, technical progress gave rise to economic growth in Uganda within the 1972-2008 period. Within the same period growth in both labor and capital productivity led to reduction in economic growth.

Table 4: Influence of technical progress, productivity growth and growth in input ratios on economic growth

	Reg. 13	Reg. 14	Reg. 15	Reg. 16
Dep. Variable	D(Y)/Y	D(Y)/Y	D(Y)/Y	D(Y)/Y(-1)
Constant (C)		0.017156		
D(A)/A	2.307158	1.830849	2.250396	2.356271
D(Lp)/Lp	-1.297782		-1.020470	
D(Kp)/Kp		-0.600926		-1.559541
D(K/L)/(K/L)	0.608788	-0.530930		
D(L/K)/(L/K)			-0.390206	0.746076
Sample Period	1972-2008	1972-2008	1972-2008	1972-2008
R-Squared R^2	0.999016	0.981006	0.966022	0.965280
Adjusted R^2	0.998958	0.979279	0.964023	0.963238
S.E. of Reg.	0.001569	0.006997	0.009220	0.009408
Sum of e^2	8.37E-05	0.001616	122.4608	0.003009
DW Statistic	2.006656	1.697038	1.858348	2.070167
F-Statistic	17265.67	568.1247	483.3226	472.6309

Note: All t – values were above $|3.82|$, Prob. < 0.0001, Prob. (F-statistic) = 0.000000. Since the p value of obtaining each of the t or F values above was close to zero, we rejected the null hypothesis that individually or together the independent variables had no effect on economic growth.In all Durbin-Watson tests revealed no serial autocorrelation.

Growth in the capital-labor ratio had a positive influence whereas growth in the labor-capital ratio had a negative influence on economic growth within the given period, as the influence was transmitted through growth in capital productivity.

Similarly, growth in labor-capital ratio had a positive influence whereas growth in capital labor-ratio had a negative influence on economic growth in the given period, because the effect was transmitted through growth in labor productivity (see Table 4).

7.5. Decomposition of technological progress into output and productivity

7.5.1. Aims section 7.5

(a) Estimate the contribution of output to technical progress.

(b) Estimate the contribution of capital productivity to technical progress.

(c) Estimate the contribution of labor productivity to technological progress.

7.5.2. Analyses of the contributions of output, labor productivity and capital productivity to technology

In the study we find that for 1 unit increase in the level of technology, were contributed to by 0.451, 0.187 and 0.362 percent increase in output, capital productivity and labor productivity respectively in Uganda within the given period (see Equation 52 below).

$$\begin{array}{ccccccc} \log A & = & 0.450719\log Y & + & 0.187412\log Kp & + & 0.361866\log Lp \\ t & & 12737866 & & 156677.8 & & 95093.01 \\ R^2 & = & 1.000000 & & F & = & 1.63\times 10^{12} \\ \bar{R}^2 & = & 1.000000 & & N & = & 40 \\ DW & = & 1.993018 & & Period & = & 1970-2009 \end{array} \quad \ldots\ldots\ldots.. (52)$$

Thus, labor productivity had a greater contribution than capital productivity to the technological progress in Uganda within the given period. Therefore, we conclude that within the given period, Uganda’s technological progress was labor deepening.

Thus, growth in inputs could have contributed 0.45 percent towards technological progress in Uganda within the given period in terms of embodied technology in inputs and the balance 0.55 of the technical progress could have come from both capital and labor productivity.

7.6. Estimation of the influence of input ratios on technological progress

7.6.1. Objectives of 7.6

(a) Estimate the contribution of output to technical progress.

(b) Estimate the contribution of capital productivity to technical progress.

(c) Estimate the contribution of labor productivity to technological progress.

(d) Estimate the effect of capital–labor ratio on technological progress.

(e) Estimate the effect of labor–capital ratio on technological progress.

7.6.2 Analysis of the influence of input ratios on technological progress

From Regression Equation 52, it is clear that a 1 percent increase in labor productivity contributed 0.361866 percent to technological progress. The effects of growth in capital–labor ratio on technological progress was transmitted through labor productivity because a 1 percent increase in capital–labor ratio caused labor productivity to rise by 0.361866 percent in the country within the given period. This exactly same percentage as labor productivity contribution to technonolocal progress (see Regression 17 and 18). Similarly, it is true that a 1 percent increase in capital productivity contributed 0.187412 percent to technological progress. The effects of growth in labor–capita ratio on technological progress could have been transmitted through capital productivity because a 1 percent increase in labor–capital ratio caused capital productivity to rise by 0.187412 percent in the country within the given period.

This is exactly the same percentage by which a 1 percent increase in capital productivity contributed to technonolocal progress. The finding confirms the fact that capital productivity, labor productivity or technological progress is the efficiency with which conversion of inputs into outputs occurs. In fact productivity is the efficiency in production and can be expressed as an output–input ratio. Therefore, managers in the economy could have driven the technological progress or productivity growth through appropriate variations in input ratios because they were the ones coordinating the application of labor and capital in production.

Regression Equation 17 and 19 reveal that growth in labor–capital ratio crates capital productivity just as much as it destroys labor productivity. This observation is confirmed by 0.361866 percent increase in K/L ratio and 0.361866 percent decrease in L/K as contribution to 1 percent increase in technology. Simlarly, Regression Equation 18 and 20 reveals that growth in capital–labor ratio crates labor productivity just as much as it destroys capital productivity.

Table 5: Contributions of productivity and input ratios to technological progress

	Regression 17	Regression 18	Regression 19	Regression 20
Dep. Variable	Log(A)	Log(A)	Log(A)	Log(A)
Log(Y)	0.450719	0.450719	0.450719	0.450719
Log(Kp)	0.549297		0.549279	
Log(Lp)		0.549279		0.549279
Log(K/L)	0.361866			-0.187412
Log(L/K)		0.187412	-0.361866	
Sample Period	1970-2009	1970-2009	1970-2009	1970-2009
R-Squared R^2	1.000000	1.000000	1.000000	1.000000
Adjusted R^2	1.000000	1.000000	1.000000	1.000000
S.E. of Reg.	5.79×10^{-7}	1.20×10^{-6}	5.79×10^{-7}	1.20×10^{-6}
Sum of e^2	1.24×10^{-11}	5.35×10^{-11}	1.24×10^{-11}	5.35×10^{-11}
DW Statistic	2.216576	1.827547	2.216576	1.827547
F-Statistic	3.84×10^{12}	8.91×10^{11}	3.84×10^{12}	8.91×10^{11}

Note: All t – values were above $|82972.57|$, Prob. < 0.0000, Prob. (F-statistic) = 0.000000. Since the p value of obtaining each of the t or F values above was close to zero, we rejected the null hypothesis that individually or together the independent variables had no effect on economic growth.In all Durbin-Watson tests revealed no serial autocorrelation.

7.7. Estimation of the effects of technology and input ratios on productivity

7.7.1. Objectives of 7.7

(a) Estimate the effects of technical progress on capital productivity.

(b) Estimate the effects of technical progress on labor productivity.

(c) Estimate the effects of capital–labor ratio on capital productivity.

(d) Estimate the effects of capital–labor ratio on labor productivity.

(e) Estimate the effects of labor –capital ratio on capital productivity.

(f) Estimate the effects of labor –capital ratio on labor productivity.

(g) Estimate the effects of capital or labor on capital productivity.

(h) Estimate the effects of capital or labor on labor productivity.

7.7.2. Analysis of effects of technology and input ratios on productivity

Technology is efficiency just as much as capital productivity or labor productivity is efficience because from Table 6, Regressions 21 to 24, a 1 percent growth in technology was accompanied by 1 percent growth in either capital productivity or labor productivity.

Decomposition of technological progress and productivity can help in tracing the transmission mechanism of input ratios and determining their influence on either technological progress or economic growth. In the transmission mechanism, increasing the K/L ratio raises labor productivity and this can best be done through reduction of labor use in production, but not by increasing capital stock. That is because mere increase in capital stock reduces either capital productivity or labor productivity (compare Regressions 21 to 24).

Smilarly, increasing the L/K ratio raises capital productivity and this can best be done through reduction of capital use in production, but not by increasing labor stock. That is because mere increase in labor stock reduces either capital productivity or labor productivity.

Table 6: Effects of technology, inputs and input ratios on productivity

	Regression 21	Regression 22	Regression 23	Regression 24
Dep. Variable	Log(Kp)	Log(Kp)	Log(Lp)	Log(Lp)
Log(A)	1.000002	1.000002	1.000003	1.000003
Log(L/K)	0.812587	0.361867		
Log(K/L)			0.187412	0.638132
Log(K)		-0.450720		-0.450720
Log(L)	-0.450720		-0.450720	
Sample Period	1970-2009	1970-2009	1970-2009	1970-2009
R-Squared R^2	1.000000	1.000000	1.000000	1.000000
Adjusted R^2	1.000000	1.000000	1.000000	1.000000
S.E. of Reg.	5.79×10^{-7}	5.79×10^{-7}	2.50×10^{-6}	2.50×10^{-6}
Sum of e^2	1.24×10^{-11}	1.24×10^{-11}	1.56×10^{-10}	1.56×10^{-10}
DW Statistic	2.217042	2.217041	1.666149	1.666149
F-Statistic	2.83×10^{12}	2.83×10^{12}	2.41×10^{10}	2.41×10^{10}

Note: All t – values were above $|88328.21|$, Prob. < 0.0001, Prob. (F-statistic) = 0.000000. Since the p value of obtaining each of the t or F values above was close to zero, we rejected the null hypothesis that individually or together the independent variables had no effect on economic growth.In all Durbin-Watson tests revealed no serial autocorrelation.

8. Summary, Conclusions and Recommendations

8.1. Introduction

On the basis of empirical findings regarding effects of technological progress and productivity on economic growth in Uganda within the 1971–2008 period the study came up with some findings.

Firstly, growth in capital productivity or laborproductivity cause decline in economic growth because growth in capital productivity or labor productivity depletes output through creation of excess capacity or preference of leisure instead of work (i.e. labor). Secondly, capital growth, labor growth or technological progress results in economic growth.

8.2. Summary

To examine the effects of technological progress and productivity on economic growth, data on Uganda were collected from the United Nations Statistics Department, and relevant estimates were done and used in conducting the relevant econometric tests. The study found the technical progress in Uganda to be labor deepening. The capital-labor ratio could have positively contributed to technology through its positive effects on lobor productivity.

8.3. Conclusions

On the basis of empirical findings regarding dtermination of whether technological progress was capital or labor deepening in Uganda within the 1970–2009 period the study has come up with some findings. In the case of Uganda technical progress was found to be labor deepening since increase in technology raised the marginal product of labor more than marginal product of capital within the 1972-2008 period.

Growth in capital-labor ratio was found to have a positive influence on labor productivity, but a negative influence on capital productivity. But, growth in labor-capital ratio was found to have a positive influence on capital productivity, but a negative influence on labor productivity.

Fifthly, the study found that in Uganda labor was being substituted for capital more than capital was being substituted for labor in the production process.

8.4. Policy prescriptions

The following were the policy prescriptions suggested by the study:

(a) In order to stimulate economic growth the following should be: (i) promotion of technical progress through training to bolster the application of knowledge from science, (ii) creation of more jobs and (ii) promotion of rapid capital accumulation.

(b) More resources should be allocated to the agricultural sector through raising the capital labor ratio for stimulating production of food and agriculturally produced raw materials required by local industries as well as for food consumption.

(c) To increase capital productivity the labor-capital ratio has to be raised; and to increase labor productivity the capital-labor ratio has to be increased.

(d) To raise the marginal product of an input requires increasing the marginal rate of substitution of that input.

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