Effects of Technological Progress and Productivity on Economic growth in United Arab Emirates

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Abstract:

The study focused on the effects of technological progress and productivity on economic growth in United Arab Emirates (UAE) between 1970 and 2010. Empirical statistical tests were conducted after running regressions and deriving relevant econometric models. The study came up with four findings. Firstly, growth in technological progress resulted in economic growth, employment generation and capital accumulation.

Second, increase in capital productivity gave rise to reduction in economic growth because more productive capital could have resulted in more idle capacity; thus causing depletion of output through reduction in capital employed in production. Third, increase in labor productivity gave rise to reduction in economic growth because more labor productivity might have caused workers to enjoy more leisure instead of working more; thus causing depletion of output through reduction in labor used in production.

Lastly, technical progress in UAE was labor deepening, stimulated exports, but had a negative influence on imports.

Keywords: *Technical, Productivity, Economics, Growth.*

Objectives of the Study

The study aimed at estimating the following:

(a) The effects of technological progress, growth in capital stock and growth in labor stock on economic growth in United Arab Emirates (UAE).
(b) The effects of growth in labor productivity and capital productivity on economic growth in the UAE.
(c) The effects of technical progress, labor productivity and capital productivity on input growth in the UAE.
(d) Whether technical progress in the UAE was capital or labor deepening.
(e) Determining the influence of technological progress and labor productivity on aggregate exports and import levels of UAE.

Literature Review

Schiller (2006) contends that for economic growth in the US to continue, average productivity per worker must be increased further. Moreover, Schiller (2006) argues that between 1978 and 1984 growth in productivity slowed dramatically and prevented GDP growth. To Schiller (2006) growth in productivity gives rise to economic growth (Schiller, 2006: pp. 359-340).

The argument Schiller (2006) is advancing is contrary to the ideas that this study is putting forward that growth in labor productivity causes (a) decline in economic growth, (ii) reduction in capital accumulation and (iii) unemployment, the reason being that growth in productivity prompts labor to trade off leisure for work and that when productivity of a worker grows he would accomplish his regular (daily) tasks within a shorter period of time and spends the rest of the time he has spared to do his own work or enjoy leisure. Otherwise, increase in productivity would result in faster depletion of output in terms of raw materials which ought to be paid for if production is to continue.

Like Schiller (2006), Gomez-Salvador et al. (2006) contends that "productivity gains are a key factor driving long-run growth". This study refutes the claim by Gomez-Salvador et al. (2006), but supports their argument that slowdown in labor productivity growth appear to be strongly related to employment growth particularly in US and EURO area.

Gomez-Salvador et al. (2006) adds that productivity growth is a primary source of growth in real output per capita. In fact, in their empirical analyses they found that from 1950 to 2005 US and EURO area there was an inverse labor productivity and economic growth (Gomez-Salvador, 2006: pp. 1-133). Hence, there is need to empirically test whether growth in productivity causes capital accumulation, employment and economic growth.

Theoretical Framework

The theoretical models 1 and 2 below were developed from the Cobb-Douglas production function given by

$$Y = A^{\lambda} K^{\alpha} L^{\beta}$$

Where Y is output (GDP), A is level of technology, K is capital stock, L is labor stock, λ is coefficient on level of technology, and α and β are parameters of returns to scale. Manipulating the Cobb-Douglas production function given above provides the Equations 1 and 2 given below.

The production function given was rewritten as given below

$$\frac{dY}{Y} = \frac{1}{1-\alpha-\beta}\left[\lambda\frac{dA}{A} + \alpha\frac{dK}{K} + \beta\frac{dL}{L}\right] \text{………..} (1)$$

implying growth in level of technology, capital accumulation and employment result in economic growth.

Technical Progress Creates Employment but Labor Productivity Growth Lead to Unemployment

The mathematical Equation 2 below implies that productivity growth dLp/Lp causes growth in unemployment (i.e. reduction in employment), whereas both technical progress dA/A and capital accumulation dK/K result in labor employment growth dL/L.

$$\frac{dL}{L}=\frac{1}{1-\beta}\left[\lambda\frac{dA}{A}-\frac{dL_P}{L_P}+\alpha\frac{dK}{K}\right]\text{…………….. (2)}$$

We take the economy to be operating under decreasing returns to scale i.e. $0<\alpha+\beta<1$ because the economy is operating within the feasible region of production.

The parameters λ,α,β are all positive. Similarly, the variables L,A,Lp,K are all positive, but their growth rates may be either positive or negative. Increase in capital productivity may result in unemployment because a rise in productivity may cause laborers to substitute leisure for work.

Technology refers to knowledge required to produce the goods and services and as a result increase in technical progress cause labor to be more skillful and innovative and able to perform many tasks well within a given period. Capital stock refers to goods used to produce other goods implying that increase in capital stock provides labor with more tools to work with to produce more goods and services.

Technical Progress Creates Economic Growth Whereas Productivity Growth Results in Decline in Capital Accumulation

As depicted by Equation 3, increase in technical progress (i.e. applied knowledge to produces capital goods) results in more capital accumulation. Whereas, growth in capital productivity brings about reduction in capital accumulation because it may lead to faster depletion of the existing capital in order to acquire more raw materials required to produce more capital.

Raising the level of labor to produce more capital goods brings about faster accumulation of capital. It is labor that produces capital. Therefore, the more labor is engaged in the production of capital goods the faster is the capital accumulation.

$$\frac{dK}{K}=\frac{1}{1-\alpha}\left[\lambda\frac{dA}{A}-\frac{dK_P}{K_P}+\beta\frac{dL}{L}\right]\text{……..………. (3)}$$

where $0<\alpha,\beta<1$ a phenomenon of constant returns to scale.

Technical Progress Creates Employment, Whereas Both Capital and Productivity Growth Result in Unemployment

To capture both the influence of both capital and capital productivity on unemployment we take labor supply to be a function of technical progress, labor productivity and capital productivity as given by

Manipulation of the above function provides a linear equation given by

$$\frac{dL}{L}=\frac{\partial L}{\partial A}\frac{A}{L}.\frac{dA}{A}-\frac{\partial L}{\partial LP}\frac{Lp}{L}.\frac{dLp}{Lp}-\frac{\partial L}{Kp}\frac{Kp}{L}\frac{dKp}{Kp}$$

……………………………………………………………..…. (4)

$K=f(A,Lp,Kp)$ or

$$\frac{dK}{K}=\frac{\partial K}{\partial A}\frac{A}{K}.\frac{dA}{A}-\frac{\partial K}{\partial Lp}\frac{Lp}{K}.\frac{dLp}{Lp}-\frac{\partial K}{\partial Kp}\frac{\partial Kp}{K}.\frac{dKp}{Kp}$$

…………………………………………………..…………. (5)

Where the coefficients represent the respective elasticity of labor supply.

Technological Progress Promotes Capital Accumulation Whereas Both Capital and Productivity Growth Result in Reduction in Capital Accumulation

To capture both the influence of both capital and capital productivity on capital accumulation we take capital stock to be a function of technical progress, labor productivity and capital productivity as given by

dY/Y.

$$\frac{dY}{Y}=\left[\lambda\frac{dA}{A}-\alpha\frac{Kp}{Kp}-\beta\frac{Lp}{Lp}\right]/(1-\alpha-\beta)\text{……... (6)}$$

where the respective coefficients represent a given elasticity of capital stock.

Technical Progress Causes Economic Growth, Whereas Capital and Labor Productivity Growth Result in Reduction in Economic Growth

Expansion in applied knowledge to produce goods and services (i.e. technical progress) give rise to economic growth, whereas increase in productivity results in faster depletion of output and trade off of leisure for work resulting in reduction in economic growth .

Expressing Theory of Labor Productivity

If some given mount of labor can take amount of hours to produce Q units of output in a day then their labor productivity equals Q/a units of output per hour. Similarly, if the same amount of labor is employed for b hours to produce Q units of output per day then its daily output equals . Q/b. If $b<a$ then the labor becomes more productive when its productivity is Q/b than when its productivity is . Q/a.

Implying that laborers will save $a-b$ hours for their leisure when labor productivity has increased by $\frac{Q}{b}-\frac{Q}{a}$.

Thus labor productivity $Lp=(\frac{Q}{b}-\frac{Q}{a})$ becomes a function of leisure Z and is given by

$$Z=(a-b)=f(Lp)\text{ or }Z=f\left[Q\left(\frac{a-b}{ab}\right)\right].$$

Therefore, if daily amount of hours of work L plus daily hours of leisure Z equals H hours, then labor function becomes $L=H-Z=H-Z(Lp)$.

$$\text{Or }\frac{\partial L}{L}=-\left(\frac{\partial Z}{\partial Lp}.\frac{Lp}{L}\right)\frac{\partial Lp}{Lp}=-\gamma\frac{\partial Lp}{Lp}.$$

The labor growth and labor productivity growth relationship derived from the theory of excess capacity (i.e. leisure) is in agreement with the same relationship that can be derived from the definition of labor stock in terms of output and labor productivity.

Here we define labor as output per unit of labor productivity i.e. $L = \frac{Q}{Lp}$ or growth in labor stock is growth in output less growth in labor productivity i.e.

$$\frac{dL}{L} = \frac{dQ}{Q} - \frac{dLp}{Lp}.$$

Substituting labor productivity growth for labor growth in the Cobb-Douglas production function enables us to determine the potential influence of labor productivity on economic growth.

Expressing Theory of Capital Productivity

Suppose that a firm operating at full capacity can produce Q units of output in a day by employing K_2 units of capital, then daily capital productivity of the firm equals Q/K_2 units of output per unit of capital. If the capital productivity increased to Q/K units of output per unit of capital per day, then the same amount of output could be produced by Q/b in a day. Such a production process generates excess capacity (i.e. idle capital stock) amounting to $K_2 - K$ units daily and capital productivity goes up by

$$\frac{Q}{K_2} - \frac{Q}{K}.$$

As a result the idle capacity $K_1 = K_2 - K$ becomes a function of capital productivity as given by . $K_1 = K_1(Kp)$. Total capital stock (i.e. full capacity assumed to be constant) equals idle capital stock K_1 plus active capital stock K and is expressed by

Or $K = K_2 - K_1 = K_2 - K_1(kP)$.

By differentiating the active capital stock function with respect to time we get:

$$\frac{\partial K}{\partial t} = -\frac{\partial K_1}{\partial Kp} . \frac{\partial Kp}{\partial t}.$$

Or $\frac{\partial K}{K} = -\left(\frac{\partial K_1}{\partial Kp} . \frac{Kp}{K}\right)\frac{\partial Lp}{Kp} = -\mu \frac{\partial Kp}{Kp}$.

Hence, increase in capital productivity results in depletion of the active capital stock. The capital growth and productivity growth relationship derived from the theory of excess capacity is in agreement with the same relationship that can be derived from the definition of capital stock in terms of output and capital productivity. Here we define capital as output per unit of capital productivity i.e.

$$\frac{dK}{K} = \frac{dQ}{Q} - \frac{dKp}{Kp}$$

or growth in capital stock is growth in output less growth in capital productivity i.e. $K = \frac{Q}{Kp}$

Substituting capital productivity growth for capital growth in the Cobb-Douglas production function enables us to determine the potential influence of capital productivity on economic growth.

Methodology

Econometric Models

Econometric models were developed in accordance with the five theoretical models given above.

Growth in technology level, capital accumulation and employment result in economic growth.

$$\frac{dYt}{Yt} = \beta_1 \frac{dAt}{At} + \beta_2 \frac{dKp_t}{Kp_t} + \beta_3 \frac{dLt}{Lt} + \varepsilon_t \text{ .... (7)}$$

Labor productivity growth leads to unemployment, whereas both growth in technological progress and capital stock cause increase in labor supply as portrayed by Model (8).

$$\frac{dLt}{Lt} = \beta_1 \frac{dAt}{At} + \beta_2 \frac{dLp_t}{Lp_t} + \beta_3 \frac{dKt}{Kt} + \varepsilon_t \text{ .... (8)}$$

Where $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$ and ε is the disturbance term.

Capital productivity growth results in decline in capital accumulation, whereas both growth in labor stock and technical progress result in capital accumulation as given by model (9).

$$\frac{dKt}{Kt} = \beta_1 \frac{dAt}{At} + \beta_2 \frac{dKp_t}{Kp_t} + \beta_3 \frac{dLt}{Lt} + \varepsilon_t \text{ .... (9)}$$

Where $\beta_1 > 0, \beta_2 < 0, \beta_3 > 0$ and ε is the disturbance term.

Both capital and productivity growth result in unemployment, whereas technical progress leads to increase in employment. See model (10).

$$\frac{dLt}{Lt} = \beta_1 \frac{dAt}{At} + \beta_2 \frac{dLp_t}{Lp_t} + \beta_3 \frac{dKp_t}{Kp_t} + \varepsilon_t \text{ .... (10)}$$

Where $\beta_1 > 0, \beta_2 < 0, \beta_3 > 0$ and ε is the disturbance term.

Both capital and productivity growth result in reduction in capital accumulation, whereas technical progress leads to increase in capital accumulation. See model (11).

$$\frac{dKt}{Kt} = \beta_1 \frac{dAt}{At} + \beta_2 \frac{dLp_t}{Lp_t} + \beta_3 \frac{dKp_t}{Kp_t} + \varepsilon_t \text{ .... (11)}$$

Where $\beta_1 > 0, \beta_2 < 0, \beta_3 < 0$ and ε is the disturbance term.

Both capital and labor productivity growth, result in reduction in economic growth, whereas technical progress leads to increase in economic growth. See model (12) given below.

$$\frac{dYt}{Yt} = \beta_1 \frac{dAt}{At} + \beta_2 \frac{dLp_t}{Lp_t} + \beta_3 \frac{dKp_t}{Kp_t} + \varepsilon_t \quad \text{(12)}$$

where $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 < 0$ and ε is the disturbance term.

Taking Logarithm or Differencing as a Solution to Heteroscedasticity

The problem of heteroscedaticity is that variance of the random variable u_t is not constant. Symbolically this problem of heteroscedasticity can be expressed as:

$Var(u_t) = \sigma^2_{ut}$ is not constant,

Where the subscript implies that individual variances may be different at any time t.

If the σ^2_{ut} is not constant and its value depends on the value of the dependent variable Y_t then

$\sigma^2_{ut} = f(Y_t),$

where $t = 1,2,3,....,n$ (Koutsoyainnis 2001, pp. 181-182). Alternatively, if there is heteroscedasticity we can symbolically write it as

$E(u_t^2) = \frac{1}{n}\sum_{t=1}^{n} u_t^2 = \sigma^2_{ut}$ is not constant

(Gujarati 2003: p. 283).

Taking logarithm is one obvious solution to solving the problem of heteroscedasticity. Differencing is also one of the ways of solving the heteroscedasticity problem.

Proof: Let the variance of u_t be written as

$$\sigma^2_{ut} = \frac{1}{n}\sum_{t=1}^{n} u_t^2 = f(Y_t) = a + b\hat{Y}_t \quad \text{(13)}$$

Differencing Equation (1) requires two sets of expressions as follows:

$$\sigma^2_{ut} = \frac{1}{n-1}\sum_{t=2}^{n} u_t^2 = f(Y_t) = a + b\hat{Y}_t \quad \text{(14)}$$

$$\sigma^2_{ut-1} = \frac{1}{n-1}\sum_{t=1}^{n-1} u_t^2 = f(Y_{t-1}) = a + b\hat{Y}_{t-1} \quad \text{(15)}$$

Where a and b are constants.

Subtracting Equation (15) from Equation (14) is equivalent to differencing Equation 13 as given below.

$$\sigma^2_{\bar{u}t} - \sigma^2_{ut-1} = \frac{1}{n-1}(u_n^2 - u_1^2) = f(Y_t) - f(Y_{t-1}).$$

Thus $E[\sigma^2_{\bar{u}t} - \sigma^2_{\bar{u}t-1}] = \frac{1}{n-1}E(u_n^2 - u_1^2).$

Or $(n-1)E[\sigma^2_{\bar{u}t} - \sigma^2_{\bar{u}t-1}] = \sigma^2_{un} - \sigma^2_{u1}$ .... (16)

Also $E[\sigma^2_{\bar{u}t-1} - \sigma^2_{\bar{u}t-2}] = \frac{1}{n-2}E(u_n^2 - u_2^2).$

Or $(n-2)E[\sigma^2_{\bar{u}t-1} - \sigma^2_{\bar{u}t-2}] = \sigma^2_{un} - \sigma^2_{u2}$ .... (17)

Thus subtracting Equation 17 from Equation 16 provides

$$E[\sigma^2_{ut} - \sigma^2_{ut-1}] = \sigma^2_{u2} - \sigma^2_{u1} \quad \text{(18)}$$

$\therefore$ Equation 16 implies that $E(\sigma^2_{ut} - \sigma^2_{un-1})$ is constant.

$\therefore$ $E[\sigma^2_{ut} - \sigma^2_{ut-1}] = E[\sigma^2_{un-1} - \sigma^2_{ut-2}]$ is constant.

Proof: After differencing we have the following equations

$$\sigma^2_{ut} - \sigma^2_{ut-1} = a + b_t\hat{Y}_t - (a - b\hat{Y}_{t-1}) \quad \text{(19)}$$

$$\sigma^2_{ut-1} - \sigma^2_{ut-2} = a + b\hat{Y}_{t-1} - (a - b\hat{Y}_{t-2}) \quad \text{(20)}$$

Implying that

$$\sigma^2_{ut} - \sigma^2_{ut-1} = b(\hat{Y}_t - \hat{Y}_{t-1}) \quad \text{(21)}$$

$$\sigma^2_{ut-1} - \sigma^2_{ut-2} = b(\hat{Y}_{t-1} - \hat{Y}_{t-2}) \quad \text{(22)}$$

We take the growth rate of the variable in the question to be constant in the long run (i.e. along it long run path).

$$\therefore \frac{\sigma^2_{ut} - \sigma^2_{ut-1}}{\sigma_{ut-1} - \sigma^2_{ut-2}} = \frac{b(\hat{Y}_t - \hat{Y}_{t-1)}}{b(\hat{Y}_{t-1} - \hat{Y}_{t-2})} = 1.$$

Or $\sigma^2_{ut} - \sigma^2_{ut-1} = \sigma^2_{un-1} - \sigma^2_{ut-2}.$

Or $E[\sigma^2_{ut} - \sigma^2_{ut-1}] = E[\sigma^2_{un-1} - \sigma^2_{ut-2}]$

is constant as given above in Equation 16.

Finally, differentiating Equation 18 with respect to time provides

$2\sigma_{u2} - 2\sigma_{u1} = 0.$ Or $\sigma^2_{un-1} = \sigma^2_{ut-2}.$

Furthermore, differentiating Equation (13) with respect to σ^2_{ut} provides

$$1 = \frac{1}{n}\sum_{t=1}^{n} 2u_t = f'(Y_t).$$

Or $1 = \frac{2}{n}\sum_{t=1}^{n} u_t$ .... (23)

Differencing Equation (23) once gives

$$0 = \frac{2}{n-1}\sum_{t=1}^{n}(u_n - u_1) = \frac{2}{n-1}\sum_{t=1}^{n}\Delta u_t.$$

Or $\sum_{t=1}^{n}\Delta u_t = 0$ .... (24)

Differentiating Equation (13) with respect to time provides

$$2\sigma_{ut} = \frac{2}{n}\sum_{t=1}^{n} u_t = f'(Y_t)$$

Or $\sigma_{ut} = \frac{1}{n}\sum_{t=1}^{n} u_t$ .... (25)

Differencing Equation (19) and equating it Equation (18) gives

$$\sigma_{un} - \sigma_{u1} = \frac{1}{n-1}\sum_{t=1}^{n}\Delta u_t = 0 \quad \text{(26)}$$

Implying that $\sigma_{un} = \sigma_{u1}$. Or $\sigma^2_{u1} = \sigma^2_{un}$.

Therefore, we can deduce from Equations (16) and (18) that

$$\sigma^2_{u1} = \sigma^2_{u2} = ... = \sigma^2_{un} \text{ is constant.}$$

Moreover, from Equations 16 and 17 we find that if $u_1, u_2, ..., u_n$ is a random sample from density $f(Y_t)$ where $t = 1,2,....., n$ then

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(u_i - \bar{u})^2 \text{ for } n. > 1 \text{ .... (27)}$$

Could be defined by the sample variance

$$E(S^2) = E(\sigma_{ut}^2) = E(\sigma_{t-1}^2) = \sigma_u^2 \text{ .... (28)}$$

Where σ_u^2 is the population variance.

Implying that

$$E(\sigma_{ut}^2) - E(\sigma_{ut-1}^2) = \sigma_u^2 - \sigma_u^2 = 0 \text{ .... (29)}$$

Also $E(\sigma_{ut-1}^2) - E(\sigma_{ut-2}^2) = 0$ .... (30)

$$\therefore \sigma_{u1}^2) = E(\sigma_{u2}^2) = ... = \sigma_{un}^2 = 0 \text{ .... (31)}$$

(Mood at el.1986: pp. 229-230; Kmenta 1971: pp. 137-139) Hence, differencing a time series before running a egression causes the unstable variance of the error term to become constant. Thus, since differencing and taking logarithms are employed in the analyses, the heteroscedasticty was not found to be a problem in the analyses of the study.

Tests of Hypotheses

Using data from UAE from 1970 to 2010 consisting of 40 to 41 observations after adjusting endpoints we obtained the regression models given below. In all the regression results the $F - Statistic = 0.000000$, $p - value = 0.0000$. The $p - value$ is the probability of obtaining a value of 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 with absolute confidence.

Also for 36 degrees of freedom at 0.001 level of significance the t value were all greater in absolute terms than all the computed t values obtained. Hence, under the null hypothesis that a given coefficient value was zero we, rejected the null hypothesis.

All the computed F values were greater than the critical F value and they followed F distribution with 3 and 36 degrees of freedom in the numerator and denominator respectively. (Note that there are 37 observations and three explanatory variables). From the table we found that in all regressions cases the F value 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 obtaining the respective F value 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 fifteen results given below, the coefficient of multiple determination, R^2 and adjusted R^2(i.e. $\bar{R}^2$) 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 five regression results with 37 degrees of freedom the computed Durbin-Watson statistic $D.W.$ was greater than the table $D.W. = d_U = 1.60$ at 5 percent level of significance, confirming that there was no serial correlation (i.e. autocorrelation) problem.

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 i.e. $\hat{u}_t^2$.

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 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.

Empirical Findings And Discussions

Due to serial correlation the returns to scale on capital was estimated by regressing on as provided by results in Table 1 where was disposable income and was aggregate level of exports.

were got by regressing d(Y/E) on and as provided in Table 2.

1st Set of Regression Results

N=40	Dependent Variable d(Yd/E)	Sample Period: 1970-2010
Variable	Coefficient	t-statistic
d(K/E)	0.142902	10.6215
R-Squared		0.740593
Adjusted R-Squared		0.740593
Durbin Watson Statistic		1.865191

Table 1. Estimating returns to scale on capital

Returns to scale on capital was found to be 0.142902. Implying that returns to scale on labor was (1-0.142902) = 0.857098.

2nd Set of Regression Results

N=40	Dependent Variable d(Y/E)	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
d(K/E)	0.076456	5.128662
D(L/E)	0.438835	3.872108
R-Squared		0.849510
Adjusted R-Squared		0.845550
Durbin Watson Statistic		1.712160
F-Statistic		214.5085

This model was constructed on assumption that disposable income was a function of capital and labor only. Thus the model derived was given by

3rd Set of Regression Results

N=40	Dependent Variable d(Y)	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
d(A)	384876.0	7.604102
D(K)	0.071505	2.775273
D(L)	0.556511	6.142769
R-Squared		0.663547
Adjusted R-Squared		0.645360
Durbin Watson Statistic		2.085467
F-Statistic		36.48538

Table 3. Effects of change in levels of technology, capital and labor on change in output

$Yd = K^{0.142902}L^{0.857098}$. The capital stock series K used was derived from the annual series of investments levels I using the expression $K_t = K_{t-1} + I_t$.

Having derived both the capital and labor stock series the coefficients on both labor and capital and respectively, the parameters were employed in deriving the series for level of technology $A = Y/(K^{0.076456}L^{0.438835})$ in accordance with the celebrated Cobb-Douglas production function.

In Table 3 we deduced that one unit change in the level of technology was found to have caused output to change by 384876 units. Whereas one unit change in capital or labor could have caused output to change by 0.071505 units or 0.556511respectively within the given period.

4th Set of Regression Results

N=40	Dependent Variable d(Y)/Y(-1)	Sample Period: 1970-2010
Variable	Coefficient	t-statistic
d(A)/A	1.954890	21.74010
d(Kp)/Kp	-0.214294	-3.492763
d(Lp)/Lp	-0.694072	-18.98961
R-Squared		0.903705
Adjusted R-Squared		0.898500
Durbin Watson Statistic		1.865191
F-Statistic		173.6178

Table 4. Effects of technical progress and capital and both labor productivity on economic growth

From Table 4 we concluded that in one way or the other one percent increase in technical progress could have caused aggregate output to grow by 1.954890 percent, capital productivity to fall by 0.214294 and labor productivity to go down by 0.694072 percent within the 1971 to 2010 period.

5th Set of Regression Results

N=40	Dependent Variable d(K)/K	Sample Period: 1972-2010
Variable	Coefficient	t-statistic
d(A(-1))/A(-1)	1.657569	27.44905
d(Kp(-1))/Kp(-1)	-0.953122	-23.03494
d(Lp(-1))/Lp(-1)	-0.586167	-2392952
R-Squared		0.860072
Adjusted R-Squared		0.852298
Durbin Watson Statistic		1.801747
F-Statistic		110.6377

Table 5. Effects of technical progress and growth in labor and capital productivity on capital growth

According to results in Table 5, the study found out that one percent growth in technological could have stimulated growth in capital accumulation by 1.657559 percent whereas growth in capital productivity could have reduced both capital accumulation and employment growth by 0.953122 and 0.586167 respectively.

Likewise, according to the findings revealed in Table 8, it appears as if the same amount by which technical progress promoted labor growth was the same amount by which labor productivity growth reduced capital growth, since one percent increase in technical progress was accompanied by 1.782006 percent rise in economic growth whereas one percent growth in labor productivity was accompanied by 1.782006 percent decline in labor stock.

6th Set of Regression Results

N=41	Dependent Variable log(K)	Sample Period: 1970-2010
Variable	Coefficient	t-statistic
log(A)	1.082783	925408.1
log(Kp)	-1.082785	-1224265
log(L)	0.475165	762461.7
R-Squared		1.000000
Adjusted R-Squared		1.000000
Durbin Watson Statistic		2.278880
F-Statistic		8.81E+12

Table 6. Effects of growth in levels of technology, capital and labor on economic growth in UAE

Furthermore, one percent growth in employment could have caused capital accumulation to rise by 0.136246 per annum within the given period. From Tables 7 and 8 we deduced that employment had a grater influence on capital accumulation then the capital had on employment.

7th Set of Regression Results

N=41	Dependent Variable log(L)	Sample Period: 1970-2010
Variable	Coefficient	t-statistic
log(A)	2.063093	15494511
log(Kp)	-0.157736	-191438.4
log(Lp)	-1.905358	-1583002
R-Squared		1.000000
Adjusted R-Squared		1.000000
Durbin Watson Statistic		2.198066
F-Statistic		6.75E+12

Table 7. Effects of technical progress, and growth in labor and capital productivity on labor growth

Thus increase in either capital or labor productivity could have depleted output by increasing more idle labor or capital stock.

Similarly, as depicted by Table 6 the study found out that one percent growth in technological could have stimulated growth in capital accumulation by 2.063093 percent whereas growth in capital productivity could have reduced both capital accumulation and employment growth by 0.157736 and 1.905358 respectively. Thus increase in either capital or labor productive could have depleted output by increasing more idle labor or capital stock.

According to the findings revealed in Table 7, it appears as if the same amount by which technical progress promoted capital growth was the same amount by which capital productivity reduced capital growth, since one percent increased in technical progress was accompanied by 1.082783 percent in economic growth whereas one percent growth in capital productivity was accompanied by 1.082785 percent decline in capital stock.

Furthermore, one percent growth in employment could have caused capital accumulation to rise by 0.475165 per annum within the given period.

Likewise, according to the findings revealed in Table 8, it appears as if the same amount by which technical progress promoted labor growth was the same amount by which labor productivity growth reduced capital growth, since one percent increase in technical progress was accompanied by 1.782006 percent rise in economic growth whereas one percent growth in labor productivity was accompanied by 1.782006 percent decline in labor stock. Furthermore, one percent growth in employment could have caused capital accumulation to rise by 0.136246 per annum within the given period. From Tables 7 and 8 we deduced that employment had a grater influence on capital accumulation then the capital had on employment.

8th Set of Regression Results

N=41	Dependent Variable log(L)	Sample Period: 1970-2010
Variable	Coefficient	t-statistic
log(A)	1.782006	1275469
log(Lp)	-1.782006	-1183318
log(K)	0.136246	218317.6
R-Squared		1.000000
Adjusted R-Squared		1.000000
Durbin Watson Statistic		2.221774
F-Statistic		8.78E+12

Table 8. Effects of growth in technology, labor productivity and capital on labor growth

In accordance with Table 9 we found out that in the short-run within the feasible region growth in capital productivity resulted in depletion of capital productivity by inducing idle capital.

9th Set of Regression Results

N=40	Dependent Variable d(K)/K	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
d(Y)/Y	0.976767	145.4020
d(Kp)/Kp	-0.893439	-127.8096
R-Squared		0.994702
Adjusted R-Squared		0.994562
Durbin Watson Statistic		1.779555
F-Statistic		7134.041

Table 9. The short-run feasible influence of capital productivity and economic growth on capital growth

Similarly, in accordance with Table 10 we found out that in the short-run within the feasible region growth in labor productivity resulted in depletion of labor productivity by inducing idle capital.

10th Set of Regression Results

N=40	Dependent Variable d(L)/d(E)	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
d(Y)/d(E)	0.708708	9.193842
d(Lp)/d(E)	-1.64E+10	-3.951146
R-Squared		0.704951
Adjusted R-Squared		0.697187
Durbin Watson Statistic		1.819561
F-Statistic		90.79226

Table 10. The short-run feasible influence of labor productivity growth on employment growth

From Tables 5 and 6 we discovered that technical progress contributed significantly to capital accumulation (i.e. growth in capital stock in the UAE within the 1972 to 2010 period i.e. 1 percent increase in level of technology could have caused capital stock to grow by 1.66 percent.

Similarly, from Tables 7 and 8 we found that technological advancement contributed greatly towards employment generation (i.e. increase in labor stock) in UAE within the aforementioned period i.e. 1 percent growth in level of technology could have caused labor stock to grow by 2.06 percent. Technological progress appears to result in either capital accumulation or employment generation because technical progress leads to dramatic increase in economic growth and part of the earnings derived from output sold could be used in hiring more labor or purchase of more capital goods.

11th Set of Regression Results

N=40	Dependent Variable d(Y)/d(L)	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
C	0.854521	6.798913
d(K)/d(L)	0.029972	7.766313
d(A)/d(L)	558961.6	33.40668
R-Squared		0.987379
Adjusted R-Squared		0.986696
Durbin Watson Statistic		1.817446
F-Statistic		1447.270

Table 11. Determining whether technical progress of UAE was capital deepening by using marginal

The rate at which capital productivity was deleting capital stock was found to be equal to the level of technological progress. Similarly, the rate at which labor productivity was deleting labor stock was found to be equal to the level of technological progress.

12th Set of Regression Results

N=40	Dependent Variable d(E)/E	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
d(A)/A	1.468556	10.70031
d(L)/L	0.486941	5.579231
R-Squared		0.731826
Adjusted R-Squared		0.724769
Durbin Watson Statistic		1.833158
F-Statistic		103.6989

Table 12. Effects of technological progress and growth in labor on growth in exports

The result could mean that increase in productivity is always accompanied by productivity since productivity comes about due to use of new and more efficient techniques of production.

According to Table 11 technical progress in the UAE was found to be labor deepening because marginal product of labor was found to have risen faster than that of capital. Marginal product of labor rose by 0.854521 per annum whereas that of capital rose by 0.029972 per annum.

As depicted by Table 12, 13 and 14 both employment growth and technical progress were found to be promoting export growth.

Whereas from results in Table 13 we could deduce that labor productivity growth was causing decline in export growth.

13th Set of Regression Results

N=40	Dependent Variable d(E)/E	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
d(A)/A	2.135923	9.749968
d(Lp)/Lp	-0.584247	-5.784842
R-Squared		0.740594
Adjusted R-Squared		0.733767
Durbin Watson Statistic		1.789503
F-Statistic		108.4884

Table 13. Effects of technological progress and labor productivity on export growth of UAE

From results in Tables 14 and 15 we could deduce that export and import growth were reinforcing each other. Imports might have increased exports via increase in imported raw and increase in production of more goods for exports. Also increase in exports could have increased the capacity of the UAE to imports more goods and services within the given period.

14th Set of Regression Results

N=40	Dependent Variable d(E)	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
d(A)	416043.0	9.433015
D(M)	0.604525	12.63482
R-Squared		0.836862
Adjusted R-Squared		0.832568
Durbin Watson Statistic		2.002388
F-Statistic		194.9309

Table 14. Effects of change in level of technology and imports on change in exports

However, as depicted by results in Table 15 technological progress was found to be an important factor in reduction of imports growth. That could have been the case because technical progress might have made the UAE to produce more goods both for her home consumption and exports.

15th Set of Regression Results

N=40	Dependent Variable d(M)/M(-1)	Sample Period: 1971-2010
Variable	Coefficient	t-statistic
d(A)/A(-1)	-1.756122	-8.958690
D(E)/E(-1)	1.490136	11.27934
R-Squared		0.701596
Adjusted R-Squared		0.693744
Durbin Watson Statistic		2.284002
F-Statistic		89.34428

Table 15. Effects of technological progress and exports on imports of UAE

Conclusion

Theoretical models developed were empirically tested after transforming them into the relevant econometric models. The macroeconomic data on UAE collected from the United Nations Statistics were used in conducting the relevant hypothesis tests and empirical analyses. The study found that in United Arab Emirates (UAE) between 1970 and 2010 the following happened:

(1) Growth in technological progress resulted in economic growth.

(2) Increase in either capital productivity or labor productivity gave rise to reduction in economic growth.

Either capital or labor productivity could have caused reduction in economic growth because labor productivity growth might have caused workers to enjoy more leisure instead of working more or growth in capital productivity could have made capital more efficient and resulted in more idle capacity; thus causing depletion of output through reduction in the amount of capital or labor used in production.

(3) Within the feasible region of production either capital productivity or labor productivity had a negative influence on growth.

(4) In the short-run and within the infeasible region of production either capital productivity or labor productivity had positive influence on economic growth.

(5) Growth in either labor or capital productivity could have influenced economic growth through the growth in either capital or labor.

(6) Technical progress in UAE was labor deepening within the given because rise in the marginal product of labor was found to be greater than that of marginal product of capital.

(7) Technological progress in the UAE stimulated export growth, whereas it had a negative influence on imports. Growth in exports and exports reinforced one another, probably because, increase in imported raw materials stimulate more production of export goods, while earnings from exports can be used to more raw materials for production of goods for exports.

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