THE EFFECTS OF TECHNOLOGY AND LABOR ON GROWTH IN EMERGING COUNTRIES

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Abstract
This paper evaluates the impact of technological innovation and the labor market on economic growth in Africa based on a sample of six countries from 1995 to 2017. The outcomes by estimating panel ARDL (PMG & MG) on an adopted Cobb Douglass production function. Findings, among others, reveal that (1) technological innovation has a positive relationship and it is statistically significant on economic growth, (2) labor has a positive relationship but not statistically significant (3) the "Cobb Douglass" total production function hypothesis holds. The study recommends that concerted efforts should be towards investing in technological innovations as well as the provision of better conditions of service.
Keywords: Technology, Labor, Growth, Emerging Countries, Panel ARDL

1. INTRODUCTION

One of the foremost recognizing factors between the developed and developing nations is the application of suitable technology as well as its diffusion to distinctive divisions of the economy (Ekekwe, 2010). The growth in technology across the world, particularly within the 21st century has significantly affected different segments of the economy over nations around the world. In this case, the rise in technology has brought about growth in cross-border trade, investment, and so on. Moreover, there has been an increment in cross-border listings of firms in foreign stock markets, a rise in wireless transactions through the electronic payment of goods and services, inter alia (Osabuohien, 2010). As expressed by Mukoyama (2003), technological progress is the engine of growth in any nation. In any case, to sustain this growth, fitting research and development (R&D) ought to be considered, which can be facilitated by directing resources (financial) and infrastructural development to enhance technological diffusion.

The most growth literature has stated the significance of technological innovation. An important highlight of technological innovation emphasized within the literature is a trademark. In the event that developed countries seem to harvest the foremost advantage – in terms of economic growth and from this type of technological progress, numerous developing countries do not appear to take after suit. Education and investment seem to be the reasons as to why most developing countries are not getting the complete significant package of technological progress. A constrained number of studies emphasize the positive relationship between technological innovation and economic growth in Africa (Chavula, 2013; Donou-Adonsou & Sylwester, 2017).

This paper investigates the effect of technological innovation and labor force on economic growth in some African nations. More particularly, the study looks at whether technological innovation coupled with the labor force affects growth positively. This study expands the literature in two ways. To begin with, the study sheds light on the long-run relationship of technological innovation and labor force on growth in emerging nations by applying a panel ARDL approach. This study also adds up to the existing literature on technology and growth

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but this time including the labor force. Besides, evidence in Africa is restricted, and earlier studies have not considered the subject matter in the African context.

The rest of the paper is as follows. In section 2, we offer a theoretical background and related literature. In Section 3, we depict the empirical model, the methodology, and the data. Section 4 gives the results and discussions, whiles section 5 concludes the study.

2. LITERATURE REVIEW

Growth & development economists, all agree on the significance of technological innovation on economic growth. Without a doubt, even ongoing articles in many economics journals regardless of acknowledging that "in some central way growth is tied in with utilizing technologies to turn out to be more productive and to reveal new ideas (Quibria, 2019). Helpman (2009) one of the engineers of the persuasive quality stepping stool model of economic growth, has expressed that, there is persuading proof that total factor productivity (TFP) assumes a significant role in representing the watched cross-country variety of economic development. Technological change is a significant determinant of TFP.

Broughel and Thierer (2019) have indicated that a difference in technology in the unadulterated sense, combined with organization changes at different degrees, are the primary driving factors behind the constant increment of living standards. Acemoglu and Robinson (2013) describes two driving improvements, financial specialists, and recommends, "Sustained growth requires innovation, which replaces the old with the new in the economic domain and furthermore destabilizes set up power in relations to politics.

2.1. Innovation & Growth Nexus

The association between economic growth and innovation presents an extraordinary intrigued for researchers, as a result, the concept could be a good wrangled about a theme within the financial and economic literature. This concept has its beginning within the inquiry realized by Solow (1956), who pointed out the presence of a long term relationship between economic growth and innovation. Schumpeter (1939) makes the qualification between economic growth and economic development. Hence, from his point of view, the economic growth speaks to a gradual and dynamic alter of the economic system, coming about from exogenous variables of the economic system and on the other hand, the economic development which is produced by irregular internal changes caused by economic innovations, coming from the economic system. The economic growth model created by Schumpeter contends competition through innovation and the significance of education in guaranteeing economic growth, these suspicions are upheld additionally by empirical thinks about (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005).

Moreover, from one viewpoint, the financial and economic literature Wong, Ho, and Autio (2005) alludes to theoretical models (Romer, 1986; Solow, 1956), which looks at the association between technological innovation and economic growth. In the neoclassical model of Solow (1956), the economic growth is supported by capital and labor force. Nadiri (1993) has utilized a Cobb-Douglas function to feature the connection between innovation, output and productivity development. In this model, economic growth is impacted by the growth rate of innovations, which are resolved exogenously. Then again, in the endogenous growth model created by Hasan and Tucci (2010), the economic growth is endogenously decided and is impacted by the agents' choices to augment benefits, mulling over angles identified with entrepreneurship by displaying the innovation procedure dependent on microeconomic data.

The empirical studies from the monetary and financial literature that pointed out the connection between economic growths, innovation, make references both to developed and emerging markets, utilizing both macroeconomic and microeconomic information.

Ulku (2004) has researched the connection between economic growth, research and development expenditures, innovation for 20 OECD nations and 10 nations that are not OECD individuals, by applying the model that was proposed by Romer (1986) by utilizing a panel model, based on GMM philosophy. The outcomes acquired give proof that innovations have a positive control on growth per capita, both for developed and emerging economies. Another end was those developed OECD nations could build the degree of innovation dependent on research and development expenditures, and there is an association between OECD nations since certain nations guarantee their innovation by utilizing the expertise of other OECD nations. Besides, the innovation is endogenous in an economy and backing the economic growth, however, the assumption of the presence of steady growth of innovation unsupported, showing that innovation prompts an expansion in the output for a brief period, and cannot clarify the ceaseless economic growth.

Another examination acknowledged by Westmore (2013) was planned to research the determinants of R&D consumptions and patients and the connection between innovation and economic growth, by utilizing a panel model, in light of an example of 19 OECD nations, during the period 1980-2008. The experimental outcomes give proof that tax incentives and public support for research and development and for patient rights energize innovation exercises in the private sector.

In addition, the outcomes have not distinguished a direct impact of these policies on total productivity growth. Likewise, the policies that help rivalry are significant for the transmission of knowledge from the two sources, both local and outside. With respect to Central and Eastern European nations, Petrariu, Bumbac, and Ciobanu (2013) have analyzed the association between financial development and advancement, by utilizing a board model. Their discoveries showed that the degree of development of an economy, reflected in the designation of assets for research and development is the principal support for innovation. The outcomes called attention to that Central and Eastern European economies recorded quick economic growth, yet it did not depend on the innovation procedure. Contrasted and the growth rate, innovation is viewed as makeup for the lost time process.

3. DATA AND ECONOMETRIC MODEL

The study explores the relationship between economic growth, technological innovation, and the labor, over the short as well as the long term. For an empirical test, this study considers emerging economies with an increase in technological advancement in trademarks and patents, which is a driving force for economic growth. The countries incorporate Algeria, The Gambia, Madagascar, Malawi, Tunisia, and South Africa. The study employs data collected yearly between 1995 and 2017. The Data for the study is taking from the World Development Indicator (WDI) 2018. Variables of interest incorporate Gross Domestic Product (Growth, measured in current USD) as a dependent variable, technological innovation (tech) proxies as a trademark, Capital (Cap) proxies as Government Capital Formation measured in current USD and Labor (Lab). The connections among the factors in the study were considered and adopted from the Cobb Douglas production function Douglas (1976) in the form as follows:

$Yt = AKt\alpha Lt\ 1\text{-}\propto$ … (1)

Where Yt is total production, A is the technology coefficient Kt is capital, Lt is labor, with α and 1-α are, respectively, the shares of capital and labor in the production. The above model was adopted and produced as

Growth=F (Tech, Cap, Lab)….. (2)

Where

Growth= Gross Domestic Product

Tech= Trademark

Cap= Capital Formation

Lab= Labor

3.1. Specification of Econometric Models

In order to decide the TFP (growth), as expressed by Stiglitz (2004) study that considers the contribution of capital to increase production, which is estimated by the increase in the capital percentage multiplied by its market share; and following a similar thought, the percentage increase owing to labor is the expansion in labor percentage multiplied by its share. The growth rate in TFP is clarified by factors other than labor and capital. Among these factors, the study focused on the utilization of Gross Domestic Product (Growth, measured in current USD) as a dependent variable, technological innovation (tech) proxies as a trademark, Capital (Cap) proxies as Government Capital Formation measured in current USD and Labor (Lab). Of course, the TFP (growth) is determined by estimating the model beneath in (2), and gives an econometric equation derived from the above function and provided as:

$Growth = \alpha + \beta_1 Tech_{it} + \beta_2 Cap_{it} + \beta_3 Lab_{it} + \varepsilon it$….. (3)

This examination is estimated utilizing the ARDL technique as created by Pesaran, Shin, and Smith (1999) for appraisal of the long-term relationship elements (i.e., associations with a tendency to change) between the key variables.

Whereas utilizing this estimation, the panel ARDL testing approach recognizes variables between being dependent and explanatory. To execute the method for testing the ARDL model of the vector error correction model (VECM) from equation (2). The general ARDL and VECM approach are as follows:

$\Delta Y_{l;it} = \alpha_{li} + \gamma_{1i} Y_{l;it-1} + \sum_{\iota=1}^{p} \gamma_{li} X_{l;it-1} \sum_{\iota=1}^{p-1} \delta_{1ij} \Delta Y_{l;\, it-j} \sum_{\iota=1}^{p-1} \sum^{k}_{l=2} \delta_{lij} \Delta X_{l;it-j} + \varepsilon_{l;it}$………(4)

The study estimates the short-term dynamic relationship by evaluating an error correction model (ECM). The ECM is as follows:

$\Delta Y_{l;it} = \alpha_{li} + \sum_{j=1}^{p-1} \beta_{1ij} \Delta Y_{l;it-j} + \sum_{j=1}^{p-1} \sum_{l=2}^{K} \beta_{lij} \Delta X_{l;it-j} + \mu_{li} ECT_{l;it-1} + \varepsilon_{lit}$….. (5)

With which the residuals ε_{lit} (l = 1, 2, 3) are independent and normally spread with the zero mean and constant variance and ECM l, it - 1 (l = 1, 2, 3) is the error correction term (ECT) well-defined by the long-term association. The parameter μ_{li} designates the speed of adjustment to the equilibrium level.

3.2. Materials and Methods

In this study, the relationship between technological innovation, labor market and economic growth for the period 1995–2017 was examined by Pedroni (1999) panel co-integration and Panel ARDL strategies. The study is then assessed by pooled mean group (PMG) Pesaran et al. (1999) and mean group (MG) M. H. Pesaran and Smith (1995) strategies in a few developing nations: Algeria, The Gambia, Madagascar, Malawi, Tunisia, and South Africa as well as conducting the Hausman test to estimate the appropriate model suitable for the study. Twenty-three yearly data for each country is from the World Bank Development Indicators.

3.3. Methods

Panel unit root test. Im, Pesaran, and Shin (2003) tests are being utilized in this panel study. This unit root test approach is as an average of ADF statistics. The IPS unit root test has the following equation:

$Y_{it} = \rho i y i_{,t-1} + \sum_{j=1}^{p} \varphi ij \Delta y_{i,t-j} + Z^{1}_{it} + \varepsilon_{it}$ …….. (6)

The null hypothesis indicates that all series within the panel have unit root H_0: qi = 1 and alternatively part of the series is stationary: H_1: qi < 1.

Panel co-integration test. The Pedroni (1995) test is the foremost, well known among panel co-integration tests. Pedroni test takes into consideration heterogeneity by utilizing particular parameters, which permits to differ over individuals of the sample. The Panel co-integration test, which permits for cross-section interdependence with distinctive individual effects, is as follows:

$\Delta Y_{it} = \alpha_i + \delta_{it} + \Delta Y_{i,\, t-p} + \varepsilon_{it}$………(7)

Pedroni (2004) has proposed seven distinctive statistics to test panel data co-integration. The first four are based on pooling, which is called the inside dimension and the last three are based on the between dimension. Both sorts of testis focus on the null hypothesis of no co-integration. The calculated test statistics must be smaller than the organized basic esteem to reject the null hypothesis of the nonappearance of co-integration.

The study estimates the Pedroni heterogeneous panel and group mean panel co-integration statistics. Panel statistics and group statistics hinge on the null hypothesis,

H_0: $\hat{p}_l=1$ for all i, where $\hat{p}_l$, is the assessed autoregressive coefficient of the residuals in the lth unit.

For this procedure, the paper utilizes the Schwarz-Bayesian criteria (SBC) criteria as the fitting lag length criterion and a maximum lag of 2 employed in the ARDL model.

Panel ARDL test. M. H. Pesaran, Shin, and Smith (1997) and Pesaran et al. (1999) recommended the ARDL approach for the co-integration investigation within the single-equation models. The ARDL approach to co-integration includes two steps for estimating a long-run relationship. The primary step is to explore the presence of a long-run relationship among all variables. On the off chance that there is a long-run relationship (co-integration) between variables, the momentous step is to assess the long-run coefficients agreeing to the ARDL model's outcomes. Agreeing to them, cross-equation limitations in the long-run parameters is executed by maximum likelihood estimation for utilizing this approach in panel data.

Then, assessments are provided by the PMG & MG Estimators. Hausman (1978) to estimate the appropriate model suitable for the study.

The Panel ARDL strategy had been utilized by Nautz and Offermanns (2007) for the PPP (purchasing power parity) investigation in Europe. The Panel ARDL model may be a variety of the ARDL (p, q) model within the Pesaran et al. ARDL-UECM model for the standard log-linear useful determination of the long-run relationship between variables. Both models are specified below:

$$\Delta Growth_{l;it}= \alpha_{li} +\gamma_{1i}Growth_{l;it-1}+\gamma_{2i}tech_{l;it-1}+\gamma_{3i}cap_{l;it1}+\gamma_{4i}lab_{l;it1}+\sum_{\iota=1}^{p-1}\delta_{1ij}\Delta Growth_{l;it-j}+\sum_{l=0}^{k}\delta_{2ij}\Delta tech_{l;it-j}+\sum_{l=0}^{k}\delta_{3ij}\Delta cap_{l;it-j}+\sum_{l=0}^{k}\delta_{4ij}\Delta lab_{l;it-j}+\varepsilon_{l;it} \quad \text{.........(8)}$$

The short-term dynamic relationship is acquired by evaluating an error correction model (ECM). The ECM is characterized as follows:

$$\Delta Growth_{l;it}=\alpha_{li}+\sum_{j=1}^{p-1}\beta_{1ij}\Delta Growth_{l;it-j}+\sum_{j=0}^{p-1}\beta_{2j}Tech_{l;it-j}+\sum_{j=0}^{p-1}\beta_{3ij}Cap_{l;it-j}+\sum_{j=0}^{p-1}\beta_{4ij}\Delta Lab_{l;it-j}+\mu_{li}ECT_{l;it-1}+\varepsilon_{lit} \quad \text{.....(9)}$$

With which the residuals ε_{lit} (l = 1, 2, 3) are independent and normally spread with the zero mean and constant variance and ECM l, it - 1 (l = 1, 2, 3) is the error correction term (ECT) well-defined by the long-term association. The parameter μ_{li} designates the speed of adjustment to the equilibrium level.

4. DATA ANALYSIS

TABLE 1 - VARIABLES DESCRIPTION

Variable	Obs	Mean	Std. Dev.	Min	Max
Growth	144	7.09e+10	1.05e+11	4.90e+08	4.20e+11
Tech	131	6845.427	10270.08	272	37976
Cap	139	1.79e+10	2.67e+10	3.60e+07	9.70e+10
Lab	144	7991897	5945716	352169	2.30e+07

Source: Authors Calculations, Data from WDI.

Table 1 presents the variables utilized in this research, which are the gross domestic product (growth), capital (cap), labor (lab), and technological innovation (tech) as well as their averages, standard deviations, and minimum and maximum values. The study records that the minimum and maximum values of the variables are 3.60 and 37976 respectively.

TABLE 2 - CORRELATION STATISTICS

Variables	Growth	Tech	Cap	Lab
Growth	1.0000			
Tech	0.9124	1.0000		
Cap	0.9059	0.6953	1.0000	
Lab	0.8297	0.8372	0.7105	1.0000

Source: Authors Calculations, Data from WDI.

A correlation matrix that talks of the relationship between each combination of variables are displayed in Table 2. A negative sign of a correlation coefficient appears there is an inverse relationship between the two variables. The correlation matrix appears that all the explanatory variables have the anticipated positive relationship with the dependent variable (growth). Usually as anticipated, the hypotheses give a strong and positive relationship between growth and the independent variables in economic studies.

TABLE 3 - VAR LAG SELECTION STATISTICS

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-8265.230	NA	1.57e+62	154.5650	154.6650	154.6055
1	-7520.426	1420.000	1.91e+56	140.9425	141.4421	141.1451
2	-7451.787	125.7309	7.15e+55	139.9586	140.8579*	140.3232
3	-7416.504	61.99293*	5.00e+55*	139.5982*	140.8971	140.1248*

*Shows lag order selected by the criterion. Akaike Information Criterion (AIC), final prediction error (FPE,); Hannan-Quinn Information criterion (HQ); LR, sequential modified LR test statistic (each test at the 5% level); Schwarz information criterion (SC).

To decide the suitable lag length for a series, this study considered lag 2, based on the significant minimum lag values of LR, FPE, AIC, SC, and HQ criterion (Table 2).

TABLE-4: IPS UNIT ROOT RESULTS

Variable	Lag	Level Intercept	1st Difference Intercept	Order
Growth	2	2.00307	-2.17750**	I (1)
Tech	2	2.73622	-3.35275***	I (1)
Cap	2	0.77378	-1.74532**	I (1)
Lab	2	6.19987	-2.18744**	I (1)

NB: *** Significant at the 1% level, ** Significant at the 5% level Source: Authors Calculations, Data from WDI.

For co-integration, the investigation begins with assurance of which properties of the time series datasets are univariate. For integration, the idea necessitates that the arrangement of variables integrates at the same order with stationary linear mixes. In the event that the data arrangement does not pursue the same order of integration, at that point, no significant relationship can appear. While if the series integrates the same order, one can continue to test co-integration. Unit root tests for stationarity are performed at the level and 1st Difference intercepts for all variables.

Although IPS tests (Table 1) confirm that unit-roots exist and are non-stationary at the level of all variables, with all variables showing stationarity at the 1st Differencing. This means that all the variables integrate in the same order, thus I (1).

TABLE 5 - PEDRONI CO-INTEGRATION RESULTS

	Within Dimensions			
	Statistic	**Prob.**	**Statistic**	**Prob**
Panel v-Statistic	1.826779	0.0339**	0.554249	0.2897
Panel rho-Statistic	-0.857976	0.1955	-0.795457	0.2132
Panel PP-Statistic	-1.609508	0.0538*	-2.190863	0.0142**
Panel ADF-Statistic	-2.692484	0.0035**	-1.002284	0.1581
	Between Dimensions			
Group rho-Statistic	0.350248	0.6369		
Group PP-Statistic	-1.741747	0.0408**		
Group ADF-Statistic	-1.308794	0.0953*		

NB: ** Significant at the 5% level, * Significant at the 10% level Source: Authors Calculations, Data from WDI.

From the above, Table 5 reports both the within and between dimensions of panel co-integration test statistics for each panel dataset. These results talk about the averages of the individual autoregressive coefficients related to the unit root estimations of the residuals for each nation within the panel. Results from both dimensions dismiss the null hypothesis of no co-integration.

TABLE 6 - PANEL ARDL RESULTS

	Pooled Mean Group (PMG)			Mean Group (MG)		
	Long Run			Long Run		
Variables	Coef.	Std. Err.	P>Z	Coef.	Std. Err.	P>Z
Tech	4169147	1321610	0.002***	5777567	6271498	0.357
Cap	1.737807	.0988509	0.000***	2.468129	.5781848	0.000***
Lab	233.2935	371.8694	0.530	-1060.889	8518.965	0.901
	Short Run			Short Run		
ECT	-.3079067	.1341324	0.022**	-.6115708	.0519359	0.000***
Tech D1	-971894.2	480264.4	0.043**	-1550267	2075504	0.455
Cap D1.	1.740794	.7476461	0.020**	1.117884	.8448169	0.186
Lab D1.	3492.968	2066.29	0.091*	-8916.23	9849.467	0.365
_cons	1.20e+09	1.00e+09	0.231	-1.81e+09	2.47e+10	0.942

NB: *** Significant at the 1% level, ** Significant at the 5% level, * Significant at the 10% level Source: Authors Calculations, Data from WDI.

Conditions for the long-run relationship between technological innovation, the labor force, and economic growth is ascertained. From the results of the Hausman test, the study confirms the utilization of the PMG model. In this way, the study interprets the results based on the PMG model estimates. Table 6 uncovers the outcomes of both the long and short-run results of the PMG model. The results indicate that all the explanatory variables relate positively to growth, in the long run, confirming the accepted general assertion of the Cobb Douglass production, stating that all three factors such as technology, capital, and labor affects total factor productivity. Statistically, technological innovation and capital are significant at a conventional level of 5%. Expanding the results, it depicts that an increase in the research and development of technology will equally result in an increase in growth among the countries. The values of the coefficient state that there is a substantial increase of 100% on average when there is a percentage increase in technological innovation. The results proving that technological innovation increases growth to confirm the conservation hypothesis of (Bujari & Martínez, 2016; Hasan & Tucci, 2010). The results further prove that to increase economic growth, countries, and nations should invest in technological advancement over the long term.

In the same vein, the outcome proves that a percentage increase in capital results in a greater increase in growth of about 100% on average. This result hypothesizes that there is a direct positive connection between capital and growth. A study by (Adams & Klobodu, 2018; Deléchat, Wakeman-Linn, Wagh, & Ramirez, 2009) supports this outcome in their studies. On the other hand, investigations by (Sandri, 2014; Song, Storesletten, & Zilibotti, 2011) gives the opposite outcome.

With the results of the labor force, the study finds a significant association between the labor force and growth. The coefficient sign depicts that increase in skills, techniques and the number of labor will increase growth substantially. The hypothesis that labor increases growth in emerging countries is also confirmed in the result attesting to the earlier results proved by (Appiah, Amoasi, & Frowne, 2019; Maestas, Mullen, & Powell, 2016) in a study conducted in emerging African countries.

In the short-run estimates, both capital and labor exert positive contributions on growth. Technological innovation in the short run had no positive contribution to the growth of emerging economies since research in technology advancement takes a longer time to produce results.

TABLE 7 - HAUSMAN TEST RESULTS

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	0.15	2	0.9263

Source: Authors Calculations, Data from WDI.

The Hausman test result and the linking p-values of the coefficient are shown out in Table 6 where the null hypothesis that MG is appropriate against the alternative hypothesis. This examination found out that the Hausman test rejected the null hypothesis supporting the propriety of the PMG estimates for this situation.

5. CONCLUSIONS

In this study, we look at the relationship between technological innovation, labor and economic growth in selected African countries. Utilizing the panel ARDL (PMG & MG) estimator, the results demonstrate that technological innovation contributes to economic growth coupled with the labor and capital. In summarizing the outcome of the study, the Cobb Douglass production function which is adopted within the study expresses that, total production is not affected as it were by capital and labor, but to incorporates technology decided by factors such as modern innovations, externalities, human capital, and investment decisions. These results suggest that technological innovation counting on skilled labor and adequate capital enhances economic value.

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