INFORMATION TECHNOLOGY AND THE PRODUCTIVITY PARADOX: EMERGING EVIDENCE FROM THE AFRICAN ECONOMIES

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ABSTRACT

Technological progress is considered a source of growth and productivity gains for national economies. Thus, understanding the factors that determine the diffusion of new technologies across countries is important to understanding the process of economic development. This project therefore investigates whether technological revolution has revolutionary economic consequences and in particular, is economic productivity growing at a much faster rate today, and if so, will it continue to do so in the future? Using the dynamic panel data methodology, emerging evidence from African economies will be revealed.

1.0 BACKGROUND AND RESEARCH PROBLEM

It is very evident that differences in the standard of living lead to large difference ion quality of life. However, it is very apparent that the underlying reasons for such large differences are. It is therefore not surprising that governments in all countries (developed and developing) here shown in a great interest in and are placing high hopes on modern information technology. Could it provide poor countries with the short-cut to prosperity by allowing them to bypass some bases of development in the conventional long-lasting and belt-tightening process of structural change from an agrarian to an industrial and ultimately to a knowledge based services economy? (World Bank 1998)

The views on the possible impact of the information revolution on African Countries can be grouped in two opposing schools of thought. The first school predicts that as African countries in cur as increasing 'technological deficit', the welfare gap between them and the industrialized world would increase. That is, Africa risks further reduction in its ability to generate the resources necessary to accelerate its growth rate and reverse the trend of increasing poverty. Another school believes that information technology may actually help reduce the income gaps between rich and poor countries (Negroponte, 1998). The basic issue separating the two schools with regard to the impact of information technology an Africa Countries is the question of whether Africa could in the first place have adequate access to the global information infrastructure, and hence to the information technology age. The prediction of the position of poverty, Africa countries would not be able to finance the investments in information infrastructure and computer hardware and software required to access the information technology age. This would mean that they would risk increased marginalization in the global economy with severe competitive disadvantage for their goods and services, and hence for their development prospects. The prediction of the second school is based on the argument that the information technology would provide the means for countries to turn their disadvantages into advantages; adjust to the new ways of doing business and put in place the required infrastructure of telecommunications and information systems. (Oshikoya and Hussain, 1998)

The often-advocated information technology will change the World, stem from the basic promise that computing and information processing investments has a visible impact on productivity and income. While there is substantial evidence that new information technologies are in many ways transforming the operations of modern economies, the impacts on productivity have been much harder to detect (see Brynoltsson and Hitt, 1996; Brynoltsson and Yarg, 1996). Most of the macro-level evidence is for the US economy and given the small number of studies on other countries, it is hard to infer whether the productivity paradox is a feature unique to USA and some other advanced economies or whether it is a more general phenomenon. This concentration of research on the USA is quite surprising against the background of the voluminous literature explaining cross-country differences in Productivity and economic growth. The reason for the lack of interest in the role of information technology must be the simple fact that IT investment is not a variable included in any of the datasets which have been used in these studies (Durlauf and Quah, 1998)

However, a notable study of the role of information and communication technology in economic growth is the World Bank's (1998) World development report entitled knowledge for development, which argues strongly for the increasing role of knowledge in economic development. A cross-country analysis of economic growth was presented in support of the argument. Unfortunately, the analysis was silent on the impact of the information technology on economic growth, but instead it pays attention to the role of the communication infrastructure. This may reflect the lack of an impact. The study also suffers from the same weakness as most of similar cross-country regressions do; namely it is rather adhoc and is not explicit based on any model of economic growth. As an improvement, Pohjola (2002) was based on an explicit model of economic growth, which has recently been applied in a number of studies exploring economic growth impacts of various components of capital. This study adopted the augment version of the basic Solow model that includes accumulation of Human capital and information technology as well as physical capital.

In order to understand the effects of IT on today's economy, one should look at the past decades. For the African economies, the observed productivity showdown remains quite poorly understood. This project therefore seeks to investigate whether technology revolution have had significant impact on these economies production structure as well as aggregate productivity statistics.

2.0 OBJECTIVES OF THE STUDY

The broad objective of this project is to investigate the hypothesis that the technology revolution, after all, has had important consequences on productivity. Specifically, we wish to investigate whether information technology has led to radical changes in productivity among different sectors related to the developments themselves have resulted in measures of aggregate performance that do not accurately reflect the (positive) effects on these economies.

3.0 METHODOLOGY

The new technology revolution (IT) plays a dual role in the modern economy. It is both as output from the IT producing industries and in input into the IT using industries. Essentially, the current technological revolution is characterized by the fast improvement in the quality of IT equipment and software, and the resulting sharp decline in their quality adjusted prices. Utility-maximizing firms respond to the change in relative prices by substituting IT equipment, software and services for other goods and services. He rapid technological advance makes it possible for the shares of IT to increase in both gross domestic product and in capital stock while IT prices decline. To identify the channels through which IT affects output, productivity and economic growth, it is helpful to express the aggregate production function n he form

$$Y_t = Y(Y_t^{KT}, Y_t^{o}) = A_t\, F(C_t, K_t, H_t, L_t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where, at any given time t, aggregate value added Y is assumed to consist of ICT goods and services Y^{ICT} as well as of other production Y^{o}, These outputs are produced from aggregate inputs consisting of ICT capital C, other (i.e non-ICT) physical capital K, human capital H and labour L. The level of technology is here represented in the Hicks neutral or output-augmenting form by parameter A. ICT can now be seen to enhance output and economic growth in the following ways. The production of ICT gods and services Y^{ICT} contributes directly to the total value added generated in an economy. Again, the use of ICT capital C as an input in the production of all goods and services generates economic growth. It is even likely that the benefits from ICT use are larger than the benefits from its production since the latter are limited to just are sector of the economy. ICT can also enhance economic growth via the contribution of ICT industries to technological change. If the rapid growth at the macroeconomic level as well.

To assess the direct contribution of ICT, are differentiate the LHS of (3.1) with respect to time t to obtain

$$\hat{Y} = W_{ICT}\, \hat{Y}^{ICT} + W_0\, \hat{Y}^{0} \qquad \ldots\ldots (3.2)$$

Where the ^ symbol denotes the rate of change and the weights W_{ICT} and W_o are the nomianl output shares of ICT and other goods and services, respectively. Here, ICT's direct contribution to GDP growth (WICT Y_{ICT}) in equation 3.2, is calculated by multiplying the nominal output share of ICT goods and services by the growth rate of their volume of production. Whereas it may not be possible for all countries in the world to be producers of ICT, it is certainly feasible for them to become its users. The rapid decline in the relative price of computing and communication equipment and software makes investment in them attractive. Therefore, the estimation of the impact of ICT investment has been approached in the principal ways: Production function estimation, growth accounting and applied growth theory.

For the production approach, suppose that the function (3.1) assumes the simple Cobb-Douglas form:

$$\mathbf{Y = AC^{\alpha c}K^{\alpha K}H^{\alpha h}L^{\alpha l} \ldots\ldots\ldots\ldots\ldots\ldots (3.3)}$$

Taking natural logarithms results in the following equation in levels

$${}_nY = {}_nA + \alpha_c\,{}_nC + \alpha_k\,{}_nK + \alpha_h\,{}_nH + \alpha_l\,{}_nL \ldots\ldots\ldots (3.4)$$

And given information about the observable variables Y, C, K, H and L, one can estimate the parameters A, $\propto_c$, $\propto_k$, $\propto_h$, and $\propto_l$. This could be done in a Time series analysis for one country at a time or, if one is willing to assume that the $\propto$-coefficient are the same in all countries. However, section analysis is often carried out for growth rates. Differentiating (3.4) with respect to time t, one obtains.

$$\hat{A} = \hat{A} + \acute{a}_c \hat{C} + \acute{a}_k \hat{K} + \acute{a}_h \hat{H} + \acute{a}_l \hat{L} \quad \ldots\ldots(3.5)$$

Where the ^ symbol denotes the rate of change. This could again be statistically estimated overtime or across countries. However, if one is prepared to make prevail in production and that all factors are paid their marginal products, the ∝-coefficients represent the respective factor shares in total income and sun to be one. The standard technique of growth accounting can then be applied directly to assess the output growth contributions of the factors of production. Given that all the other factors in (3.5) are observable, except the rate of technological change Â, it is obtained as the residual and is often called the growth rate of total multifactor productivity.

The practical problem with applying either the production function or the growth accounting approach is the poor availability of data for ICT capital and its share in national income. Those that do exist do not cover the 1990s (the decade of the New Economy). Thus, the estimation of capital stocks can be avoided by applying growth theory. The augmented neoclassical model to economic growth extends the basic Solow model to include more then one type of capital (man kin, Romer and Weil, 1992). We now write the production function in a form slightly different from (2)

$$Y = C^{\alpha c} K^{\alpha k} H^{\alpha h} (AL)^{1-\alpha c-\alpha k-\alpha h} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.6)$$

The difference is that technological change is here assumed to be of the labour-augmenting type and that constant refund prevails in production. The model can be closed by specifying the accumulation of each of the three types of capital stocks-ICT, other physical and human capital. The Solow model assumes that a constant fraction of output is invested in each type of capital. Defining as the level of output per effective labour, y = Y/AL, and C, K and H as the respective stock of capital per unit of effective labour, the following differential equations govern the evolution of the stocks:

$$\frac{\partial c(t)}{\partial t} = S_c y(t) - (a+n+\delta c)\, c(t)$$

$$\frac{\partial k(t)}{\partial t} = S_k y(t) - (a+n+\delta n) k(t), \qquad (3.7)$$

$$\frac{\partial h(t)}{\partial t} = S_h y(t) - (a+n+\delta n)\, h(t),$$

Here the S-coefficients are the savings rates in each type of capital, and δ's are the rate of their depreciation. Labour input is assumed to grow and technology to advance at the exogenous rates of n and a, respectively. Solving (3.7) for the steady -state values of the capital stocks and inserting into the production function (3.6) results in

$$I_n\frac{Y}{L} = \alpha_0 + \frac{\alpha_c I_n S_c}{I-\beta} + \frac{\alpha_K I_n S_h}{I-\beta} + \frac{\alpha_h I_n S_h}{I-\beta} - \frac{\alpha_c+\alpha_k+\alpha_h}{I-\beta} I_n(a+n+\delta) \quad \text{…………..} \ (3.8)$$

Where $\alpha_0 = I_n A(o) + at$, $\beta = \alpha_c + \alpha_k + \alpha_h$.

Here the depreciation rates δ are assumed to be the same for all types of capital, and $\beta<1$ by assumption. The confusion is that the steady state level of output per labour, i.e of labour productivity is positively related to the rates of saving in each type of capital but negatively related to the rates of population growth and depreciation of capital. Consequently, labour productivity should be higher in those countries, which invest more than the others in ICT capital, other things being equal. Indeed, equation (3.8) can be estimated for a cross-section of countries if data are available on the rates of investment (i.e. saving) in each type of capital. There is thus no need to measure the capital stocks and the problem with (3.8) is that countries are assumed to be in a steady state, which may be unrealistic given that convergence to the steady state is known to be slow. However, the model can be easily modified to take convergence into account by specifying the estimable equation as

$$I_n \frac{Y(t)}{L(t)} - I_n \frac{Y(0)}{L(0)} = \boldsymbol{q} I_n A(0) + at + \boldsymbol{q} \frac{\boldsymbol{a}_c}{I - \boldsymbol{b}} I_n S_c +$$

$$\boldsymbol{q} \frac{\boldsymbol{a}_k}{I - \boldsymbol{b}} I_n S_k \frac{Y(0)}{L(0)} + \frac{\boldsymbol{a}_c}{I - \boldsymbol{b}} I_n S_c -$$

$$\boldsymbol{q} \frac{\boldsymbol{a}_c \boldsymbol{a}_k \boldsymbol{a}_h}{I - \boldsymbol{b}} I_n (a + n + \boldsymbol{d}) - \boldsymbol{q} I_n \frac{Y(0)}{L(0)}$$

(3.9)

Where Y(0) and L(0) denote output and labour in the initial period and where $\theta = (l - e^{-\lambda t})$ with $\lambda = \beta(a+n+\delta)$ measuring the speed of convergence. The model predicts that labour productivity grows faster in the countries, which interest more than the others in ICT capital, other things being equal.

Using dynamic panel date methodologies, general model can be estimated as a single equation with individual effects of the form:

$$Y_{it} = \sum_{k=1}^{P} {}_k Y_{i(t-k)} + \boldsymbol{b}''(L) X_{it} + \boldsymbol{l}_t + \boldsymbol{h}_i + V_{it} \qquad \ldots(3.10)$$

$$(t = q = 1,........., T_i; i = 1,..., N)$$

Where η_i and λt are respectively individual and time specific effects, χit is a vector of explanatory variables $\beta(L)$ is a vector of associated polynomials in the lag operator q is the maximum lag length in the model. The number of time periods available on the ι^{th} individual, Ti, is small and the number of individuals N, is large. Identification of the model requires restrictions on the serial correlation properties of the error term V_{it} and/or on the properties of the explanatory variables χ_{it}. It is assumed that if the error term was originally autoregressive, the model has been transformed so that the coefficients α's and β's satisfy some set of common factor restrictions. Thus only serially uncorrelated or moving average errors are explicitly allowed. The V_{it} are assumed to be independently distributed across individuals with zero mean, but arbitrary forms of heteroskedaticity across units and time are possible. The χ_{it} may or may not be correlated with the individual effects η_I, and for each of these cases they may be strictly exogenous, predetermined or endogenous variables with respect to V_{it}. A case of particular interest is where the levels χ_{it} are correlated with η_i but where (and possibly Δy) as instruments for equations in levels.

The $(T_I - q)$ equations for individual i can be written conveniently in the form:

$$\mathbf{y_i = w_i \delta + L_i \eta_i + v_i} \quad \text{……….(3.11)}$$

where δ is a parameter vector including the $\alpha_k{}^{'s}$ and $\beta_k{}^{'s}$ and the $\lambda^{'s}$, and w_I is a data matrix containing the time series of the lagged dependent variables, the $\chi^{'s}$ and the time dummies. Lastly, L_I is a (Ti - q) x I vector of ones. Dynamic panel data models can be used to compute various linear Gmm estimators of δ with the general form:

$$\delta = \left[\left(\sum_i w_i^{*t} z_i\right) AN \left(\sum_i Z^t{}_i W_i^*\right)\right]^{-1} \left(\sum_i w_i^{*t} z_i\right) AN \left(\sum_i Z^t{}_i y_i^*\right) \quad 3.12$$

$$AN = \left(\frac{1}{N} \sum Z'_i H_i Z_i \right)$$

(3.13)

and W_i^* and y_i^* denote some transformation of W_i and y_i (e.g. levels, first differences, orthogonal deviations, combinations of first differences (or orthogonal deviations) and levels, deviations from individual means). Z_i is a matrix of instrumental variables, which may or may not be entirely internal and Hi is a possibly individual specific weighting matrix . if the number of columns of Z_i equals that of W_i^*, AN becomes irrelevant and δ^

$$d = \left(\sum Z'_i W_i^* \right)^{-1} \left(\sum_1 Z'_i y_i^* \right)$$

reduces to 3.14

In particular, if Z_i = W_i and the transformed W_i and y_i are deviations from individual means or orthogonal deviations, then d^ is the within groups estimator.

4.0. EXPECTED OUTPUT

The original divide is indeed wide, but not much is known about the patterns of ICT diffusion across countries and about the determinants of its adoption. The importance of human capital, openness to trade and direct investment, telecommunication infrastructure, and internet access are emphasized in most studies, which exists. But even there impacts seem to be different between the developed and developing countries. It is evident that given the dissimilarities in the production and consumption profile between these group of countries, the optimal way to benefit from ICT are likely to be different as well. Thus, our research project is designed and expected to provide this evidence.

5.0. POLICY RELEVANCE

The need for well-justified cross-country diffusion metrics is strong. The recent proliferation for various "e-readiness" and similar indexes, and a recently announced initiative by the World Bank's information for development program to fund such studies underscores the strong interest of policy makers and business community alike. Researchers who are studying how the Internet is influencing and changing the economic, political and social systems of various counties have been limited by the absence of measures that are more accurate, descriptive, and sophisticated.

Therefore our research project has implications for policy makers striving to take advantage of the potentials of IT investment to drive productivity and economic growth.

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APPENDIX

S/NO	COUNTRIES	INCOME PROFILE	REGION
1	SIERRA LEONE	LI	WA
2	NIGER	LI	WA
3	BURKINA FASO	LI	WA
4	GUINEA BISSAU	LI	WA
5	MALI	LI	WA
6	NIGERIA	LI	WA
7	TOGO	LI	WA
8	GAMBIA	LI	WA
9	BENIN	LI	WA
10	GHANA	LI	WA
11	MAURITANIA	LI	WA
12	GUINEA	LI	WA
13	SENEGAL	LI	WA
14	COTE D'IVORE	LI	WA
15	LIBERIA	LI	WA
16	CAPE VARDE	LI	WA
17.	MOZAMBIQUE	LI	EA
18	ETHIOPIA	LI	EA
19	TANZANIA	LI	EA
20	BURUNDI	LI	EA
21	MALAWI	LI	EA
22	RWANDA	LI	EA
23	MADAGASCAR	LI	EA
24	UGANDA	LI	EA
25	KENYA	LI	EA
26	LESOTHO	LMI	EA
27	COMOROS	LI	EA
28	ERITREA	LI	EA
29	SOMALIA	LI	EA
30	SUDAN	LI	EA
31	CHAD	LI	CA
32	CENTRAL AFRICAN REPUBLIC	LI	CA
33	CAMEROON	LI	CA
34	CONGO (REP)	LI	CA
35	GABON	UMI	CA
36	EQUAT. GUINEA	LI	CA
37	SAO T. & PRINC	LI	CA
38	ZAMBIA	LI	SA
39	ANGOLA	LI	SA
40	ZIMBABWE	LI	SA
41	NAMIBIA	LMI	SA
42	BOTSWANA	LMI	SA
43	SOUTH AFRICA	UMI	SA
44	MAURITIUS	UMI	SA

45	DJIBOUTI	LMI	SA
46	SEYCHELLES	UMI	SA
47	SWAZILAND	LMI	SA
48	ZAIRE	LI	SA
49	EGYPT	LMI	NA
50	MOROCCO	LMI	NA
51	ALGERIA	LMI	NA
52	TUNISIA	LMI	NA
53	LIBYA	UMI	NA
54	CONGO (DEM. REP)	UMI	CA
55	MAYOTTE	UMI	SA