DOES R&D INVESTMENT DRIVE ECONOMIC GROWTH? EVIDENCE FROM AFRICA

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Abstract- The bulk of research on the impact of research and development (R&D) has been carried out in developed economies where the intensity of R&D expenditure has been relatively high and stable for many years. However, there is a paucity of similar studies in developing countries. In this paper, we provide empirical estimates of the impact of R&D investment on economic growth in a developing African economy (Mauritius) where R&D expenditure intensity has been low initially, but rising, albeit moderately in recent years. Using a dynamic time series analysis over the period 1980 to 2014 in a Vector Autoregressive framework, R & D is shown to have a positive and significant effect on the economic progress of the island, although the impact is considerably less when compared to both other ingredients of growth and also to reported elasticities from developed economies. Interestingly, there is evidence of bi causality between R & D and growth. Furthermore, R & D positively impacts on both domestic and foreign investment, suggesting the possibilities of indirect effects.

Keywords- R&D, Economic growth, VAR, Africa

I. INTRODUCTION

Achieving economic growth is one of the most important macro-economic objectives of government given its direct impact of living standard and the general welfare of the population. As a result, the search for fundamental determinants behind the growth process is an ongoing research theme. While research have focused on a number of well known determinants such as capital stock, FDI, Human capital and productivity, financial development and openness among others, the importance of Research and development (R&D) as an engine of growth has only recently been documented. Research and development contributes to economic growth by expanding the resource base and enabling more efficient use of existing resources (Fagerberg, 1994; Grossman and Helpman, 1991; Jones, 1995 and Stokey, 1995). R&D plays a major role in innovation, raising productivity, and increasing economic growth. Following the seminal work of Griliches et al (1984), the growth literature has inherited since then from a number of studies which investigated the numerous facets of innovation at both the theoretical and empirical level. This was also recently highlighted by Beaudreau et al (2012). In this regard, one could argue that both at micro and macro level, the prevalence of R&D investment and innovation as a vehicle for growth and development is well recognized. At the macro level, governments have started to invest massively in R&D projects. Together with government funded R&D, there was a proliferation of private R&D and foreign R&D. Moreover, technical progress was considered as a crucial element thereto and one of the major drivers of such progress is through R&D in new products, new production processes and new knowledge. R & D processes “comprises of creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this stock of knowledge to devise new applications”. (OECD, 1993, p. 29).

In addition, R&D is also identified as a method of investigation where new scientific knowledge is discovered due to a series of linear and sequential stages consisting of Basic Research, Applied Research and Development. In fact, the R&D model assumes that science has a monopoly over knowledge, technology is an outcome of science, and economic development is due to technology development. The R&D model confines innovation to technology and then technology to R&D. (Mahdjoubi, 2009).

More so, R&D is also viewed as an engine of innovation. For instance, it is well documented that the relationship between R&D and innovation is a complex and non-linear one. However, it is argued that it is difficult for substantial advances in technology to occur without work undertaken on a systematic basis, and R&D is a good indicator of this broader phenomenon. Hence, with the different types of R&D, the effect of R&D on growth and productivity occurs through different channels. From an overall perspective, investment in R&D undertaken by firms’ results in new goods and services, higher quality of output and in new production processes. However, despite the argument that the literature is fraught with studies investigating the relationship between R&D investment and economic growth in developed countries, nevertheless those analyzing a similar relationship, but for developing economies, remain very scanty to say the least. For the case of Africa, the investigation...
concentrates of agricultural R&D, poverty and economic growth. (Alejandro Nin-Pratt, 2011)
The aim of the study is to examine the effect of R&D expenditure on the economic growth in Mauritius using annual data covering the period 1980-2013. Given the dynamic nature of economic growth in addition to endogeneity and causality issues, we employ a Vector Autoregressive framework after testing for the time series properties of the data. The short run dynamic and long run co-integration relationship are subsequently investigated by using the multivariate co-integration and its vector error correction model (VECM). Mauritius poses as a good case study being touted as a successful African economy, with a GDP per capita standing at USD 16100 in 2013 and a HDI index of 0.771. The government has made education a priority on the island since independence as witnessed by the free primary and secondary education system and also very affordable and subsidized (at times free) for full time undergraduate in all fields. Nevertheless one could argue that Mauritius is at cross roads with the island facing the dilemma of up scaling the development path and not fall into the so-called middle income trap. In this regard, it is well documented that investment in R&D to foster the innovative capacity of a country is a critical element for any country striving for a developed country status. As such, the present study will attempt to shed light on the influence of R&D investment on the past and current economic performance of the island. More importantly, the findings may provide important policy implications for future R&D strategies and policies. The rest of the paper is structured as follows; section 2 reviews the literature briefly while section 3 dwells in the methodology and discusses the findings of the regression results and section 4 concludes.

II. LITERATURE REVIEW

2.1 Theory on R&D and growth

According to the endogenous growth theory propounded by Romer (1990), R&D is regarded as an important factor which provides new knowledge, promotes economic growth and increases productivity for an economy.. It is further argued by Svensson (2008), that investments in R&D can provide long-term growth and lead to increasing returns to scale. This is mainly due to the fact that previous R&D investments that were made to generate specific knowledge do not need to be made again. The imitation of previous production does not therefore have to bear the burden of any R&D costs. More so, economic theory recognises expenditure on research and development as a crucial investment as it generates considerable positive production spillovers. These can be in the form of production of final output or in productivity gains. Two types of externalities are identified with the R&D process. One is related to the R&D workers and the second one is associated with existing level of economic useful knowledge. For instance, with innovation, there is significant increase in labour productivity and capital stock of an economy. Moreover, companies who have acquired knowledge through investment in R & D may find difficulties in preserving the knowledge. Same can be copied by rival firms unless it is protected by patent rights. Hence, R&D is classified as a public good which can lead to significant spillovers to other companies and can lead to rising returns to scale. As identified by various authors such as Stokey, (1995) and Jones and Williams, (2000), apart from the positive externalities, the R&D process come along with negative externalities such as Creative destruction which is described as the "process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one.” Hence, the extent to which R&D processes leads to economic growth is highly debatable.

2.2 Empirical Review

There are several studies that have investigated the link between R&D and growth and productivity in developed countries. Studies investigating the link between investment in R&D and productivity and economic growth usually use some form of production function. R&D investment can take several forms. For instance, we note privately funded R&D, publicly funded R&D and foreign R&D. These types of R&D enter the production function together with other variables such as labour and physical capital. Studies which have investigated this link differ significantly. Studies vary mainly in terms of a company analysis, industry analysis and aggregate level (nation) analysis.

Previous studies investigating the link between R&D and economic growth found a positive relationship between output elasticity and investment in R&D for developed countries. However, it has been found that there is no link between R&D and growth in poor countries, though the poor countries tend to invest more in R&D in relation to GDP than middle-income countries (Birdsall and Ree, 1993; Gittleman and Wolff, 2001). More so, the research literature argues that it is important to consider the spillover effects from other countries. This is done by dividing R&D into that undertaken within the country and that undertaken abroad. Several studies at the aggregated national level have shown that the R&D conducted in other countries is as important or more important than the R&D conducted within the country for the growth of productivity in the country concerned (Lichtenberg, 1993; Coe and Helpman, 1995; Eaton and Kortum, 1999; Guellec and van Pottelsberghe, 2004). Overall, the conclusion that can be derived from the studies analysed revealed that government funded R&D has a positive effect on productivity and growth but the effect is significantly low as compared...
to privately funded R&D. More so, the defense-related R&D that is funded by the Government has a negative rather than a positive effect on productivity and growth.

In relation to Government and University research, previous studies have shown that there is a direct impact on scientific knowledge and generates basic knowledge. The basic research performed mainly by universities boosts the stock of knowledge of the society. These basic researches have the potential to open new opportunities to business research, which in turn affects productivity. In this regards the flow of knowledge from research done at universities to industry is crucial. This concept is supported by the Triple Helix model. This model supports the idea that the potential for innovation and economic development in a Knowledge Society lies in a more prominent role for the university and in the hybridization of elements from university, industry and government to generate new institutional and social formats for the production, transfer and application of knowledge.

III. METHODOLOGY AND ANALYSIS

The model that has been used in this study is based on the general principles of some earlier studies on modeling economic growth in Mauritius and Africa (Seetanah, 2008, Pottelsberghe et al, 2001) whereby an extended Solow growth was used. The model takes the following two functional forms:

\[ GDP = f(CSTOCKR&D,OPENNESSEDUFDI) \]

The dependent variable output, GDP was proxied by the real per capita gross domestic product (GDP). CSTOCK is the country’s capital stock (constructed using the Perpetual Inventory Method, PIM)), OPENNESS is total of export and an import divided by the GDP of the country and is a measure of openness, EDU is a measure of the quality of human capital and is measured by the Secondary enrolment ratio. FDI, a proxy for the level of FDI in the country is also included in the model and is measured as the ratio of Inward FDI to GDP.

Data for Research and Development was collected from the financial statements as obtained from the Annual Report of the Accountant-General in Mauritius. We used data on grants on research provided to the different sectors of the economy to measure R&D expenditure. These include agricultural research, research and experimentation, grants to Mauritius sugarcane industry research institute, grant to food and agricultural research council and grant to Mauritius research council.

The variables were made available from the Central Statistical Office (GDP, CSTOCK, OPENNESS, EDU), Bank of Mauritius (FDI) and Accountant General Annual Reports (R & D). The econometric specification of our model is illustrated below and is of a log linear one.

\[ gdp_t = \beta_0 + \beta_1 icstock_t + \beta_2 r & d_t + \beta_3 openness_t + \beta_4 edu_t + \beta_5 fdi_t + \epsilon_{it} \quad (3) \]

t denotes the time dimension. The small letters denote the natural logarithm of the variables. Uni-variate time series properties

Before considering the appropriate framework of the econometric model, it is important to investigate the univariate properties of all data series and to determine the degree to which they are integrated. Both the augmented Dickey-Fuller (ADF) (1979) and Phillips-Perron (PP) (1988) unit-roots tests have been employed for that purpose and the results and shows that all our variables are non stationary in levels but integrated of order 1 (I (1)) and thus stationary in difference. Further analysis in term of cointegration using the Johansen Maximum Likelihood approach (based on Maximum Eigenvalue and the Trace test for cointegration) confirmed the existence of cointegration with one cointegrating vector for our specification. Engle and Granger (1987) showed by the error-representation theorem that cointegrated variables implies in effect an error correction model (ECM). He argued that regression of the first difference of cointegrated variables would result in misspecification error.

In this study, given the dynamic nature of economic growth, we employ a Vector Autoregressive model (in line with Seetanah, 2008 and Santos et al, 2014). Accordingly, in the presence of cointegration, the VAR is formulated in a Vector Error Correction model (VECM) to analyse the dynamics, casual and endogeneous nature of the relationship in the short run. This involves the inclusion of the lagged errors of the cointegrating regression as one of the independent variables in the regression equation.

The Vector Error Correction Model: We derive the model following Johansen (1988, 1996), Hendry
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(1995), Enders (1995), and Seetanah (2008) and specify the following:

\[ Z_t = \Psi_1 Z_{t-1} + \Psi_2 Z_{t-2} + \ldots + \Psi_{n-k} Z_{t-k} + \mu + \eta_t \]

For the present analysis, the VAR consists of 6 endogenous variables (n=6),

\[ Z_t = [gdp, capstock, &dopenness, edu, fdi] \]

\[ \Delta Z_t = \Gamma_1 Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \ldots + \Gamma_{r-1} \Delta Z_{t-r+1} + \Gamma_r \Delta Z_{t-r} + \mu + \eta_t \]

Where \( \Delta Z_t \) is the vector of growth rates of the above six variables, and the \( \Gamma \)s are estimable parameters, \( \Delta \) is a difference operator, \( \eta_t \) is as defined above. \( \Pi \) is the long run parameter matrix with rank equal to \( r \) (in our case it is one), the number of cointegrating vectors such that \( 1 < r < n-1 \).

With \( r \) cointegrating vectors (\( 1 < r < 6 \)), \( \Pi \) having a rank of \( r \) can be decomposed as \( \Pi = \alpha \beta' \), with \( \alpha \) and \( \beta \) both being \( (n \times k) \), or \( 6 \times 1 \) matrices. \( \alpha \) has been defined as the adjustment or loading coefficients which measure the strength of the cointegrating vectors in the VEC model or in other words the speed of adjustment. The \( \beta \)'s are parameters in the cointegrating relationship and represent the long run coefficients.

Table 1: Estimated Cointegrating Vector

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>( \Delta gdp_{t-1} )</th>
<th>( \Delta gdp_{t-2} )</th>
<th>( \Delta gdp_{t-1} )</th>
<th>( \Delta )openness</th>
<th>( \Delta edu_{t-1} )</th>
<th>( \Delta fdi_{t-1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.13**</td>
<td>0.43**</td>
<td>0.34**</td>
<td>-0.245**</td>
<td>0.325**</td>
<td>0.45**</td>
</tr>
<tr>
<td>( \Delta gdp_{t-1} )</td>
<td>0.33**</td>
<td>0.38**</td>
<td>0.17**</td>
<td>0.111**</td>
<td>0.276**</td>
<td>0.52**</td>
</tr>
<tr>
<td>( \Delta gdp_{t-2} )</td>
<td>0.46**</td>
<td>0.77**</td>
<td>0.08**</td>
<td>0.18**</td>
<td>0.089</td>
<td>0.453**</td>
</tr>
<tr>
<td>( \Delta gdp_{t-1} )</td>
<td>0.04**</td>
<td>0.10**</td>
<td>0.46**</td>
<td>0.029**</td>
<td>0.056</td>
<td>0.27**</td>
</tr>
<tr>
<td>( \Delta openness )</td>
<td>0.21**</td>
<td>0.11**</td>
<td>0.08**</td>
<td>0.465**</td>
<td>0.207</td>
<td>0.54**</td>
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<tr>
<td>( \Delta edu_{t-1} )</td>
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</tr>
<tr>
<td>( v_{t-1} )</td>
<td>0.30**</td>
<td>0.34**</td>
<td>0.34**</td>
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<tr>
<td>( R^2 )</td>
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<td>0.48</td>
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Nevertheless, such a finding is hardly surprising, even more so since similar results have also been reported recently by Zuzana Křítková (2012) for the Czech Republic, Ho, Wong, To, (2009) for the case of Singapore and Sylwester (2001) for the case of a sample of OECD countries; nations which are considered to have reached higher stages of economic development than Mauritius. On the other hand, Coe and Helpman’s (1995) have reported much higher elasticities (approximating 23%) in their study on the G7 nations. Such contradictory above findings may lead us to argue that the impact of R&D is more pronounced once a country reaches a relatively higher level of economic development.

Test of weak exogeneity of the variables of the respective equations in the VAR, using a Wald test, confirm that the variables are not weakly exogenous and thus the same model specification is used.

Estimates of the Error-Correction Model The OLS estimates of the error-correction model are presented in Table 2. The system of equation passes the diagnosis tests related to serial correlation (based on Lagrange multiplier test of residual serial correlation) and heteroscedasticity (based on the regression of squared residuals on squared fitted values).

Table 2: Estimates of the Error-Correction Model

Significant at 10% level ** significant at 5% level

The results from the table (column 2, the GDP equation) confirm a positive and significant contribution of R & D to growth even in the short run. Interestingly the lower reported coefficient might suggest that it take some time for R & D investment to ripple into the economy and achieve maximum potential.

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The other explanatory growth variables have the expected sign and significance, although with lower coefficients as compared with the long run. These results are in line with theoretical rationales. Moreover it can be observed that the adjustment parameter is -0.3 which indicates a relative average adjustment speed of the system to its long run equilibrium. This reflects the speed at which the disequilibrium is corrected for in the next period. This adjustment speed coupled with the fact that the short run parameter is smaller than the long run parameter might indeed also suggests that the other explanatory variable takes time to attain their full impact on the economy.

The VECM framework also allows us to investigate causality and indirect effects of R and D on other major variables included in the model. Referring to column 4 (the R and D equation), it can noted that R & D also depends on the output level of the economy, that is when output increases, more resources are available (especially for government through more taxes among others) to further ploughed back in R and D budget or in the formation of Research Scientists (confirming bi-causality). Such finding related to feedback effect between the R & D and growth is in line with Wu and Zhou (2007) who reported similar bi causal effect for the case of China. It is also important to record that R & D is related to the human capital and FDI level of the country with the latter being generally regarded as crucial bringers of technology and innovation which very often serve to up skill the recipient country’s labour force and upgrade the indigenous technological and innovative capacity through skills and technological diffusion respectively. Referring to equation 3 (capital stock equation) and 7 (FDI equation), in both cases R & D is validated to have some enhancing impacts on capital stock and FDI respectively. Taking the fact that both capital stock and FDI have been shown to in turn contribute to the GDP of the country (refer to 2nd column), one may deduce that R & D also have indirect economic benefit via these two channels.

CONCLUSION

By using rigorous VAR framework, this study investigates the causal relationship between R&D investment and economic growth in Mauritius for the period 1980 to 2014. The econometric results indicate that investment in research and development is a contributor of economic growth as depicted by the presence of positive and significant links between the two both in the long run and short run. The relatively reported low output elasticity of R & D may be explained by the fact it is only recently that Mauritius has been emphasizing on research and development as an ingredient of productivity gains and growth. Moreover, the other variables included in the regression equation as control, also affect growth rate concomitantly. These include domestic capital stock, openness, education and foreign direct investment. Interestingly, the results further suggest a bi directional causality between R&D investment and economic growth. Besides, the results further report that R & D expenditure positively influences capital stock and FDI level of the country which in turn impact favorably on economic growth.

Results of the study are encouraging for research institutions and government. Findings suggest that investment in research and development is an economically worthwhile endeavor. The bidirectional causal link between GDP and R&D indicates interesting feedback effect implying that more efforts and policies may be needed in order to boost R&D investment if the Mauritian economy intends to register more growth... Apart from increasing the R&D investments, there is also a requirement to intensify the efficient utilization of R&D funds and to channel them to where they are allocatively efficient. While many research institutions provide funding for researchers and scientists for research and development activities, there is a need to closely monitor research activities. While it is generally the case that most applications for research funding are peer-reviewed, there is a need of greater monitoring of research work undertaken to ensure that deliverables as initially stated are met. There is also a need for providers of research funding to ensure that in addition to the scholarly impact, research should also have spill-over effects in the local economy. Government should give priority of applied research and those activities that lead to development of new products and services.

REFERENCES


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