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Full Length Research Paper

Innovation barriers and drivers in Sub-sahara African economies (1976-2012): A cointegration analysis

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The study was designed to analyze the challenges against innovations and econometrically deduce the long-run determinants of innovation levels in Sub-Sahara Africa. The study relied on secondary data accessed from World Bank data base spanning over 37 years (1976- 2012). Data obtained were analyzed using canonical cointegration regression (CCR) method. It was found that poor education (secondary school enrollment) was exerting negative influence on innovation levels in SSA ($p<0.05$) in the long-run. Credit to the private sector as well as value of official aids received, labour mobility proxied by number of passengers transported via air planes and electricity consumption were significantly and positively influencing the long-run level of innovation in the region. Their t-statistics were all significant at $p<0.01$. Based on the findings, the study recommended increased funding of education, R&D as well as increasing access to finance for entrepreneurship development; international communities and donors especially should be encouraged to contribute to building global innovation systems by supporting SSA firms: While SSA countries should remove barriers to labour mobility through flexible immigration policies.

Key words: Innovation, barriers, sub-Sahara African, economies ,cointegration analysis.

INTRODUCTION

Innovation may be defined as the purposeful implementation of new technical, economical, organizational and social problem solutions that are oriented to achieve the company objectives in a new way (UK Essays, 2014). The World Bank (2011) noted that agricultural development depends on innovation. It stressed that innovation is a major source of improved productivity, competitiveness, and economic growth throughout advanced and emerging economies, and plays an important role in creating jobs, generating income, alleviating poverty, and driving social development. World Bank added that if farmers, agribusinesses, and even nations are to cope, compete, and thrive in the midst of changes in agriculture and economy, they must innovate continuously. Thus, investments in science and technology have key roles to play as it is a key component of most strategies to improve and maintain agricultural productivity and innovate. Research, education, and extension investments are necessary components but have not been sufficient for agricultural innovation to occur. Other conditions and complementary interventions are equally needed. In addition to a strong capacity in R&D, components of effective agricultural innovation are

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collective action and coordination, the exchange of knowledge among diverse actors, the skills, incentives and resources available to form partnerships and develop businesses, and enabling conditions that make it possible for actors to innovate. These conditions and complementary interventions have not been consistently addressed to date, noted World Bank (2011).

A report by Standing Committee on Agricultural Research (SCAR) Collaborative Working Group AKIS (2012) noted that innovation starts with mobilising existing knowledge. Innovation is viewed as a social process, more bottom-up or interactive than top-down from science to implementation. It was also stressed that pure technical innovations are socially embedded in a process with clients, advisors etc. Often partners are required to implement an innovation.

Innovation is first of all the duty of businesses at the same time a government responsibility too. Innovation does not only benefit those who innovate, but provide other gains: Future innovators as well as the clusters of business and the economy at large with a better competitive position and in the long run more jobs and higher incomes benefit from dividends of innovations. These are so-called positive externalities (spill-over effects) that an investor in innovation process does not take into account and can lead to underinvestment in innovation.

A second reason for governments to promote innovation, the report noted is that this is one of the policy instruments to mitigate negative external effects such as environmental pollution in agriculture and food production. Given that innovation is a risky business and benefits from the exchange of ideas, it noted, learning and innovation net-works have proven to be an adequate vehicle for empowering groups of farmers to investigate new options to make their business more viable or sustainable. It also seems to be an efficient form for information brokers such as farm advisors. This implies policy instruments that finance collectives in net-works, including food chain partners, non-governmental organisations (as advocates of sustainability), extension and research. It should be noted that innovation policies have recourse to many more instruments than research: For instance labour market policies, regulation (with standards or mandates) or de-regulation and access to risk bearing capital can be as important as research or could strengthen its impact.

Social innovation was described by the report as not only referring to the social aspects of the innovation process, nor only the objective that innovations should also be sustainable in the corporate social responsibility sense, but to also the fact that social problems need innovative approaches. These include rural development in regions with aging or declining populations, decreasing (governmental) service levels and (sometimes) uncompetitive agriculture. In a farming (a major enterprise of sub-Saharan Africas, social innovation with urban farming and food projects can contribute to improved quality of life in poor neighborhoods of big cities with high levels of unemployment and high rates of obesity. Social innovation can go along with the desire to strengthen the link between urban life on one hand and food and the rural area on the other hand.

Lipsey et al. (2005) stressed the importance of technological innovation for human development by highlighting, in vivid terms how, in the 21st century, discoveries of technologies such as modern dental and medical equipment, penicillin, bypass operations, safe births, control of genetically transmitted diseases, personal computers, compact discs, television sets, automobiles, opportunities for fast and cheap worldwide travel, affordable universities, central heating, air conditioning, biotechnology, internet, mobile telephony etc. have evidently transformed the quality of human lives. Adebisi and Babatunde (2011) aptly noted that industrial technological innovation had led to substantial economic benefit for the innovating company and the innovating country including countries in Africa. This is why Oyelaran-Oyeyinka (2009) noted that in the long-run, Africa"s industrialization and development would need to centre on knowledge accumulation and technology capabilities building, since capabilities are built not as an end in themselves but to nurture different kinds of innovation in diverse sectors of the economy that contribute to economic development. However, in spite of the slowdown of the development process in most African countries - where the majority of the labour force remains employed in low productivity or subsistence agriculture, Bogliacino et al. (2009) noted that innovation has received a growing attention also in Africa. They however, stressed that the opportunities for catching up and imitation were bedeviled by several challenges including the lack of capabilities, an industrial techno-structure, inadequate demand and access to markets. They also noted that many African countries" most crucial barrier to innovation was problem of finance and inability to cope with the risk structure in innovation. This current research believes there are other challenges beyond those itemized in the foregoing which needs to be empirically verified.

Earlier studies on innovation had focused mostly on organized firms as could be seen in Sutz (2000), Roud (2008), Yegorov (2008), Meschi et al. (2008) to mention but a few mostly outside Africa. Innovation studies in Africa are still emerging and would require more scholastic inputs to guide policy on fostering the growth of innovation and economic transformation of Africa. This study would make a meaningful contribution to this emerging discourse to engender African economic growth and development drive. There are also several strands of literature emerging, including studies on the relations between openness, innovation and market outcomes, also in terms of quantities and skill composition of employment (Bogliacino et al., 2009).

Most of the studies mentioned above applied surveys based on cross sectional data that do not account for long-run effects of such variables on innovation. Moreover, to the best knowledge of this researcher, no empirical studies have been seen to have identified the long-run effects of major factors hypothesized to drive innovations in Sub-Sahara Africa especially with respect to analyzing issues of credit to the private sector, educational status, infrastructure and communication which may be peculiar problems of Africa in her bid to grow her innovative capacities. This study would, therefore, like to chart a new course by using econometric approach to deduce the long-run impacts of these potential candidates for determining innovations in Sub-Sahara Africa. A study of this nature, the researcher believes, will provide meaningful scientific evidence to African policy makers on salient barriers as well as drivers they would need to grapple with in their attempts to fast track innovation and economic growth in their various economies. Given the foregoing background, this study was designed to specifically (i) use available literature to review some gaps and barriers to innovation in Sub-Sahara African economies; and (ii) explore the long-run effects of credit supply to the private sector, education access; electricity consumption, ease of mobility and communication (proxied by air transport) and access to mobile telephones as well as net inflow of official development assistance and official aid on innovation in Sub-Sahara Africa from 1976-2011.

LITERATURE REVIEW

From Solow‟s seminal work on growth theory to the “new growth economics”, technical change has remained the engine of long term growth (Baker, 2005). Whether one is examining the phenomenal growth of Silicon Valley or the stagnant poverty of much of rural Africa, the congruence between economic growth and technical change is striking, noted Baker (2005), all due to innovation levels in these areas.

Three models of innovation were cited by Adebisi and Babtunde (2011). These include the *linear model,* the *simultaneous coupling model* and the *interaction model*. Two major schools of thought, they noted dominated the traditional arguments about innovation. The first, the social deterministic school argued that innovation was the result of a combination of external social factors and influences, such as demographic change, economic influences and cultural changes. The point held here was that when the conditions were right innovations would take place. Meanwhile the second approach, the individualistic school, argued that innovation was the result of unique individual talents and such innovators are born. In summary the *linear model* posited that **t**he recognition that innovation occurs through the interaction of the science base (dominated by industry) and the need of the market was a significant progress. The analysis of the interaction of these activities arises from the basis of nowadays innovation models. There is a much debate and disagreement about precisely what activities drives innovation and more importantly, the internal processes that affect a company‟s ability to innovate. There are two basic variations of this model for product innovation. First and most crudely, there is the technology driven model (often referred to as „technology push‟) where it is assumed that scientists make unexpected discoveries, technologists apply them to develop product ideas and engineers and designers turn them into prototypes for testing. The manufacturers are left to devise a way of producing the product efficiently. Moreover, the marketing and sales departments will promote the product to the potential consumer. *Simultaneous coupling model* held that if we think **t**hat innovations are stimulated by technology, customer need, manufacturing or a host of other factors, including competition, we are wrong. Instead the model concentrates on what is driving the downstream effort rather than on how innovation occurs (Adebisi and Babtunde, 2011). The simultaneous coupling model suggests that it is the result of the knowledge within all three functions that will foster innovation. The *interaction model* further explained the linkage between technology – push and market –pull models. It stressed that innovations occur as the result of the interaction of the market place, the science base and the organization‟s capabilities. Like the coupling model, there is no explicit starting point. The use of information flows explains how innovation transpires and that they can arise from a wide variety of points. This model is deemed to be more comprehensive representation of the innovation process. According to Rothwell and Zegveld (1985) it can be regarded as logically sequential, though not necessarily continuous process that can be divided into a series of functionally district but interacting and inter-dependent stages.

The relationship between innovation, finance and economic growth was earlier explained by Joseph Schumpeter in his publication, *Business Cycles*, which outlines his theory of the economic process of “creative destruction.” In the theory, Schumpeter argues that entrepreneurs play a critical role in capitalist economies, stimulating business through financial investment and innovation. This creative activity, he maintained, destroys outmoded technologies and business practices (Microsoft Encarta, 2009).

Barriers to innovation in Sub-Sahara Africa

UK Essays (2014) summarized the major barriers to innovation, from literature to include the following categories of barriers: Competency barriers, financial barriers, organizational barriers, risk barriers and legal barriers. Under competency barriers, innovators are

challenged by shortage of qualified personnel for innovation projects; lack of marketing capability to market new or significantly improved products; and lack of information on technology relevant for innovation projects. In terms of financial barriers, he cited high costs of innovation projects; lack of internal and external financing for innovation projects; and difficulty of predicting the costs of innovation. In organizational barriers internal resistance to innovation and organizational rigidities which impede innovation projects were cited. Risk barriers included high risk related to the feasibility of innovation projects; high risk related to successful marketing of the innovation and high ease of copying innovation by others. As for legal barriers, fear of legislation and regulation having not an impact on innovation projects was cited. However, it was summed by the author that the four most frequently reported innovation barriers stated by SMEs are related to financing including high costs, time and shortage of qualified personnel for innovation projects. Kaufmann and Tödtling (2002), Kleinknecht (1989) and Freel (1999) (cited in UK Essays, 2014) found that the two most common barriers to innovation are the financial aspect; that is, lack of capital and too high risk associated with innovation projects, and the lack of manpower; that is, shortage of qualified personnel and lack of time for innovation activities. While the financial aspect is common in both large and small firms, it is the lack of manpower that is more frequent in SMEs. UK Essays found that small and medium-sized enterprises in Africa are not able to innovate because they lack the necessary qualified employees or staff who will lead the innovation process and its management. Qualified marketing personnel who will market the innovative ideas and capacity are difficult to find if there are any owing mostly to the educational systems in most African countries, which are more theoretical oriented than practical, creating a big gulf between educational institutions" curriculum and the practical know-how required by industry and the SMEs. Students graduate from universities but have little if not any technical skills required for the jobs they are applying for. The worse part of the issue is the students in the science and technology field in Africa are the poorly trained or educated students due to lack of infrastructure, qualified teachers, inadequate laboratories and no appropriate industry for attachments or internships. The report further hinted that although some parts of Africa such as the Northern countries and South Africa to be specific were experiencing success stories with regards to innovation, it was undoubtedly clear that most African countries especially in Sub-Saharan were still struggling to overcome the burden to financing innovation projects. They were saddled with problems of lack of internally generated funds, inability to source for external financial support, difficulty in predicting the actual cost of innovation projects and the huge capital burdens of innovation were some of the ways financial barrier exposes itself in SMEs in Africa. Thus these were said to have resulted from Governments inability to support R&D in both public and private sectors and the underdevelopment of most African Financial Systems.

Recently other major barriers which relate to peculiar cases of African refugee settlements were studied by some researchers (Coe, 2014; Koser, 2014). For instance, Coe (2014) highlighted some barriers that refugees with disabilities face when it comes to engaging with innovations in refugee situations, such as setting up a new business. It was observed that only few studies have investigated this; an indication in itself of the issue's neglect. It was observed in the report those that have - among the best recent examples cover Somalian refugees in Kenya and Syrian refugees in Lebanon - found remarkably similar barriers in three broad areas. First, is the issue of stigmatization of and discrimination against disabled people leading to their near-universal exclusion in refugee action responses. Disabled people are vulnerable to significant abuse within refugee communities based on false beliefs held by those living and working there over the reasons for their impairments - for example that they are divine punishment, some will say. Second, environmental barriers prevent physical access to disabled people and this includes inaccessible buildings, poor roads and distribution systems that overlook the access needs of people with impairments. Furthermore, inadequately formulated communications exclude those with physical, sensory and intellectual impairments. Thirdly there are institutional barriers, which can affect refugees both inside and outside dedicated camps in different ways. Such barriers include a lack of official recognition of disabled people when collecting statistics on refugees. This is important as it affects responses to their needs in refugee communities. The studies cited by Coe (2014) found a lack of acknowledgement of disabled people in official systems leading to their exclusion from plans.

Flexible immigration procedures have been identified as essential for skilled workers to move easily between countries and businesses, but, all around the world, there"s a certain tension between the needs of governments seeking to manage immigration, and businesses wanting to hire the most talented people. It has also been noted that as the global competition for talent intensifies, new policies for resolving this tension have emerged, including preferential visa regimes for certain types of workers and quotas (Koser, 2014). According to Koser, one region that lags behind in tackling these issues is Africa. While the free movement of labour is a principle already enshrined in certain sub-regional agreements, it is often either not ratified or not effectively implemented. In many parts of Africa, there exist prohibitive, time-consuming and costly obstacles to the mobility of people, including talented Africans. This does not only thwart innovation and competitiveness, but

it risks exacerbating the “brain drain” that takes skilled Africans away from their own continent. For many business enterprises in Africa, it is easier to employ a skilled non-African expatriate than a skilled African expatriate. Overall, barriers to African talent mobility are a drag on the continent‟s growth and economic performance. As African countries pursue policies designed to encourage economic growth, freer movement of talented people is becoming an increasingly important issue.

A recent pilot survey of several multinational businesses operating in 17 African countries, conducted by the World Economic Forum‟s Global Agenda Council on Migration (cited in Koser, 2014), identified four issues: Visa requirements issues, stiff quotas on foreigners coming to work in the country in immigration policy; cumbersome procedures as obstacles to applying for, processing and renewing visas and work permits were reported. Another issue raised by the UNECA report was the issue lack of staff or skills already discussed in this review.

To sum it up, Baker (2005) recognized that there are a number of suggested, inter-related causes for the technical stagnation in the literature. These he noted ranged from lack of credit, human capital, appropriate institutions or infrastructure to excessive risk aversion. It is around these major points that this study will select variables that will capture these gaps and test their influences on innovation levels in Sub-Sahara Africa (based on available data). For instance, according to FAO (2003) royalties and licenses issued for agricultural technologies are instruments for the protection of intellectual property rights (IPR). In that case, in the absence of data on number of intellectual property rights and innovations, this author is convinced that royalties and licenses‟ receipts of a region or a country could approximate patented innovations. It is this assumption that guides the selection of the only data that approximates innovation in the World Bank development indices data used for this study, that is, “Royalty and license fees, receipts (BoP, current US$) in the World Bank database (World Bank, 2012). The enormity of getting the direct data to proxy “innovation” explained the worry of Bogliacino et al. (2009) who noted that most studies have looked at technology using indicators such as R&D and patents but R&D could not explain all dimensions of innovation. However, the best form of measure of innovation in quantitative terms still remains an issue of debate in the emerging field of innovation studies.

RESEARCH METHODS

Methodological Issues

Regression with non-stationary time series is associated with spurious regression except when there exists a linear combination (or more than one) between these variables that reduce the dimension of the space spanned by them (Greene, 2008). This condition is termed cointegration. multivariate cointegration analysis is a recent method in time series analysis originally developed to provide adequate tools for empirical analysis of economic time series but the applicability cannot be restricted to only economic data. Innovation scientists too stand to benefit from these models. The recognition that economic time series are non-stationary remarkably changed the approach of econometric modeling, introducing the concepts and tools associated with integrated-cointegrated data. Unit root processes (variables containing a stochastic trend) can be found in many other fields, for example in climate data, and cointegration analyses of such climate data have been reported in literature (Kaufmann and Stern, 2002; Kelly, 2000) though not as much as in economic analysis. Given the foregoing, there is huge potential for analyzing time series innovation data with cointegrated models. Greene (2008) noted that it is important to use cointegration methods rather than the usual regression methods when there are unit roots in the data because the standard regression estimates are derived under the assumption of stationarity, implying that the variables are not trending, or if they are, that the trend is a deterministic time trend. An simple example is given as follows: Assume for simplicity that rate of innovation, R_t follows a random walk:

$$R_t = R_{t-1} + \mu_{t,\ t=1,\ \ldots R}$$
$$= \mu_t (1 + L + L^2 + \ldots Lt) + R_0$$
$$= \sum_{i=1}^{t} \mu i + Ro \quad (1)$$

Where $\mu_t \sim N(0, \delta^2)$ is the rainfall change from t-1 to t; so that $\Delta R_t = \varepsilon_t$. R_0 is the initial value, and L is the lag operator such that L^m xt = xt-m. By assuming that the rainfall changes have a zero mean we have from the outset stated that rainfall cannot have a deterministic trend, but as long as the coefficient to R_{t-1} is equal to 1.0; it will have a stochastic trend, defined by the cumulated changes (μ_i). This is the reason why a variable containing a stochastic trend, defined as the cumulated sum of Independent Normal errors, in short, $\varepsilon_{t.,}$ distributed as IN(0, δ^2_ε) is often called a unit root process, in short

I(1). A stochastic variable, similarly generated from IN(0, δ^2_ε) errors, but with a coefficient less than 1.0 in absolute value is then called an I(0) process. Regressing I(1) variables on each other has the unfortunate consequence of rendering the usual χ^2; F; and t distributions invalid. This means, for example, that the *t* ratios in such regression models would not be distributed as Student *t* statistics and it is not easy understand whether a coefficient is significant or not. According to Meyer (2003), when there are only two time series it is easy to test for cointegration, usually done by regressing the output series on the input series and testing the residuals for stationarity. If the residuals are stationary it indicates that the two series are cointegrated and the relationship between the two series is expressed using an error correction model. In its simplest form this model is given by the equation:

$$\Delta\alpha_t = \gamma_0 \Delta b_t + \gamma_1(\alpha_{t-1} - \beta b_{t-1}) + \mu_t \quad (2)$$

In equation (2), α_t denotes the output series, b_t denotes the input series and the series μ_t is a white noise process of independent errors. The symbol is the difference operator used to indicate the change in a variable from one period to the next. In the equation the vector (1- β) is referred to as the co-integrating vector because it produces a stationary process despite the fact that x and y are non-stationary. When there are more than two non-stationary time series it is not so easy to test for cointegration and one needs to use canonical correlation analysis (Meyer, 2003). This approach is

also reputed to give more reliable results for the two series case. In canonical correlation analysis, observed Meyer, components are extracted from two sets of variables in such a way as to maximize the correlation between these components. It was further noted that if one of the variable sets consists of indicator variables canonical correlation analysis is equivalent to a discriminant analysis; but where both sets of variables consist of indicator variables canonical correlation analysis is equivalent to a correspondence analysis. This tool, according to Harvey (1989) has been used to develop structured time series models. In the latter case the two sets of variables were identical except that the predictor set is lagged by one period.

In econometric and financial data it is always useful to determine whether variables have a long-term relationship. Such variables are deemed to be cointegrated and the relationship between them can be described using an error correction model. When there is cointegration in a regression model, there are several models that can be used to test and model the relationship. In the last two decades, several econometric methods have been used to test for cointegration. For unit root testing, Dickey-Fuller (1979) and Philips and Perron"s (1988) approaches are commonly applied. Johansen (1996) had used canonical correlation to test for cointegration between time series. With respect to univariate cointegration approaches, there are several examples of methods including Engle-Granger (1987) and the fully modified OLS procedures of Phillips and Hansen"s (1990). In multivariate cointegration, Johansen and Juselius (1990), and Johansen"s (1996) full information maximum likelihood procedures are widely utilized. Of late, single cointegration approach, known as autoregressive-distributed lag (ARDL) model of Peseran and Shin (1999) and Pesaran et al. (2001) has become popular amongst the researchers. Lots of literatures abound on these models. It is possible to analyze long-run co-movements between trending variables, as well as short-run dynamic adjustment and feed-back effects within the same model using VAR (Johansen and Juselius, 1990). Such model can enable investigation be carried out on how, for instance, climate shocks (rainfall and temperature changes) can exhibit a long-run permanent effect on the variables of the system and which had just a temporary effect. Such analysis may potentially provide results on causal mechanisms in the long run and short run.

It was Park (1992) who developed a new procedure for statistical inference in cointegrating regressions known as canonical cointegrating regressions (CCR), that is, special regression models formulated with the transformed data. The required transformations he proposed involve simple adjustments of the integrated processes using stationary components in cointegrating models. Canonical cointegrating regressions, therefore, he noted, represent the same cointegrating relationships as the original models. However, they were constructed in such a way that the usual least squares procedure yields asymptotically efficient estimators and chi-square tests. This methodology is applicable to a very wide class of cointegrating models, including models with deterministic and singular, as well as stochastic and regular, cointegrations. This present study intends to adopt this reliable model in estimating the effects of climate variability and some economic variables on rubber production in Nigeria. The inspiration for the choice of CCR model is also due to the fact observed by Chang and Martinez-Chombo (2003) who asserted that the CCR method effectively deals with endogeneity and serial dependence of the error introduced as time series functional forms are approximated.

Study area

The study area is Sub-Sahara Africa. There are 54 different African countries, including the 48 nations of the mainland and the 6 surrounding island nations. In 2008, Africa"s population, which is mostly rural, topped the 976 million mark. For the majority of these inhabitants, agriculture is the main source of livelihood (Mokwunye, 2009). The continent is commonly divided along the lines of the Sahara, the world"s largest desert, which cuts a huge swath through the northern half of the continent (Microsft-Encarta, 2009). The countries north of the Sahara make up the region of North Africa, while the region south of the desert is known as sub-Saharan Africa. Sub-Saharan Africa is sometimes referred to as "Black Africa," but this designation is not very helpful, given the ethnic diversity of the entire continent. North Africa consists of the countries of Algeria, Egypt, Libya, Morocco, Sudan (now North and South Sudan as distinct countries), and Tunisia. All other parts of Africa besides North Africa are regarded as Sub-Saharan Africa. SSA is generally subdivided into the regions of West Africa, East Africa, Central Africa, and southern Africa (Microsoft-Encarta, 2009). Traditional agriculture in SSA is basic and at best yields enough food and income for the household to survive. The average rural household lacks access to scientifically improved seeds, farm machinery, or sophisticated methods of farm management. On most African farms, the soil must be worked with crude tools or small, animal-drawn ploughs. Use of artificial fertilizers is highly limited and almost nonexistent. Insect pests and vermin are constant threats, sometimes destroying more than half of the crops. Farmers raise crops mainly to supply food for the family. However, there may be small surpluses, which are sold to purchase other foods and essential goods. The beadwork of the Zulu of South Africa is of exceptional fine quality. These examples illustrate the use of traditional geometric designs. Beading is used for jewelry, pouches, and other accessories and is also often used in mask making. Cottage industry employs close to 32% of the rural labour force, not counting the numerous farmers also engaged in this activity on the side. This is largely responsible for the local supply of clothing, footwear, farm implements, and construction materials, as well as for processed foods. The sector also produces crafts, cloth, jewelry, and decorative artifacts to sell to tourists in urban areas and at tourist attractively. The above background calls for improvement in innovation in economic activities of Sub-Saharan Africa.

Data collection and sampling method

This study depended mainly on secondary data obtained from World Bank data base. The seven variables used in this survey spanned across 37 years, 1976-2012. The choice of the variables was based on their completeness, availability in reliable data base and usefulness in theoretical context of the issues being addressed and econometric criteria.

Data analysis

Data collected were analyzed using cointegration analysis (specifically canonical cointegration regression method), an econometric modeling technique for long-run relationship modeling.

Model estimation

The multiple regression model to be estimated is of the form:

$$\ln Yt = \beta_0 + \beta_{it} \ln \sum X_{it} + \mu_t \quad \text{(that is, a double log model)} \qquad (3)$$

Where, ln = natural log transformation sign; X_i is range of explanatory variables or series from X_1 to X_6; X_1 = Air transport,

passengers carried (count); X_2 = Domestic credit to private sector (% of GDP); X_3 = Net official development assistance and official aid received (constant 2010 US$); X_4 = School enrollment, secondary (% gross); X_5 = Mobile cellular subscriptions (per 100 people); X_6 = Electric power consumption (kWh); and Y, the dependent variable = Innovation receipts in millions of US dollars (using "Royalty and license fees, receipts" as proxy). ∑ = summation sign.

Let $\ln Y_t = y_t$; and $\ln X_1$ to $\ln X_6 = X_{it}$. To make it a cointegration model, we applied the following Park"s (1992) CCR method which whose canonical form is:

$$y_t = X_t'\beta + D_{1t}'\gamma_1 + u_{1t} \quad (4)$$

Where $D_t = (D_{1t}', D_{2t}')'$ are deterministic trend regressors and the *n* stochastic regressors, X_t are governed by the system of equations:

$$X_t = \Gamma_{21}'D_{1t} + \Gamma_{22}'D_{2t} + \epsilon_{2t}$$
$$\Delta\epsilon_{2t} = u_{2t} \quad (5)$$

The p_1-vector of D_{1t} regressors enter into the cointegrating equation and the regressors" equation while the p2-vector of D_{2t} regressors are deterministic trend regressors which are included in the regressor equations but which are included in the regressors equations but excluded from the cointegrating equation (if a non-trending regressor such as the constant is present, it is assumed to be an element of D_{1t} so it is not in D_{2t}).

Following Hansen (1992), we assume that the innovations $u_t = (u_{1t}, u_{2t}')'$ are strictly stationary and ergodic with zero mean, contemporaneous covariance matrix ,∑ one-sided long-run covariance matrix Λ, and nonsingular long-run covariance matrix Ω, each of which are partitioned conformably with μ_t .

Taken together, the assumptions imply that the elements of y_t and X_t are I(1) and cointegrated but exclude both cointegration amongst the elements of X_t and multicointegration. Discussion of additional and in some cases alternate assumptions for this specification are provided by Phillips and Hansen (1990), Hansen (1992), and Park (1992).

Let y, = (y_{lt}, y_{2t}) be an m-dimensional I(1) process. The generating mechanism for y_t is the cointegrated system in its triangular form:

$$y_{lt} = \beta' y_{2t} + \mu_{1t} \quad (6)$$

$$\Delta y_{2t}, = \mu_{2t} , \quad (7)$$

where μ_t, = (μ'_{1t}, u'_{2t},) is, in the general case, strictly stationary with zero mean and finite covariance matrix ∑. The benchmark case may be defined by μ, being independently, identically and normally (IIDN) distributed (0, 2) and y_t, block-diagonal. In this situation, Δy_2, is strictly exogenous and the OLS estimator of β in (6) is the MLE. In the general case, whenever ∑ is not block-diagonal and/or the μ_t, process is weakly dependent, the OLS estimator is not efficient.

The CCR estimator is based on a transformation of the variables in the cointegrating regression that removes the second-order bias of the OLS estimator in the general case mentioned earlier. Following Montalvo (1994), we write the long-run covariance matrix corresponding to (6) and (7) as

$$\Omega = \lim_{n\to\infty} \frac{1}{n} E\left(\sum_{t=1}^{n} u_t\right)\left(\sum_{t=1}^{n} u_t\right)' = \begin{bmatrix} \Omega_{11} & \Omega_{12} \\ \Omega_{21} & \Omega_{22} \end{bmatrix}. \quad (8)$$

The matrix Ω can be represented as the following sum:

$$\Omega = \Sigma + \Gamma + \Gamma' , \quad (9)$$

where

$$\Sigma = \lim_{n\to\infty} \frac{1}{n} \sum_{t=1}^{n} E(u_t u_t') \quad (10)$$

$$\Gamma = \lim_{n\to\infty} \frac{1}{n} \sum_{k=1}^{n-1} \sum_{t=k+1}^{n} E(u_t u_{t-k}') \quad (11)$$

$$\Lambda = \Sigma + \Gamma = (\Lambda_1, \Lambda_2) = \begin{bmatrix} \Lambda_{11} & \Lambda_{12} \\ \Lambda_{21} & \Lambda_{22} \end{bmatrix} \quad (12)$$

The transformed series is obtained as[1]

$$y^*_{2t} = y^*_{2t} - (\Sigma^{-1}\Lambda_2)'\mu_t \quad (13)$$

Thus the transformed Canonical regression form will take the form of:

$$y^*_{1t} = y^*_{2t} + \mu^*_{1t} \quad (14)$$

where

$$\mu^*_{1t} = \mu_{1t} - \Omega_{12}\Omega^{-1}{}_{22}\,\mu_{2t} \quad (15)$$

Therefore, in this context the OLS estimator of (14) is asymptotically equivalent to the Maximum likelihood (ML) estimator. The reason is that the transformation of the variables eliminates asymptotically the endogeneity caused by the long-run correlation of y_l, and y_t. In addition (15) shows how the transformation of the variables eradicates the asymptotic bias due to the possible cross correlation between μ_l, and μ_2 following Montalvo (1994). The regressors in (4) and indeed in CCR models further apply Wald test to test the significance of the regressors (Park, 1990, 1992).

RESULTS AND DISCUSSION

The regression analysis commenced with a unit root test of the series using Philips and Perron"s (1988) test. The results are presented in Table 1. From the results we found that most of the series including.

The dependent variable was I(1). There was one series (ln secondary school enrolment) whose t-statistic became significant only after the 2nd differencing, that is an I(2), variable and so it was regarded as a deterministic variable while the others were treated as stochastic series in the CCR modeling.

Having fulfilled the first requirements of determining the levels of integration of the series, it was affirmed that the model that can handle a mixture of deterministic and stochastic series which are cointegrated as experienced here would be CCR model by Park (1992) we estimated the model and obtained the initial results in Table 2. It is informative to note that Long-run covariance estimation was *prewhitened* with lags = 1, and the kernel applied

Table 1. Unit root tests on the series using Philips-Perron (PP) tests.

Series	PP tau stat at levels	Prob.	Remark	PP tau stat at 1st difference	Prob.	Remark
ln innovation	-2.297	0.178	Not significant	-13.113	0.000	I(1)
ln air transport	-0.936	0.765	Not significant	-4.085	0.003	I(1)
ln domestic credit to the private sector	-1.334	0.602	Not significant	-6.699	0.000	I(1)
ln official aids	-1.006	0.740	Not significant	-5.326	0.000	I(1)
ln secondary school enrolment	-1.1009	0.705	Not significant	-1.967	0.299	Sig. at 2nd diff. with t-stat = 5.345 at prob 0.000 that is I(2)
ln mobiles access	-0.469	0.886	Not significant	-5.671	0.000	I(1)
ln electricity consumption	-2.997	0.045	I(0)	-4.651	.001	I(1)

Source: Based on Econometric analysis of the series by the authors (2014).

Table 2. Unnormalized canonical cointegration regression.

Variable	Coefficient	Std. error	t-Statistic	Prob.
ln air transport	4.319	0.727	5.944	0.000
ln domestic credit to the private sector	1.378	0.641	2.150	0.040
ln official aids	1.461	0.470	3.107	0.004
ln mobiles access	0.027	0.020	1.368	0.182
ln electricity consumption	3.154	1.145	2.756	0.010
C (Intercept)	-144.909	31.042	-4.668	0.000
ln secondary school enrolment	-9.882	1.614	-6.123	0.000
R-squared	*0.772*	Mean dependent var		*17.799*
Adjusted R-squared	*0.725*	S.D. dependent var		*1.069*
Durbin-Watson stat	*2.416*	Long-run variance		*0.091*

Source: Analysis of World Bank Data by the author (2014); Dependent Variable = ln innovation.

was Bartlett kernel using Newey-West fixed bandwidth set at 4.000. The estimated model had an R^2 estimate of 0.78, which indicates that 78% of the variation in the innovation levels was accounted for by the included explanatory variables.

The results obtained in Table 2 was normalized (restricted linearly with coefficients of the independent variables set = 0) and the summary of the normalized regression results using Wald test are presented in Table 3. Before analyzing the specific results it is interesting to note that the overall test for the null hypothesis of the joint effects of the explanatory variables‟ effects on the dependent variable [that is, C(1)=0, C(2)=0,C(3)=0, C(4)=0, C(5)=0, C(6)=0, C(7)=0] gave an F-statistic of 18065.92 ($p<0.01$) implying that the null hypothesis was rejected and that the explanatory variables significantly influenced the variation in the dependent variable. The foregoing confirms the fitness of the model estimated.

Tables 2 and 3 indicated that almost all the hypothesized explanatory variables in the model (except mobile phones access) significantly determined the level of innovation during the period in review. Apart from the natural log of domestic credit to the private sector whose slope coefficient had t-statistic significant at $p<0.05$ the other significant series were significant at 1% ($p<0.01$). All the stochastic series found significant, including ln air transport (number of passengers transported by air in SSA); ln domestic credit to the private sector; ln official aids received from donors and ln electricity consumption, exerted positive effects on the level of innovation in the economy. Curiously, education, proxied by ln secondary school enrolment, indicated a negative function with growth of innovation in the economy. It may not be surprising to note this when we recalled what UK Essays (2014) asserted that “the educational systems in most African countries, which are more theoretical oriented than practical”, meant that there was a great gap between educational institutions‟ curriculum and the practical know-how required by industry and the SMEs.

“Students graduate from universities (tertiary-level) but have little if not any technical skills required for the jobs they are applying for”, it further noted.

Table 3. Wald test.

Normalized restriction for each variable (= 0)	Wald t-stat	Prob.	Remark
ln air transport	5.944	0.000	Significant at 1%
ln domestic credit to the private sector	2.149	0.040	Significant at 5%
ln official aids	3.106	0.004	Significant at 1%
ln mobiles access	1.368	0.182	Not significant
ln electricity consumption	2.756	0.010	Significant at 1%
C (Intercept)	-4.668	0.000	Significant at 1%
ln secondary school enrolment	-6.123	0.000	Significant at 1%

Source: Based on Econometric analysis of the series by the authors (2014).

The significant positive effect of air transport of passengers in the region affirms the assertion of Koser (2014) who held that free movement of labour especially for expatriates was very essential for innovation growth. Not only that, as more Africans travel to other countries they see more innovation and are more likely to copy or adapt them. When they adopt such innovations it could lead to increased farm productivity and also aid in ameliorating hunger. Thus it could be asserted that good transport infrastructure such as efficient airlines have significant roles to play in diffusion of agricultural innovations in Sub-Sahara Africa.

The effect of finance on innovation level was affirmed by the result which indicated that domestic credit to the private sector in SSA significantly determined the level of innovation. This finding is in agreement with many authors (Kaufmann and Tödtling, 2002; Kleinknecht; 1989; Freel, 1999 cited in UK Essays, 2014) who noted that many African countries‟ most crucial barrier to innovation was problem of finance and inability to cope with the risk structure in innovation. It is particularly in sync with Joseph Schumpeters‟ theory of creative destruction. This justifies International Expert Report (2012)‟s findings which noted that a number of agricultural development institutions were already involved in a variety of pilot projects including innovative financing mechanisms in Africa. The report noted that despite recent efforts to halt the growing level of malnutrition in SSA, it was unlikely that the international community will be able to levy the needed funds out of traditional resources, which tend to be restricted and more unpredictable in times of crisis. The report suggested instead that “alternative resources such as innovative financing mechanisms, in complement to traditional ODA, are urgently needed for agriculture, food security and nutrition.” Thus the findings here that domestic credit to the private sector in SSA significantly determined the level of innovation have been aptly corroborated.

Closely related to the issue of finance is official aid (technical, human or material aid) from different donors to SSAs which was found to have exerted positive and significant relationship with innovation level in SSA. The implication for this is that SSAs still need support from donors to frog leap her innovation levels. This assertion is corroborated by a research report published by Department for International Development (DFID) (2004) which held that recent efforts to alleviate poverty in developing countries have met with largely disappointing results; leading to a refocusing of attention on the role of agriculture in promoting economic growth and poverty reduction. However, perhaps surprisingly, the share of official development assistance (ODA) allocated to agricultural development had fallen during the past two decades. This trend could have serious consequences, the reported alerted. International support was one of the key triggers for the Green Revolution, and it could be argued that declining aid flows were limiting agricultural growth, especially in regions like Africa, where agricultural performance desperately needs to be improved. The Development Assistance Committee (DAC) of the Organisation for Economic Cooperation and Development (OECD) spoke of declining aid flows to agriculture as „a matter of increasing policy concern‟ (DFID, 2004), while the International Fund for Agricultural Development (IFAD) claimed that support for agriculture had „collapsed‟ (DFID, 2004). The report noted that the issue had also featured in major international summits, including Financing for Development in 2002, the Johannesburg World Summit on Sustainable Development in 2002 and the G8 meeting in Evian in 2003, all of which included calls for increased aid commitments to agriculture. Others are more guarded in the role they ascribe to ODA in achieving agricultural growth. For this group, the issue was improving the quality, not just the quantity, of ODA to agriculture. They believed that ODA in itself was not the answer, since aid or lending programmes to agriculture had experienced persistent problems of sustainability and institutional development (DFID, 2004). They argued that the limitations of international assistance should be recognized.

It was also found that electricity consumption was significantly and positively influencing the level of innovation

in SSA in this study. This finding underlies the importance of infrastructural development especially clean and sustainable source of energy that will trigger more innovation in the continent. A recent research findings by Arentsen and Bellekom (2014) concluded that local electricity initiatives could be considered a seedbed of innovation. Electricity supply and consumption can help improve the potentials for innovation in other service sectors and manufacturing sectors in any economy. As rightly noted by Canadian Electricity Association (2015) The motivating drivers for grid modernization in Canada reflect society‟s changing expectations of utility providers with regard to economic, environmental and social sustainability. Four key drivers were guiding the service-related decisions being made by utilities: reducing greenhouse gas emissions; increasing system resiliency to climate change and extreme weather events; empowering customers to play a more central role in shaping the electricity system; and containing costs to be able to do more with less. From the Canadian example one could clearly see that electricity infrastructure development could help trigger off a lot of other desirable innovations in the society.

Diagnosis

Our econometric diagnosis that follows validates our model. The estimated Jarque-Bera statistic was 4.037 with a p value of 0.132 (Appendix 1) implying that the estimated model‟s residuals is normal and hence it can be confidently said that we did not violate the assumption of the normality of the residuals in estimating CCR. A higher order test for serial correlation was done using Q-statistics following Greene (2008). The rule for this test is that if there is no serial correlation in the residuals of the model, the autocorrelations and partial autocorrelations (AC and PAC) at all lags should be nearly zero, and all Q-statistics should be insignificant with large p-values (Appendix 2). In our case, all the estimates of the AC and PACs were very close to zero and for 16 lags estimated, only in 3 lags did we observe AC and PAC values whose p values were significant at 5%, all others had very high p values above 5% implying that almost all the Q-stat of the PACs and the ACs were not statistically significant. So we uphold the null hypothesis of no significant higher order serial correlation in the residuals of the estimated CCR model. The test for the stability of the residuals of the model was done using Hansen Parameter Test for Instability. The test (a cointegration test) gave a long-run covariance statistic (Lc statistic) of 0.752 ($p>0.10$) indicating that null hypothesis which stated that the

“series are cointegrated” cannot be rejected. It should be noted that there were 5 stochastic trends in the asymptotic distribution and 2 deterministic trends which included one user-specified deterministic regressor [that is, natural log of secondary school enrolment, which was an I(2) variable]. The foregoing results imply that our model‟s residuals have all the desirable attributes - stable, devoid of significant serial correlation and normal; therefore very fit for economic analysis and forecasting. The forecasted model (Appendix 3) had Root Mean Squared Error (RMSE) of 0.49, a Theil inequality coefficient of 0.013, and even a very low Bias Proportion of 0.000 (indicating lack of bias) and a covariance proportion of 0.98 (98%). All these attest to the fact that the model has a very strong forecasting power.

Conclusion

This study has explored, through literature review and long-run econometric analysis (using cointegration modeling) to uncover some of the salient gaps and important drivers of innovation in SSA economies. Several challenges were exposed and cited by the author based on existing recent literature on innovation challenges in SSA. This exposition gave hints on some measurable challenges which were picked (as variables and proxies) and empirically tested by this researcher. The final result indicated that the most significant factors to consider in developing innovation in SSA includes finance, aids, improved mobility of labour through easing barriers to air transport within African countries (and other countries); improved access to electricity and education.

Based on the study‟s findings, the following recommendations are made: (i) SSA governments should work hand in hand with the banks and financial institutions to support the funding of education, research and development as well as increasing access to finance for entrepreneurship development especially SMEs so as to build the level of innovation in the region; (ii) The international communities and donors especially should be encouraged to contribute to building global innovation systems by supporting SSA firms and research institutions to build their innovation capacities through funding and technical supports; (iii) SSA countries should remove barriers to labour mobility through flexible immigration policies; building and supporting of national carriers as well as private airlines; (iv) There is need for SSA countries to take the issues of electricity access to the citizens as well as educational reforms especially vocational education as national emergencies.

REFERENCES

Adebisi SA, Babatunde BO (2011). Innovation management and organization development in the Nigerian Banking System. Bulletin LXIII (1):1-82.Economic Sciences Series, Petroleum-Gas University of Ploiesti.

Arentsen M, Bellekom S (2014). Power to the people: local energy initiatives as seedbeds of innovation? Energy, Sustainability and Society, 4:2 Accessed on 5/05/2015 from http://www.energsustainsoc.com/content/4/1/2

Baker E (2005). Institutional barriers to technology diffusion in rural

Africa. Selected paper presented at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24-27 2005.

Bogliacino F, Perani G, Pianta M, Supino S (2009). Innovation in developing countries. the evidence from innovation surveys. Paper for the FIRB conference Research and Entrepreneurship in the knowledge-based economy, Bocconi University, Milan, 7-8 September.

Canadian Electricity Association (2015). Electric Utility Innovation: Toward Vision 2050. Accessed on 5/05/2015 from http://www.electricity.ca/media/ElectricUtilityInnovation/ElectricUtilityInnovation.pdf

Chang Y, Martinez-Chombo (2003). Electricity Demand Analysis Using Cointegration and Error-Correction Models with Time Varying Parameters: The Mexican Case. Department of Economics Department of Economic Research Rice University Banco de Mexico.

Coe S (2014). Africa: focus on disability - barriers to creative innovation. In SciDev.Net. Accessed on 27/08/2014 from http://allafrica.com/stories/201408121564.html

Department for International Development (DFID) (2004) Official Development Assistance to Agriculture. London: Agriculture and Natural Resources Team of the UK Department for International Development (DFID).

Dickey DA, Fuller WA (1979). Distribution of the estimators for autoregressive time series with a unit root. J. Am. Stat. Assoc. 74:427-431.

Engle R, Granger C (1987). Cointegration and error correction representation: estimation and testing. Econometrica 55:251-276.

Food and Agriculture Organization (FAO) (2003). World agriculture : towards 2015/2030: an FAO perspective. Bruinsma, J (Ed.). Earthscan Publications, USA and UK.

Greene WH (2008). *Econometric analysis*. 5th Edition. New Delhi, India: Pearson Education.

Hansen BE (1992). Tests for Parameter Instability in Regressions with I(1) Processes. J. Bus. Econ. Stat. 10:321-335.

Harvey AC (1989). Forecasting Structural Time Series Models and the Kalman Filter. Cambridge: Cambridge University Press.

International Expert Report (2012). Innovative finance for agriculture, food security and nutrition. Report of the High-Level Expert Committee to the Leading Group on Innovative Financing for Agriculture, Food Security and Nutrition. Innovative Financing to Fund Development Leading Group. Accessed on5/05/2015 from http://leadinggroup.org/IMG/pdf/Innovative_financing_for_agriculture_food_security_and_nutrition_dec_2012_english.pdf

Johansen S (1996). Likelihood-Based Inference in Cointegrated Vector Autoregressive Models. Oxford, UK: Oxford University Press.

Johansen S, Juselius K (1990). Maximum likelihood estimation and inference on cointegration–with application to the demand for money, Oxford Bull. Econ. Stat. 52:169-210.

Juselius K (2006). The cointegrated VAR model*:* Methodology and applications. Oxford University Press, Oxford.

Kaufmann A, Stern DI (2002). Cointegration analysis of hemispheric temperature relations. J. Geophys. Res. 107(D2). 10.1029/2000JD000174.

Kelly DL (2000). Unit Roots in the Climate: Is the Recent Warming Due to Persistent Shocks? Working Paper. Department of Economics, University of Miami.

Koser K (2014). The four main barriers to talent mobility in Africa. Global Council Post. Accessed on 25/8/14 from http://forumblog.org/2014/06/africa-talent-mobility-barriers/

Lipsey RG, Carlaw KI, Bekar CT (2005). Economic transformations: general purpose technologies and long-term economic growth. Oxford: Oxford University Press.

Meschi E, Taymaz E, Vivarelli M (2008). Trade openness and the demand for skills: evidence from Turkish Microdata, IZA Discussion Paper No. 3887.

Meyer D (2003). Diagnostics for Canonical Correlation. Res. Lett. Inf. Math. Sci. **4**: 79-89 Available online at http://iims.massey.ac.nz/research/letters

Microsoft-Encarta (2009). Schumpeter's theory of creative destruction. In 1993-2008 Microsoft Corporation DVD.

Mokwunye U (2009). Regional review of Africa"s agricultural research and development. GCARD 2010.

Oyelaran-Oyeyinka B (2009). Technology innovation and development: long term perspective for Africa. Keynote Paper Presented at the ATPS Annual Conference: "Africa"s Response to Global Challenges through Science, Technology and Innovation", November 24-27, 2009.

Park JY (1990). Testing for unit roots and cointegration by variable addition. In Fomby TB, Rhodes GF Jr (eds.), *Advances in Econometrics: Co-integration, Spurious Regression, and Unit Roots*, 107-133. Greenwich, Connecticut: JAI Press.

Park JY (1992). Canonical Cointegrating Regressions. Econometrica 60 (1):119-143. Journal of the Econometric Society. Available at http://www.jstor.org/stable/2951679

Pesaran MH, Shin Y, Smith RJ (2001). Bounds testing approaches to the analysis of level relationships, J. Appl. Econometrics 16:289-326.

Phillips PCB, Perron P (1988). Testing for a unit root in time series regression, *Biometrika* 75:335-359. (The year of publication do not correspond with that cited in the article).

Rothwell R, Zegvield W (1985). Reindustrialization and technology, London: Longman.

Roud V (2008). Patterns of innovative behaviour of Russian manufacturing firms: analysis of firmlevel data, paper presented at MEIDE conference.

SCAR-Collaborative Working Group AKIS (2012) Agricultural Knowledge and Innovation Systems in Transition – a reflection paper. Brussels.

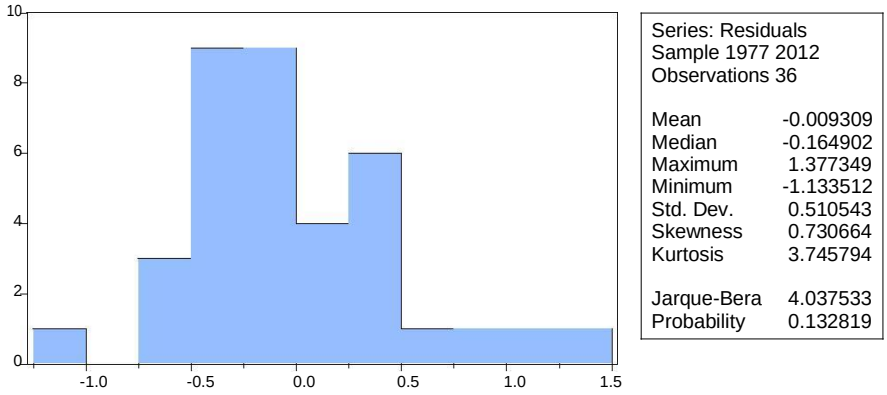
Sutz J (2000). Las encuestas de innovación latinoamericanas : an ánalisis comparativo de las formas de indagación. Working paper for the project Normalización de Indicadores de Innovación Tecnológica en America Latina. OEA.

UK Essays (2014). Barriers to innovation in SMEs in Africa. Economics Essay assessed on 26/08/2014 from http://www.ukessays.com/essays/economics/barriers-to-innovation-in-smes-in-africa-economics-essay.php

Yegorov I (2008). Innovation Policy and Problems of Creation and Development of the National Innovation System in Ukraine, paper for the UNECE conference, 14-15 February 2008, Geneva.

World Bank (2011). Agricultural innovation systems: an investment sourcebook overview. Washington D.C. The International Bank for Reconstruction and Development / The World Bank.

World Bank (2012). World Development Indicators; Accessed from http://www.worldbank.org.



Appendix 1. Test of normality of the residuals of the estimated model.

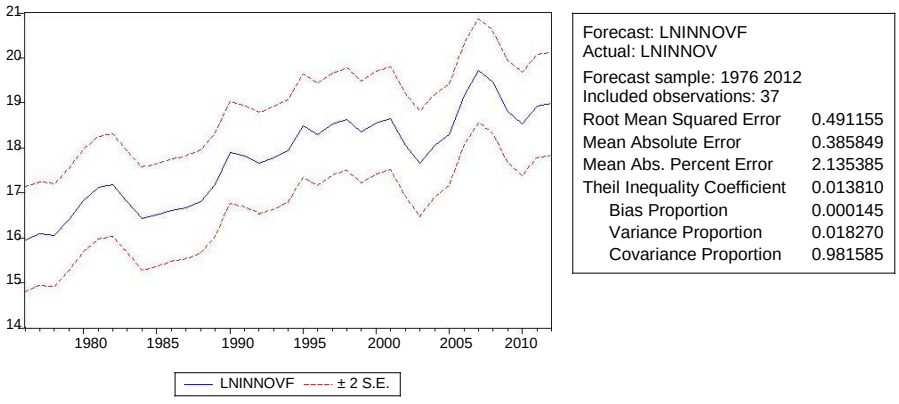
Appendix 2. Serial correlation tests on the residuals of the estimated model using q-stastistic**.**

Date: 08/29/14 Time: 19:07

Sample: 1977 2012

Included observations: 36

Autocorrelation	Partial correlation		AC	PAC	Q-Stat	Prob
**| . |	**| . |	1	-0.210	-0.210	1.7191	0.190
. |** |	. |** |	2	0.283	0.250	4.9412	0.085
***| . |	**| . |	3	-0.373	-0.308	10.719	0.013
.*| . |	***| . |	4	-0.132	-0.349	11.460	0.022
.*| . |	. | . |	5	-0.119	-0.028	12.080	0.034
. | . |	.*| . |	6	-0.053	-0.099	12.210	0.057
. | . |	**| . |	7	-0.052	-0.303	12.339	0.090
. | . |	.*| . |	8	0.048	-0.117	12.452	0.132
. | . |	. | . |	9	0.040	-0.009	12.533	0.185
. |*. |	.*| . |	10	0.107	-0.087	13.139	0.216
. | . |	. | . |	11	0.066	-0.056	13.377	0.269
. | . |	. | . |	12	-0.006	-0.049	13.379	0.342
. |*. |	. |*. |	13	0.094	0.123	13.899	0.381
. | . |	. | . |	14	-0.057	0.055	14.098	0.442
. |*. |	. |*. |	15	0.117	0.150	14.992	0.452
**| . |	.*| . |	16	-0.240	-0.109	18.942	0.272



Appendix 3. The parameters tests of the forecasted models.