RECONSTRUCTING LONG-RUN ECONOMICS: SURVEY AND ISSUES

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ABSTRACT

This article surveys the literature on the usages and applications of the notion of long-run in economics. Issues therefrom, are discussed and probable solutions proffered to thorny issues. The developing professional economist is advised to always resist the temptation to model every economic phenomenon in terms of the long-run. In some branches of economics, the focus of policy is often the short run and this should be respected in the modeling process. Where it is deemed absolutely necessary to undertake a long-run exercise, attention should be paid to issues of model specification and analysis.

Key Words: General Economics; Economic Education and Teaching of Economics; History of Economic Thought; Economic Methodology, Econometric Modeling; General Aggregative Models; Technological Change, Research and Development; Economic Growth and Aggregate Productivity.

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INTRODUCTION

In the literature, the origin of long-run in economic thinking and analysis appears to date to the Classical economists, in particular, David Hume, in his checkmating drive against the Mercantilists around the mid eighteenth century. There is perhaps no area of economics that is today immune to the long-run influence. Over time however, several economists of the classical brand and those of other persuasions have conceptualized the notion variously in the literature. The beginning student is told in microeconomics that the long-run curve could in some contexts equal the short-run curve or could be an average of the minimum points on all the short run curves. He soon discovers that there are somewhat related but computationally different counterparts in macroeconomics – permanent income, and in financial/monetary economics – term structure of interest rate.

At a later date in the course of his training, he is told that some real variables (deflated or natural) e.g. saving and(fixed) capital formations generate long-run effect. He begins to believe that all variables have long-run or steady state values. Just then, he is introduced to the concept of natural rate level of output and the associated long-run aggregate supply curve and told that only factors/variables causing shift of this curve qualify to be admitted into the class of long-run growth drivers. Not only does he begin to view variables such as, technology (National System of

Innovations), tastes and productivity growth as the critical drivers in this sense, but also has written in his memory, an economy-wide or macroeconomy long-run state.

His confused state knows no bound when as a research student, he traverses the literature on economic growth, demand for money, balance of payments and productivity growth and encounters varying application of the notion of long-run. He clearly needs help to separate the grain from the chaff in the course of his professional growth; this is the essence of this survey. It is generally non-technical and does not pretend to be exhaustive of the subject but at least, endeavors to pinpoint key issues of emphasis, focus and the attendant conceptual and application problems in the literature on the different models.

The rest of the paper is organized as follows. Section II deals with growth models as evolved dynamically while section III is concerned with financial models emphasizing long-run effect. Section IV focuses on econometric approaches to long-run modeling while section V deals with the matters arising from the review, drawing support from the writer's research endeavors and those of some of his graduate students. Section VI provides some concluding remarks.

Economic Growth

Classical economists such as Smith (1991), Malthus (1798) and Ricardo and Eck (1817) did not directly address the issue of long-run growth though occasional references to 'steady state' permeate their expositions on growth. Mostly, particularly, Smith, Malthus and Ricardo emphasized the efficacy of the 'invisible hand' in restoring the economy of the typical capitalist economy to long-run equilibrium. All of them recognize the importance of productivity (of labor – which depends on capital investment – in the case of Smith and Malthus, and of capital, in the case of Ricardo) in the drive up to the long-run. While Smith insinuated about the possibility of the economy growing continuously and powered by increasing capital investment driving labor productivity, both Malthus and Ricardo were pessimistic outright about the possibility of the economy growing beyond the 'steady state (Both Malthus and Ricardo believed that labor productivity would be counterbalanced by population growth in the steady or stationary state). Even, the mathematical formulation of the Classics' steady state condition for increasing capital accumulation by Ramsey (1928) and later applied by other neoclassical economists such as, Cass (1965) and Koopmans (1965)does not appear to have improved on the submission of the Classics; the odds against growing capital accumulation beyond the steady-state are simply very weighty (They submit that, the steady-state capital stock will be higher if capital is more productive and lower if consumers are more impatient, population growth is faster, depreciation is greater, or technological progress is more rapid).

The original classical growth models were succeeded by the Keynesian models as pioneered by Harrod (1939) and Domar (1946). The Keynesian models mostly used production functions with little substitutability among the inputs to argue that the capitalist system is inherently unstable. Since these arguments were developed during or immediately after the Great Depression, they were received sympathetically by economists. However, they are not relevant to the analysis of long-run as the Keynesians of the time did not believe in the idea (More recent Keynesian models generally admit the existence of long-run in the economy).

The next and most important contribution to modern growth theory have been the works of Solow (1956) and Swan (1956) both of neoclassical orientation. The distinctive feature of their

model which is also referred to as the exogenous growth model is in its special specification which is a production function built on the assumptions of constant returns to scale, constant saving rate, diminishing returns to factor inputs and some positive and smooth elasticity of substitution between the inputs. The assumption of factor substitutability is to allow for a stable equilibrium growth and the constant saving rate makes possible, the generation of a simple general equilibrium model of the economy.

A key prediction of the aforementioned neoclassical model is conditional convergence which interprets simply that, the lower the starting level of per capita gross domestic product (GDP) compared with the long-run or steady-state position, the faster the growth rate. Such a possibility is induced by the assumption of diminishing returns to capital according to which economies with low capital per worker tend to generate relatively higher rates of return and higher growth rates. The convergence is conditional in the Solow-Swan model because steady-state levels of capital and output per worker depend, on the saving rate, the growth rate of the population and the position of the production function that might vary across economies. Recent empirical studies have suggested additional sources of cross-country variation, particularly, differences in government policies and in initial stocks of human capital.

In terms of the long-run, the Solow-Swan model basically implies that a higher saving-investment ratio simply raises the level of income per capita but would have no effect on the rate of economic growth. This way, per capita growth must eventually come to an end. The only way to alter this equation and avoid such an implied stagnation is to augment the production processes of the economy with new technologies. In other words, unlike Malthus and Ricardo, the model explicitly recognizes the role of technological progress at generating growth beyond the steady-state. Thus, technological innovation received first mention as long-run growth driver. In recognition of this novel submission, the neoclassical economists of the late 1950s and 1960s explicitly factored technological progress as an exogenous variable into their growth models while also retaining the equally novel prediction of conditional convergence (The idea of convergence is actually traceable to Malthus in his analysis of population growth dynamics. However, it seems that the negative implication of his theory for mankind informed the very scanty mention of his convergence proposition in the literature even when some empirical regularity could be adduced to it).

The first known attempt to explicitly introduce ideas into growth models was by Arrow (1962) and later by Sheshinski (1967). In these models, ideas were unintended by-products of production or investment. This mechanism is described as learning-by-doing. The setting is such that, each new idea immediately spreads through the entire economy. This diffusion process might be technically feasible because knowledge is non-rival. This basic neoclassical model was further developed by Cass (1965),Koopsman (1965) and others. In particular, Cass and Koopsman applied Ramsey's analysis of consumer optimization in the drive to endogenize the determination of the saving rate. This extension tends to preserve the hypothesis of conditional convergence while allowing for strong transitional dynamics. However, as discovered by the authors, it is not easy to create compatibility between the theory of technological change and the neoclassical framework because the standard assumptions of competition cannot be met. The reason being that technological progress requires the creation of new ideas which as shown in the work of Arrow

(1962) and Sheshinski (1967), are partially non-rival. Cass (1972) thus represents a refinement of the initial efforts in this area.

Beginning from the early 1970s and for about 15 years, there appears to be an interregnum in long-run growth theorizing in the literature with the advent of rational expectations and on the eve of the oil shocks. Accordingly, short run vacillations dominated most of economic thinking to the extent that the incorporation of rational expectations into business cycle models received the most attention.

Resurgence occurred around the mid-1980s with the entry of endogenous growth models heralded by the pioneering works of Romer (1986) and Lucas (1988).The aim was to study the determinants of long-run growth and put more emphasis on these determinants rather than the mechanics of business cycles or the countercyclical effects of monetary and fiscal policies. However, the recognition of the importance of long-run growth was only a first step. The second step was to abandon the main idea of the neoclassical growth model according to which the long-run per capita growth rate is linked to the rate of an exogenous technological progress (The endogenous growth models are generally referred to as the AK models due to the usual presence of AK in the production function; A, represents the level of technology and K, often, is a composite of human and physical capital. Some of the models e.g. Lucas (1988) however, enter human capital distinctly and independent of physical capital).

The initial phase of the new theory which was based on the research by Arrow (1962), Sheshinski (1967) and Uzawa (1965) as re-modeled by Romer (1986), Lucas (1988) and Rebelo (1991) did not really present a theory of technological change. In these models, growth may continue limitless because, the returns to investment in capital resources, including human capital, do not diminish necessarily as economies grow; human capital and the flow of knowledge across producers help to prevent the tendency for diminishing returns to the capital accumulation. This wave of research which incorporated research and development (R & D) theories and imperfect competition into growth models began with Romer (1987, 1990) and found significant contributions by Aghion and Howitt (1992) and Grossman and Helpman (1991).

In these models, purposive R & D activity which results from some form of ex post monopoly power, results into technological progress. Thus, as long as the economy is not devoid of ideas (new ideas), the growth rate can be raised in the long-run. However, the growth rate and the inventive activity may not be Pareto optimal, due to the failure to create the new product and innovate on the production methods. In this framework, the long-term growth depends on government intervention which could take the form of taxation, maintenance of law and order, provision of infrastructural services, protection of intellectual property rights and regulations of international trade, financial markets and other aspects of the economy. Thus, the long-term growth can greatly be influenced by government actions.

The research agenda of endogenous growth also covers models of diffusion of technology. The diffusion models are related to the way in which follower economies contribute to these advances by imitation of leading-edge economies, while the analysis of innovation deals with the rate of technological progress in these advanced countries. Since imitation is cheaper than innovation, the diffusion models predict a form of conditional convergence that resembles the prediction of the neoclassical growth model. Also, it implicitly underwrites human capital as a

long-run growth driver as countries with an accumulation of such capital tend to absorb new technologies faster (See Barro (1991) citing Nelson and Phelps, 1966).

Another key exogeneity assumption of the neoclassical growth model jettisoned by endogenous growth is the growth rate of the population. To the neoclassic, the higher the growth rate of the population, the lower the steady-state level of capital and the output per capita growth rate for a given initial level of per capita output. This belief does not however, take account of the effects of per capita income and wage rates on population as well as the resources used up in the process of child rearing. Under the endogenous models, population growth is endogenized through the incorporation of an analysis of fertility choice into the neoclassical model. The results obtained from these studies are consistent with the empirical regularity of fertility rates. This is so because, fertility rates tend to fall with per capita income over the main range of experience, but it may rise with per capita income for the poorer countries. Another growth research based on the endogeneity of labor supply is concerned with migration and labor-leisure choice.

In general, the endogenous growth theory has developed into two generations. The first phase was the development of the generation of semi-endogenous growth models and the second was the Schumpeterian growth theory. The most contributors to the semi-endogenous models were Jones (1995), Kortum (1997) and Segerstrom (1998). The key element of this contribution is the abandon of scale effects in ideas generation by assuming diminishing returns to the stock of R & D knowledge. Thus, R & D is assumed to increase continuously to sustain positive total factor productivity (TFP) growth rate.

The second generation was the Schumpeterian models which have been developed by Aghion and Howitt (1994, 1998), Peretto (1998), Young (1998), Dinopoulos and Thompson (1999) and Peretto and Smulders (2002). These models maintain the assumption of constant returns to stock of R & D knowledge. However, they assume that the effectiveness of R & D decline due to the prosperity of products as the economy grows. In general, growth can still be sustainable at a constant level, provided that R and D process is kept to a fixed proportion of the number of product lines. In turn, this is proportional to the size of the population along the balanced growth path. As such, R & D has to rise over time to overcome the increasing range and complexity of products lowering the productivity effects of R & D activity, in order to ensure a sustainable TFP growth rate.

Financial Models

Most generations of classical economists believe that money or finance has no effect on the real sector and thus, it is of negligible long-run value. The debate on the famous classical dichotomy and the associated neutrality/super neutrality of money is very instructive. And, as recent as 1968, Milton Friedman of the Monetarist fame wrote on what monetary policy could do: altering the real equilibrium of the economy was not one of such. By and large, the New Classical Macroeconomic School led by Robert Lucas upholds this tradition of the Classics in its analysis of policy effectiveness under rational expectations.

A somewhat new direction to thinking about the way money or finance affects the macroeconomy began to emerge around the mid-1970s following the simultaneous publications of Mckinnon (1973) and Shaw (1973) on the doctrine of financial repression and its antidote, financial liberalization (Both scholars are traditionally, neoclassical. Note also that, the concept of

financial liberalization dates back a much longer period when it was generally referred to as financial deepening (see e.g. Wallich, 1969). However, the 1973 publications of the Mckinnon and Shaw added fresh insights). Simply put, the doctrine of financial repression identifies the interventionist policies of governments (mostly, in developing countries) as the bane of underdevelopment of the financial sector, manifesting in slow or stunted growth of the real sector of the economy. The culprit policies were identified to include, fixed or administratively determined interest rates in the face of rising/unsteady inflation, fixed exchange rate maintained through frequent reserve intervention in the foreign exchange market, reserve requirements penalizing the banking sector and discriminatory high taxes on financial transactions. While acknowledging that the descent into financial repression may have been inadvertent with financial restriction being the original target, the eventual end result, imposes severe penalty on banks' ability to competitively mobilize saving, take risk and innovate while reducing the volume (in real terms) and quality of credit and hence, investment, in the economy. Correcting these anomalies through a reform of banking and financial sector policies in order to raise the average efficiency of investment would produce a multiplicative impact on growth.

The school of thought that emerged subsequently was to generate several publications demonstrating both theoretically and empirically, the mechanisms by which the new view would affect steady state growth of the typical financially repressed developing economy. Prominent members of this school include Kapur (1976), Galbis (1977), Fry (1978, 1980a, 1980b, 1981), Mathieson (1980), and Yoon Je Cho (1986,1988). In particular, real interest rate, required reserve ratio and bank credit were emphasized as sources of long-run growth (The Neostructuralists particularly, Taylor (1983), Buffie (1984) and vanWijnbergen (1983, 1984) took serious issues with the Mckinnon- Shaw School's submission demonstrating that, the omission to accommodate the informal financial sector of the economy in the various financial models may have been the source of the school's optimistic conclusion on the role of financial sector reforms on growth). In some contexts, a narrative index of financial reform policies is constructed in order to capture both exogenous shift in policy stance as well as the endogenous response of monetary/financial policy to economic development. The resultant series is then plugged into the growth model as a long-run driver. Generally, such narrative index constructions are usually guided by Romer and Romer (1989) and Boschen and Mills (1991).

The Mckinnon-Shaw school's prescription for long-run growth appears to have received some support from the endogenous growth models. Under this extension to the endogenous models (as inspired by Romer, 1990), financial repression is modeled as a disincentive to innovative processes hence, causing productivity growth to fall. Thus, the resultant technological slow down generates adverse effect on steady-state growth. Bencivenga and Smith (1991), De Gregorio (1992), Roubini and Sala-i-Martin (1992) and King and Levine (1993) are some of the major contributors to this literature (In some of these models (e.g. Roubini and Sala-i-Martin, 1992), financial innovation is represented by a distinct variable, that is, in addition to the basic AK features).

Econometric Approaches

Overtime, economists have applied different econometric methods in the investigation of the notion of long-run as may be warranted by the foci of their studies. The observed dynamics in

this regard have been largely informed by developments not only in economics itself but also in econometric theory. For example, the emergence of the unit root – cointegration literature in the past two decades was a response to the perceived defects in the earlier econometric approaches to the issue of long-run. Also, the Lucas (1976) critique on macroeconomic policy formulation procedure resulted in the refinement of existing structural models of the economy and played a key part in the development and popularity of structural vector autoregressive (SVAR) approach to long-run modeling. As noted by Pesaran (1997), long-run estimation in economics is now commonly associated with the notion of equilibrium in the wake of the unit root – cointegration methodology, first introduced by Granger (1981) and elaborated upon for stronger theoretical basis by Engle and Granger (1987). However, Pesaran (ibid.) also observed that, much of the time series long-run analysis is being conducted without explicit account of the underlying equilibrium theories. In what follows, a brief discussion of the major econometric approaches to the analysis of the notion of long-run in the literature is undertaken.

Ordinary Least Squares

The Least squares method (OLS),has been described as the most common approach to long-run modeling (see e.g.Monfort and Mulder, 2000; Mora, 2006; Afonso, Gomes and Rother, 2007)). The method asserts very simply that, to fit a point to the data values, the sum of the squares of the vertical difference from each of the point to the fitted line must be as small as possible in the long-run. The idea of using least squares approach for long-run estimation is to minimize the sum of squared residuals associated with the data, such that, all the endogenous variables will grow at constant (not necessarily identical) rates overtime.

In time series analysis, OLS approach constitutes a veritable means of estimating classical long-run relationships. For instance, the methodology underlies the specification of long-run equilibrium equation for data that are purely non-stationary due to unit roots, but are integrated of the same order. Thus, for example, in the specification below, the error term, μ_t, is believed to be identically and independently distributed (IID).

$$y_t = \beta_0 + \beta_1 x_t + \mu_t \qquad (1)$$

The estimate obtained from the specification is referred to as long-run estimates. By its simple approach, OLS method became endeared to many and has been widely applied in the estimation of long-run phenomena. Kim, Fraser and Hyndman (2007) estimated a long-run response parameter from a general dynamic least squares model, and observed that the interval estimation obtained from the long-run response (elasticity) parameter using a general linear dynamic model was superior to other long-run response estimation methods. The authors observed that this has manifested in three main areas. First, point estimates of the long-run response are often extremely desperate (see also, Marquez and McNeilly, 1988; Askari and Cummings, 1977). Second, it is difficult to estimate accurately the sampling variability of the long-run response estimator (see also, Li and Maddala, 1999). Third, the long-run response estimator can be severely biased when small sample is used. In using interval estimation approach, the small sample biases associated with the parameter estimators are adjusted in the two stages of the bootstrap and it was observed that the outcome performed better for small sample estimates.

In another perspective, Monfort and Mulder (2000), Mora (2006) and Afonso, Gomes and Rother (2007) employed linear method and ordered response models to estimate short and long-run determinants of sovereign debt ratings. The result from the linear method showed a good performance for the estimated model while the ordered probit model differed only in term of the overall predictive power (This has become a natural approach to such type of problem when rating is a discrete variable and reflects the order in terms of the probability of default (see Afonso, *et al*, 2007).). Pesaran and Shin (1996) showed in a similar analysis, but using a general linear autoregressive distributive lag (ARDL) model, that valid asymptotic inferences on the short and long-run parameters can be made using least square estimates. So far, the use of the linear method has been limited by two factors. On the one hand, it is static and does not separate the short-run phenomena from the long-run as in the use of dynamic models such as Structural VAR and Vector Error Correction Models.

On the other hand, the use of only a set of exogenous regression equation that sets some factors to influence the dependent variable within the framework of single-equation has been considered to be faulty (Kibritcioglu and Dibooglu, 2001). Such studies usually consider one-way causalities running from selected economic (and recently, non-economic) regressors to a particular determined variable, ignoring the possible endogeneity of the variable factors. It is also noted in the study by Kibritcioglu and Dibooglu, above that, while long-run modeling is strictly within the confine of the use of OLS methodology, the issue of long-run economic growth may sometime be more complex than to be captured by estimating only single-equation regressions. Attempt at overcoming the problem is the use of log linear specifications to represent long-run situations (Al-Azzam and Hawdon, 1998). One major advantage of this approach is that it yields elasticities in a convenient form and has been found to work well with studies using error correction methods.

Two Stage Least Squares

Two stage least squares (2SLS) modeling approach is used to estimate parameters of identified structural equations. The methodology arose as an attempt to correct simultaneity biases in structural equations models. In the presence of simultaneity problem, the methodology of OLS will fail to produce robust estimates, as the resulting endogenous variable is likely to be correlated with another error term. Simultaneity problem arises when some of the regressors of a model become also endogenous. Based on the underlying assumptions of OLS methodology, the implication of such resultant situation is that there will be a correlation between the endogenous variables and another random error term.

Two stage least squares involves two stages of regressions. The first stage of the regressions attempt to get rid of the resulting correlation between the endogenous variables and the resulting random error terms. The first regression runs all the explanatory variables in the system against the exogenous variable. The second stage involves replacing exogenous parameter with its estimated value, and then applying a regression to the transformed equation. The basic idea of 2SLS is to correct the stochastic error term in the first equation of the influence on the explanatory variables with which it is correlated. The resulting estimates obtained will be consistent as well as normal (especially for large samples). The main advantage of 2SLS approach to econometric modeling is that each of the equations is/can be treated and estimated separately. The 2SLS is just an OLS specification adjusted to correct simultaneity problems. A long-run

specification of 2SLS is usually in semi-log (log-ln). In a situation where the right hand side of the equation becomes endogenous thereby, correlating with the error term, OLS estimations become imprecise. This is the reason for two stage regression approach.

The 2SLS approach requires that the long-run equilibrium relationship (i.e. the cointegrating regression) be modeled as a simple regression involving the levels of the variables. In the first step, all dynamics are ignored and the cointegrating regression is estimated by the OLS. Since the variable in such model is likely to be spurious, only a little attention should be paid to standard error estimates (and thus, t-statistics) in the cointegrating regression. This first regression however serves as a veritable source of comparison with the second regression after being corrected.

Large-Scale Simultaneous Equation Models

The use of Large-Scale Simultaneous Models (LSEM) became popular following a number of models that were developed by the Federal Reserve Board in US and other versions in UK and Australia (Brayton and Mauskopt, 1985; Murphy 1992 and Brayton and Tinsley, 1996). Two factors however account for the little popularity of the models in the recent time. First, there was the relatively poor forecasting of the models in the face of stagflation that manifested in many economies in the 1970s. Second, the advent of rational expectations economics was a major setback for the LSEMs especially, as regards the reliability of their forecasts. For example, the Lucas critique of 1976, and subsequently, Sims (1980b) critique on identification raised serious doubts about the usefulness of the models. The critique generated interests on the use of VAR for macro-econometric analysis. According to Garratt *et al* (2000), this development manifested in three important areas of macro modeling. First, its influence in cointegration analysis arising partly from the response to Sims' critique of the use of incredible identification restrictions involving short-run dynamics which subsequently, led to a consensus that the most important aspect of any structural model is its long-run relationships. Thus, a model must be identified without having to restrict its short-run dynamics. Second, in response to the criticism that large-scale models paid insufficient attention to the micro foundations of the underlying relationships and the properties of the macroeconomic system, economic theory has become better patronized in the specification of large models. Third, as a resolution to Lucas critique, rational expectations (RE) theory becomes incorporated into large-scale models.

Maximum Likelihood Estimation

The maximum likelihood approach (MLE) is used for any function that is conditioned on a set of sample outcomes. It is possible that, in the course of modeling a situation, the dependent variable may be bounded (such as between zero and one), implying that the use of the OLS methodology will be unsuitable as their resulting estimate will be biased. Maximizing the likelihood function (usually with respect to a particular value) implies finding the value of such variable in question. This amounts to maximizing the probability of obtaining the sample values that have actually been observed. This approach has been used by a number of long-run analysts. For example, Patibandla (1996) employed a Cournot Oligopoly model, and used the MLE to solve for the profit maximizing conditions for domestic sales and exports equilibrium in an import restricted market.

Cointegration Approach

Cointegration analysis is a technique applied to estimate the accuracy of correlations between two or more non-stationary variables (Amiri *et al.*, 2011). If the trending time series involved in the regression tends to move together, or are of the same wave-length, this suggest that the use of OLS regression to estimate such model is not likely to be spurious. The existence of cointegration between, say, two macroeconomic variables implies "a true long-run economic relationship" which prevents the residuals (of the resulting equation) from becoming increasingly larger in the long-run.

The use of cointegration analysis has played a key role in economics since its inception. In many instances, it has been referred to as the most revolutionary development in econometrics since the mid-1980s (Seddiighi, 2000). Before then, most economists use to apply linear regressions on non-stationary time series data which are known to produce spurious relationships (Granger, 1981).The essence of testing for cointegration is to avoid spurious regression estimates. The synchrony of the non-stationary time series is the idea behind the concept of cointegration (Gujarati, 2004). Two variables are said to be cointegrated if they have a long-term, or equilibrium relationship between them.

It is important to mention that, cointegration approach may produce different result from other methodologies mentioned earlier. For instance, Sinha (1999) employed a cointegration technique to estimate a traditionally formulated import demand function which ignored the impact of foreign exchange rationing and other restrictions, and did not find any relation between foreign exchange availability and import in India. This result is in contrast with the long-run income and price elasticity estimated by Emran and Shilpi (2008) with a model satisfying the theoretical signs and restrictions. And, the results obtained from the latter study were found to be both significant and economical.

Another major advantage of the cointegration technique is that, it also provides applied econometricians with effective formal framework for testing and estimating long-run models from actual time-series data (Utkulu, 1994). The Engle and Granger static type of long-run ordinary-least-squares regression parameters eventually became accepted as both consistent and highly efficient (Stock (1987)). This position was however not unchallenged (see Banerjee *et al*. (1986) and Blough (1988)). The argument is that ignoring the lagged terms in small samples is likely to create a bias in the estimated parameters. This criticism may have prompted methodology which either tries to incorporate dynamic components (in the form of differencing or lags), or that is concerned with appropriate corrections and modifications to the static parameter estimates. The aftermath of the two responses is that since the two groups of critics emphasize different aspects of the problem, they naturally lead to different solutions. One of the eventual results to the evolving debate was the adoption by many authors of the error-correction estimator approach.

Vector Autoregressive Approach

The Vector Autoregressive (VAR) model, pioneered by Sims (1972, 1980a), is a general framework to describe the dynamic interrelationships between stationary variables. In its original sense, the VAR methodology is used to observe the interdependencies among short-run variables. The modeling approach advocated for long-run relationship is the structural cointegrating VAR

approach. It is based on log-linear model estimated subject to long-run relationship obtained from economic theory. Pesaran (1997) observed that for the purpose of empirical analysis, it is suitable to fit the short-run relation of variables within a suitable multivariate model such as VAR with unrestricted coefficients. By implication, the long-run relation of such model can be embedded within a restricted VAR. Similar approaches of long-run methodology has been suggested using the global VAR (GVAR) model of Pesaran*et al* (2004), and which was further developed by Dees *et al* (2007).

The foregoing implies that the dynamics of adjustment to long-run equilibrium in any of such model must have been restricted. This can be achieved by utilizing the intertemporal nature of the underlying optimization problem as it is done under the rational expectations hypothesis or from the specifications of economic theory. The implication of this modeling approach is that it is relatively simple to implement for optimization problems with linear constraints and quadratic objective functions. While the choice of the preferred approach is very much dependent on the seriousness attached to the short-term predictions of theory as against the long-run, the use of any approach should be based on the desire to develop a model which has transparent theoretical foundations, and can fit into the historical time series of the data very well (Garratt *et al* (2000)). The modeling approach advocated under this methodology is based on log-linear VAR model estimated subject to long-run relationships obtained from economic theory.

Based on the assumption that individual macroeconomic series has a unit root, each of the long-run relationship derived from the theory should be associated with a cointegrating relationship between the variables, and the existence of such relationships will impose the restrictions on the variables of the model. The use of VAR requires that great care be taken in the initial stages about the choice transformation of data to use to achieve stationarity. VAR approach to long-run modeling in general, has been a source of criticisms in a number of ways. Specifically, Garratt *et al* (2000) suggests three areas of caution when using a VAR modeling technique. First, a VAR model with the first difference of I(1) variables is likely to be mis-specified if there exist a cointegrating relationship between two or more of the I(1) variables (that is, variables integrated of the order of 1). Second, care is needed on the choice of variables to be included in the VAR analysis. Third, where the impulse response function cannot be interpreted with recourse to economic theory, the estimating model will give only a few insights into the economic system that it represents. In order to increase the precision of forecasts based on VARs, Litterman (1986) suggested the combination of unrestricted VAR with Bayesian (This is otherwise referred to as Minnesota priors) analysis.

The structural VAR approach attempts to identify the impulse responses by imposing a priori restrictions on the covariance matrix of the structural errors and/or the long-run responses themselves (Garratt *et al*, 2003). In contrast with the unrestricted VAR approach, structural VARs attempt to provide some economic rationale for the use of covariance restrictions (Such restrictions may pose identification problem for the long-run relationship among variables).

Vector Error Correction Mechanism

The Vector Error Correction (VEC) model is a convenient alternative to the simple VAR model when variables are cointegrated, and provides easy interpretation and differentiation between the short and the long-run implications of the model (Jacobs and Wallis, 2010). It is a restricted VAR

which requires cointegration of some variables. In order to embody the long-run relation of a model, the variables used in the empirical analysis are expected to be I(1) such that it can be incorporated within the dynamic model. Essentially, the VEC model provides a convenient alternative form to the VAR model when variables are cointegrated, and provides easy interpretation and differentiation between the short-run and long-run implications of the model by incorporating into it, an error term which corrects for the adjustment between the short and the long-run behavior of variables.

There is usually some ambiguity over the order of integration of some nominal and short-run variables as they are being transformed or when derived from a system of equations. For instance, an application of Augmented Dickey-Fuller (ADF) test to three sets of price variables such as Δp_t, $\Delta \check{p}_t$, Δp^*_t, representing domestic, foreign and equilibrium interest rates may yield mixed results. In a situation where Phillips and Perron (PP) test cannot prove otherwise, the issue of disagreement is raised about economic modeling and macroeconomic modeling. Following from the validity of Fisher's equation, inflation and interest rate are expected to have the same order of integration (Since changes in both variables arise from the same magnitudes). The theoretical literature generally assumes these variables as I(0)s, but empirical evidence have shown mixed results where interest rate may be behaving as I(1), but with inflation integrated on a different order (Garratt *et al*, 2003). Sometimes in the test for exogeneity in long-run models, as an alternative, the GLPS (An acronym for Garatt, Lee, Pesaran and Shin (2000, 2003 and 2006) model becomes necessary. The GLPS incorporates long-run structural relationships suggested by economic theory as the cointegrating relations of a VECM (Jacobs and Wallis, 2010).

Artificial Intelligence Method

Amiri *et al.* (2011) had faulted the linear functional specifications which were based on OLS regresses. In reaction, they made use of a time series with artificial intelligence method (AIM) to test for the existence of nonlinear relationship among economic variables. The study observed that improved nonlinear Augmented Engel-Granger and Vector Error Correction methods significantly have a better ability to identify long-run cointegration and causal relationships than ordinary linear ones.

Matters Arising

A convenient starting point is to ask if 'long-term' is synonymous with 'long-run'. Frequently, the word, 'long-term' is used in the literature – growth economics, development economics, development planning and financial economics mostly, in a way that could be confused with the long-run. Long-term could be seen in terms of a finite horizon or foreseeable future. Thus, series such as long-term interest rates refer to such rates stipulated for future periods and arrived at after taking into consideration the inflation expected at the relevant future periods. Except for countries operating on the (long-run) natural rate level of output, such future interest rates may not constitute long-run values. Therefore, some care is needed in dealing with such long-term series in long-run analysis. The Lucas critique is also relevant here as such series are usually projected on the basis of ex post data which may not accommodate unexpected future developments even over the horizon being considered.

The second important commentary on this issue is that, policies generating data series following an economic reform may, as recognized by Lucas (1988), be inadvertently admitted as long-run growth variables. In this sense, it is hard to see how some of the policy issues identified in some endogenous growth models that is, apart from technological progress, qualify to be recognized as long-run variables. The effect of expenditure on the national system of innovations boosting capability and revolutionizing technical process continuously cannot be placed on the same pedestal with the provision of infrastructural services, maintenance of law and order, and, regulations of financial markets in long-run growth considerations (Regulations of international trade and protection of intellectual properties are excluded from the list because of the possibility that the former could facilitate greater absorption of new technologies by a follower country and the latter as recognized by Segerstrom (1998), could supply the incentive to innovate and produce new technology). Policies on some of these other issues tend to remain unchanged for a long time and would most likely generate level effects (Adequate provision of infrastructural services and effective law and order are features of development and may be taken for granted in an advanced economy; therefore, they are not likely to be sources of new growth in such an economy). Tagging them 'exogenous' may be insufficient so long as continuous changes are not identified with them. In this wise, studies incorporating these variables into long-run analysis may be in error (Those studies favoring the narrative measures (index) of monetary policy or the financial sector fall into this category. For such studies, a cautionary note exists in Leeper, Sims and Zha (1996) – cited in Walsh (2003) – : '….. most movements in monetary policy instruments represent responses to the state of the economy, not exogenous policy shifts).

A second observation on current usage and application of 'long-run' when posed as a question is, shouldn't there be a distinction between the run-up to the long-run and the long-run itself? The long-run effect in itself could be viewed as two folds viz: in terms of sustaining steady state growth and in terms of shifting the long-run aggregate supply curve. The first basically describes short run economic activities/policies at the steady state, while the second implies long-run shift factors. For countries traditionally viewed as operating on the natural rate level, only activities at the long-run would be of interest. Hence, short term stabilization policies could exist side by side with long-run growth policies capable of shifting outward the production possibilities frontiers. For developing countries usually seen as operating below full employment equilibrium, the focus has mostly been the short run, relying on short term macroeconomic policies to generate growth and higher level of employment.

Lately however, there appears to be a realization of the importance of long-run growth drivers in the policy making circles of these (developing) countries. Hence, these economies put much emphasis (sometimes, rhetorically though) on human capital development and technological innovation. However, the point in this section is that, in the literature, some policies that only contribute to the drive-up to long-run are often specified as long-run variables. Perhaps, the source of the confusion is that, we usually associate long-run with the notion of equilibrium without paying much attention to the differences in stages of growth requirements as noted in opening part of this section. And, as indicated in the preceding paragraph, most innovations in the financial sector fall into the class of short run growth determinants. For example, real interest rate which is often the variable of reference when discussing the benefits of financial liberalization contributes significantly to short run growth but, if we understood the notion of long-run properly, does not

exist at that point, that is, long-run. Most demand for money functions specifying price variables as long-run factors, are also in this error bracket.

A third area of concern in the current usage and application of the notion of long-run in the literature is the extent to which reliance should be placed on nominal variables. Theoretically, all nominal variables generate long-run effect on each other in the sense of run-up to the steady state. To qualify as a possible long-run growth driver, an additional quality is needed and this is exogeneity. It guarantees that such a variable could experience changes even though the economy is in stable long-run equilibrium.

Another pertinent question to ask on the issue of long-run is, what should be the appropriate definition of long-run? The present identification of the concept with the notion of equilibrium appears to reflect an economy-wide or macroeconomy context only. A simple illustration would reveal the inadequacy of this position. Here are two propositions for comparison. 1. Nigeria would be a developed country. 2. Sustained inflation is a monetary phenomenon. Both are long-run propositions, yet, one (as a process) is faster than the other. In effect, every long-run economic process has its own dynamics which is different from those of other processes. Thus, "for some processes, the long-run can be short, for some others, it can be very long (This expression dates back sometime in the literature but the actual publication, I could neither locate nor recollect. In a sense however, Hirshleifer (1980) identifies with this expression)."

In the context of the unit root – cointegration revolution in time series analysis and long-run investigation, the observation of Pesaran (1997) referenced in the preceding section is relevant and deserves some comments. It appears that too often, we forget that the unit root – cointegration development is part of a methodology referred to as 'General to Specific'. Simply described, this methodology helps to identify a congruent model that is both theory consistent and data admissible and also encompasses rival models. Thus, it warrants that econometric models of long-run should be specified according to economic theory, ensuring data admissibility through the investigation of the time series properties (for logical sequence, testing the theoretically identified long-run series for cointegration with the dependent variable if both are I(1) series), obtaining the parsimonious equation and interpreting the results theoretically (In effect, the general to specific methodology usually begins with a large model which is gradually reduced to the parsimonious through an elaborate iterative process. Accordingly, such dynamic single equation models allow for sufficient and varying interactions between the dependent and explanatory variables; they also recognize and provide for the distinction between the effects of endogenous and exogenous variables through a battery of diagnostic tests including that for exogeneity. In this wise, tests for exogeneity in dynamic models (not the cointegration – error correction type) include the Sims – Granger causality. Clearly, the criticisms of such models in Kibritcioglu and Dibroglu (2001) on failure to recognize the possible endogeneity of explanatory variables may not apply to this case). It appears that the failure to realize and follow this basic principle is the source of the myriads of long-run specifications and estimations in the literature. An adaptation of Monetarists' criticism of the structural model evidence of Keynesians is relevant here. Thus, any econometric model of the long-run is only as good as the underlying economic theory.

An analogy to the consideration of the status of nominal variables in long-run analysis is whether structural variables are always of long-run nature. Ordinarily, because of their link with the structure of the economy which can only be altered in a long-run context, there is always that

tendency to regard such variables as of long-run nature. However, a misleading and distorted picture could emerge if the actual context or process is not properly understood while embarking on the model specification. Consider for example, the case of a real export growth function in which the gross domestic product (GDP) is specified as long-run variable in the sense of reflecting the situation of slow technical change. This could go unquestioned depending on the understanding of the analyst and his/er audience or readers. For the better informed, if the relevant economy whose export growth is being modeled is opened, then, the argument changes. The problem of slow technical change can be overcome in the short run through importation. In other words, depending on the composition of imports, a sufficiently open economy can overcome any structural impediment in the short run through importation and with the country putting in place policies (e.g. skill acquisition) necessary to ensure the sustainability of long-run structural adjustment, it is clear under this scenario that, structural factors are best treated as short run determinants (The empirical evidence to support this is the case of the Austrian economy of the 1970s and the 1980s which experienced tremendous expansion in her textile export industry through an import-led innovation strategy. In Africa, the case of Mauritius remains a special study on textile export success).

Related to the above is the need for us to allow economic or socio-economic developments a role in long-run modeling. This is best illustrated with an example. At the onset of a scourge e.g. HIV/AIDS, with the notice of absence of cure, the rest of the society not only avoid the infected but the productivity of the victims too falls considerably and progressively till the ultimate. Treating the incidence of this malaise as a long-run variable via its human capital growth effect and hence, productivity slow down, appears to be smart economics. With time and breakthrough in the search for medical solution and credible treatment of the ailment coupled with increasing public enlightenment campaign on the need to accommodate and tolerate the affected, people no longer avoid the victims raising their morale. Besides, the spread of the disease is checked through the awareness campaign. And, with the help of proper medication, the productivity impact becomes considerably less. In this situation, to continue specifying the incidence of the scourge as a long-run variable would amount to a case of economics lacking in sophistication.

Two other examples of inadmissible factors in long-run modeling could further throw some light on the relevant issue under discussion. First, is the case of the ever so popular and important productivity growth, which owes its measurement procedure to Professor Robert Solow. Accordingly, it became known as the "Solow residual" which reflects the way it is generated. Quite simply, the idea is to explain observed growth of output beyond the fraction accounted for by factor inputs, mainly, labor and capital. The residual is thus generated from the growth regression involving the factor inputs as explanatory variables. Most humbly, it is submitted that this procedure amounts to finding or searching for, the missing component of an identity and this is not the same as ascertaining the factors accounting for the movements in output. A favored approach in this regard first specifies both the short and long-run determinants of productivity growth which should be computed as the percentage change in the sum of the ratios of the gross national product to capital stock and total labor input respectively. The short-run determinants would include real interest rate, real exchange rate and the supply (that is, stock) of factor inputs while the long-run determinants (fundamentals) would include technological progress (as may be captured variously by expenditure on the national system of innovations, regulations of

international trade and protection of intellectual properties)(In most economies, especially, the developing type, the incidence of corruption could be a fundamental in productivity growth consideration in the sense of hypothetically causing the full information natural rate level of output to fall short of the full capacity output). The fitted series of the regression involving the dependent variable and the fundamentals should be a more credible long-run growth determinant (shift factor).

Finally, consider a balance of payments function (BOP) into which imports, exports, interest rate, price level, exchange rate or real exchange rate, real money supply and real gross national product are specified as long-run determinants. Quite clearly, interest rate is a measure of cost of capital (not real cost though) in this model while price level changes track inflation effect. However, the two variables, interest rate and price level, generate opposing effects on the dependent variable and are also expected to grow proportionally relative to each other in the long-run. The overall (that is, long-run) effect of the inclusion of the two variables in the model is zero. Besides, they both would change equip-proportionally in the long-run relative to a change in the exchange rate. Both imports and exports simply are symptoms of disequilibrium in the BOP and not fundamental causes of such disequilibrium. Real money supply would technically have no long-run effect as there is full offsetting effect of price level on money supply changes. For most economies, nominal or real exchange rate would be stable in the long-run. Clearly, in this scenario, only the real GNP qualifies as the long-run fundamental in the sense of its growth generating an adverse development in the BOP. This clearly suggests the need for careful thought in specifying the long-run variables for any economic process.

CONCLUDING REMARKS

This survey and the issues generated were designed to assist the developing professional economists to overcome the confusion that is likely to be created by the numerous usages (implicitly therefore, definitions) and applications of the notion of long-run in the literature. This paper therefore should be seen as just a supplement in the learning process.

The various approaches to long-run analysis in the growth, financial and econometric branches of economics were identified and presented briefly in a non-technical manner. Observations on current practices in these areas were made and suggestions as to how to overcome the related pitfalls were proffered. These suggestions were wide-ranging, covering, matters of working definition, variables' admissibility, status of nominal and real variables, economic theory as the fulcrum of long-run econometric designs, the influence of dynamics in specifications as well as the computation of a notable long-run growth factor. As practicable, instances were used to illustrate the various viewpoints. These experiments came mostly from this writer's research endeavors as well as those conducted by some of his graduate students.

It is of utmost importance for the learner to always remember that, it is not compulsory always to undertake long-run analysis. Most stabilization policies (monetary or fiscal) target the short run. Hence, searching for long-run in respect thereof may be a futile exercise. No matter how well done, a long-run analysis that is unnecessary simply interprets as 'doing in a beautiful or fanciful way, what ought not to have been done at all'. It is meaningless, useless and a waste of

time and effort. Where it is absolutely desired and deemed necessary to conduct long-run analysis, careful thoughts should be given to model specification and the subsequent analysis.

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