Modeling the future of knowledge economy: evidence from SSA and MENA countries

Asongu, Simplice A

African Governance and Development Institute

15 January 2013

Modeling the future of knowledge economy: evidence from SSA and MENA countries

Simplice A. Asongu

African Governance and Development Institute,

P.O. Box 18 SOA/ 1365 Yaoundé, Cameroon.

E-mail: asongusimplice@yahoo.com

Abstract

This paper projects the future of knowledge economy (KE) in SSA and MENA countries using the four components of the World Bank's Knowledge Economy Index (KEI): economic incentive, education, ICTs and innovation. The empirical evidence provides the speeds of integration as well as the time necessary to achieve full integration. Findings broadly indicate SSA and MENA countries with low levels in KE will catch-up their counterparts with higher levels in a horizon of 4 to 7.5 years.

JEL Classification: F42; O10; O38; O57; P00

Keywords: Knowledge economy; Principal Component Analysis; Panel data; Convergence

1. Introduction

Globalization has been universally recognized as the predominant force dominating the economic universe. It aims to illuminate the world with economic prosperity by seeking a victory of markets over governments and self-interest over altruism. The phenomenon is enshrined in the global commitment to continuing and accelerating the pace of human development. In recent years, the challenges of globalization have obliged scholars to devote

a great deal of attention to the nature and functioning of the knowledge economy (KE). In fact, as globalization has become an ineluctable process (whose march can be stopped only by endangering the prosperity of nations), it has become abundantly clear that, for any continent, region or country to be actively engaged in the global economy, it must espouse competition as a benchmark to prosperity. KE which is central in competition has emerged in the late 1990s as a key theme in the OECD and World Bank reports (World Bank, 2007; Weber, 2011).

There is wide consensus among scholars that knowledge created through innovation and technical progress is a long-term driver of economic prosperity. Accordingly, the dynamics of KE mastered by Europe and North America have enabled them to inexorably determine the course development at the international level. South America and Asia have been adapting to the KE challenges of globalization with calculated steps in their current pursuits of national, regional and international projects. In fact, the KE pattern of Japan has set the course for China, Malaysia and the Newly Industrialized Economies of Asia (Korea, Taiwan, Hong Kong & Singapore), who are currently shifting toward 'knowledge-based economies' from the 'product-based economies' in the post industrialization period (Chandra & Yokoyama, 2011). While most scholarly attention on KE has been devoted to the emerging economies of Latin America and East Asia, in sub-Saharan Africa (SSA) and the Middle East & North African (MENA) countries, KE issues are also assuming central stage in discussions on development (Asongu, 2013a).

Substantial efforts to understand the structure of the emerging KE have recently been devoted to SSA and MENA countries, either through the fight against software piracy (Andrés & Asongu, 2013; Asongu, 2012ab), financial sector competition (Asongu, 2012c), production value of doctoral dissertations (Amavilah, 2009) or pro-poor nexuses (Asongu, 2013b). These recent waves of studies have principally been motivated by the need to steer

clear of mainstream African KE literature (AfDB, 2007; Bizri, 2009; Aubert, 2005; Britz et al., 2006) in order to provide the much needed policy implications (Britz et al., 2006; Makinda, 2007; Lightfoot, 2011). With this interesting background, complementing existing literature by projecting the future of KE in SSA and MENA countries is of crucial policy relevance.

This paper models the future of KE by employing all the four components identified by the World Bank's Knowledge Economy Index (KEI): education, innovation, information and communication technology (ICT) and economic incentives. The empirical evidence is based on a novel modeling technique that enables us to compute the rate of integration and time required for full integration. The theoretical underpinning is that, convergence in dynamics of KE will mean the adoption of common policies (to promote KE projects) is feasible while full (100%) convergence will imply such policies can be implemented without distinction of nationality or locality (Asongu, 2012a). The intuition motivating the theoretical underpinning is simple: the process of creation and diffusion of knowledge depends on convergence in certain criteria[1] which would lead to more common policies across members of the convergence club[2].

The rest of the paper is organized as follows. We discuss the data and outline the methodology in Section 2. Empirical analysis is covered in Section 3. Section 4 concludes.

2. Data and Methodology

2.1 Data

We examine a panel of 22 MENA and SSA countries with data from World Development Indicators (WDI) and the Financial Development and Structure Database (FDSD) of the World Bank (WB) for the period 1996-2010. Limitations to the time span and

[1]E.g, convergence in education, information and communication technology (ICT), innovation, and economic incentives.
[2]The European Union's Lisbon strategy is an eloquent example.

number of countries are constrained by KE data availability and the motivation of obtaining results with more updated future projections. The dependent variables are consistent with recent KE literature (Chavula, 2010; Weber, 2011) and entail the four dimensions identified by the World Bank KEI. The procedure for further reducing the dimensions of these variables is provided in Section 2.2.1 below.

The choice of the control variables is in accordance with theoretical underpinnings of conditional convergence which state that, if countries differ in macroeconomic and institutional characteristics on which KE is endogenous then, it is possible for conditional convergence to take place. The five control variables employed include: economic prosperity, government expenditure, rule of law, inflation and financial development[3]. Based on a preliminary assessment from the summary statistics we have noticed that, there is quite a degree of variation in the data utilized so that one should be confident that reasonable estimated relationships would emerge. From an initial correlation analysis which has served to mitigate issues of overparametization and multicolinearity, there are no issues in terms of the relationships to be estimated[4].

2.2 Methodology

2.2.1 Principal Component Analysis (PCA)

Since each dimension of KE could be correlated with its component variables individually, one might criticize the redundancy of the information provided for each dimension of the KEI. Hence, we use principal component analysis (PCA) to reduce the dimensions of the variables. This is a common statistical method that is used to reduce a larger set of correlated variables into a smaller set of uncorrelated variables, called principal components that account for a great proportion of variation in the original data set. From

[3] Please see Appendix 1 for definitions and sources of the variables.
[4] Owing space constraints, the correlation analysis and summary statistics have not been presented but can be provided upon request.

Table 1 below, the first principal component (PC) accounts for approximately 65% of the variation in all four KE dimensions. In the choice of the PCs, the criteria used to determine how many common factors to retain are taken from Kaiser (1974) and Jolliffe (2002). Hence, only PCs with a corresponding eigenvalue greater than one are retained. It is worth emphasizing that, the first PCs are almost equal across dimensions. These results demonstrate that a one PC model is appropriate for KE dimensions in our sample. For example the first PC accounts for approximately 65% of the variation in all the four KE dimensions. *Educatex* for instance which accounts for about 77% of information in the education dimension of KE is the first PC of primary school enrolment (PSE), secondary school enrolment (SSE) and tertiary school enrolment (TSE).

Table 1: Principal Component Analysis

Knowledge dimensions	Economy	Component Matrix(Loadings)			First P.C	Eigen Value	Indexes
Education	School enrolment	PSE	SSE	TSE			
		0.535	0.620	0.574	0.771	2.313	Educatex
Information & Infrastructure	ICTs	Internet	Mobile	Telephone			
		0.653	0.661	0.371	0.705	2.115	ICTex
Economic Incentive	Trade & Tariffs	Trade	Tariffs				
		-0.707	0.707		0.645	1.290	Tradex
	Credit & IR Spread	Private Credit	Interest rate spread				
		-0.707	0.707		0.679	1.358	Creditex
Innovation	Scientific Publications FDI Inflows	Reducing the dimensions of these is impractical owing to low correlation and conceptual dissimilarity.					

PSE: Primary School Enrolment. SSE: Secondary School Enrolment. TSE: Tertiary School Enrolment. PC: Principal Component. ICTs: Information and Communication Technologies. IR: Interest Rate. FDI: Foreign Direct Investment. Educatex is the first principal component of primary, secondary and tertiary school enrolments. ICTex: first principal component of mobile, telephone and internet subscriptions. Creditex: first principal component of Private credit and Interest rate spreads. Tradex: first principal component of Trade and Tariffs.

2.2.2 Estimation technique

The estimation approach based on β-convergence is consistent with the methodological underpinning motivating the study (Asongu, 2012a). Apart from this justification, the alternative view of convergence (σ-convergence) which postulates that, a

group of economies converges when the cross-country variance of the variable under consideration declines, is also inappropriate because our data structure is panel. The estimation procedure typically follows recent evidence from the convergence literature (Narayan et al., 2011; Asongu, 2012a).

The two equations below are the standard approaches in the literature for investigating conditional convergence if $W_{i,t}$ is taken as strictly exogenous (Fung, 2009, 3).

$$\ln(Y_{i,t}) - \ln(Y_{i,t-\tau}) = \beta \ln(Y_{i,t-\tau}) + \delta W_{i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

$$\ln(Y_{i,t}) = \sigma \ln(Y_{i,t-\tau}) + \delta W_{i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (2)$$

where $Y_{i,t}$ is the proxy for KE in country i at period t. σ = 1+ β. $W_{i,t}$ is a vector of determinants of KE (or control variables), η_i is a country-specific effect, ξ_t is a time-specific constant and, $\varepsilon_{i,t}$ an error term. Absolute convergence is estimated in the absence of control variables ($W_{i,t}$).

Consistent with the neo-classical growth model, a statistically significant negative coefficient on β in Eq. (1) suggests that countries relatively close to their steady state of KE growth will experience a slowdown in growth of KE, known as conditional convergence (Narayan et al., 2011; 2). In the same vein, according to Fung (2009, 3) and recent African convergence literature (Asongu, 2012a), if $0 < |\sigma| < 1$ in Eq. (2), then $Y_{i,t}$ is dynamically stable around the path with a trend in KE the same as that of W_t, and with a height relative to the level of W_t. The variables contained in $W_{i,t-\tau}$ and the individual effects η_i are measures of the long-term level the KE is converging to. Therefore, the country-specific effect η_i emphasizes other determinants of a country's steady state not captured by $W_{i,t-\tau}$.

Requirements for conditional convergence elucidated above are valid if and only if, $W_{i,t}$ exhibits strict exogeneity. Unfortunately, this is not the case in the real world because,

while *institutional quality*, *inflation*, *financial development, economic prosperity* and *government expenditure* (components of $W_{i,t}$) influence KE, the reverse effect is also true. Thus, we are faced here with the issue of endogeneity where control variables ($W_{i,t}$) are correlated with the error term ($\varepsilon_{i,t}$). Also, country- and time-specific effects could be correlated with other variables in the model, which is very likely with lagged dependent variables included in the equations. A way of dealing with the problem of the correlation between the individual specific-effect and the lagged endogenous variables consists of eliminating the individual effect by first differencing. Therefore Eq. (2) becomes:

$$\ln(Y_{i,t}) - \ln(Y_{i,t-\tau}) = \sigma(\ln(Y_{i,t-\tau}) - \ln(Y_{i,t-2\tau})) + \delta(W_{i,t-\tau} - W_{i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) \quad (3)$$

However Eq. (3) still presents another issue. Estimation by Ordinary Least Squares (OLS) is still biased because there remains a correlation between the lagged endogenous independent variable and the disturbance term. To address this concern, we estimate the regression in differences jointly with the regression in levels using the Generalized Method of Moments (GMM) estimation. Arellano & Bond (1991) have suggested an application of the Generalized Method of Moments (GMM) that exploits all the orthogonality conditions between the lagged dependent variables and the error term. The procedure uses lagged levels of the regressors as instruments in the difference equation, and lagged differences of the regressors as instruments in the levels equation, thus exploiting all the orthogonality conditions between the lagged dependent variables and the error term. Between the difference GMM estimator (Arellano & Bond, 1991) and system GMM estimator (Arellano & Bover, 1995; Blundell & Bond, 1998), the system GMM will be given priority; in line with Bond et al. (2001, 3-4)[5]. This GMM estimation approach has been extensively applied in the

[5] "We also demonstrate that more plausible results can be achieved using a system GMM estimator suggested by Arellano & Bover (1995) and Blundell & Bond (1998). The system estimator exploits an assumption about the initial conditions to obtain moment conditions that remain informative even for persistent series, and it has been shown to perform well in simulations. The necessary restrictions on the initial conditions are potentially consistent with standard growth frameworks, and appear to be both valid and highly informative in our empirical

convergence literature. In contrast to Narayan et al. (2011), we shall adopt Fung (2009) owing to software specificities[6].

In model specification, we adopt the *second-step* GMM because it corrects the residuals for heteroscedasticity[7]. The assumption of no auto-correlation in the residuals is crucial as lagged variables are to be employed as instruments for the dependent variables. Moreover, the estimation is contingent on the assumption that the lagged values of the dependent variable and other independent variables are valid instruments in the regression. Accordingly, we report only the second order autocorrelation (AR(2)) test because, when the error terms of the level equation are not auto-correlated, the first-order auto-correlation of the differenced residuals should be significant whereas their second-order auto-correlation should not be. The validity of the instruments is examined with the Sargan over-identifying restrictions test (OIR) while the general significance of the model is assessed by the Wald statistics for the joint significance of estimated coefficients.

According to Islam (1995, 14), yearly periodicity is too short to be appropriate for studying convergence, as short-run disturbances may loom substantially in such brief time spans. Hence, considering the data span of 15 years, we are consistent with Asongu (2012a) in using two-year non-overlapping intervals (NOI)[8]. Beside the two justifications provided above, we may cite three additional premises on which this choice of the two-year NOI is based. Firstly, NOI with a higher numerical value (say three-year NOI) absorbs more short-run disturbances at the cost of weakening the model. Hence the preference for the two-year NOI over the three/four/five-year NOI is further justified by the need to exploit the time series

application. Hence we recommend this system GMM estimator for consideration in subsequent empirical growth research". Bond et al. (2001, pp. 3-4).

[6] Whereas, Narayan et al. (2011) have used Eq. (1) after eliminating fixed effects, this paper is based on Eq. (3) instead; in line with (Fung, 2009). The Fung (2009) has been used in recent African convergence literature (Asongu, 2012a). The system GMM has been employed in recent KE convergence literature (Karagiannis, 2007).

[7] In the *first-step*, the residuals are assumed to be homoscedastic.

[8] Accordingly, we have 8 two-year non-overlapping intervals: 1996; 1997-1998; 1999-2000; 2001-2002; 2003-2004; 2005-2006; 2007-2008; 2009-2010.

dimensions as much as possible. Secondly, a corollary to the above point is the positive side of additional degrees of freedom necessary for conditional convergence modeling. Hence, given the time span of 15 years, a higher order of NOI will greatly limit conditional convergence analysis. Thirdly, heuristically from a visual analysis, KE dynamics do not show evidence of persistent business cycles (short-term) disturbances that require higher NOI.

Ultimately in the analysis, τ is set to 2. Accordingly, we compute the implied rate of convergence by calculating $\sigma/2$. The estimated coefficient of the lagged differenced endogenous variable is divided by 2 because we have used a two year interval to mitigate the short-term disturbances. With $0<|\sigma|<1$, we conclude the presence of convergence. The broader interpretation suggests that, past differences have a less proportionate effect on future variations, implying the variation on the left hand side of Eq. (3) is decreasing overtime (Asongu, 2012a).

3. Empirical results

3.1 Presentation of results

Tables 2-3 below present results that answer three questions motivating the paper. In other words, policy makers are most likely to ask the following three questions concerning the future of KE. (1) Is KE converging within SSA and MENA countries? (2) If so, what is the rate and timing of the convergence process? (3) For which KE dimensions do answers to the first and second questions apply? Whereas an answer to the first question will guide on the feasibility of harmonizing blanket policies, the answer to the second will guide on an optimal timeline for such blanket policies. Accordingly, the answer to the third question (given that the first-two are already answered), will determine the feasibility-of, timeframe-for and exclusiveness (or non arbitrariness) of the blanket policies. This third question is most relevant because, it underscores the imperative for common policies to be contingent on the

prevailing speeds of and time for full (100%) convergence within each identified KE dimension.

Table 2 below presents the information criteria on which the rates of convergence and time needed to achieve full convergence are computed and summarized in Table 3. We report only the initial lagged endogenous estimated coefficients for the KE dynamics, the second order autocorrelation test, the Sargan OIR test for instrument validity and the Wald statistics for the general significance of the model. Based on the findings, the null hypotheses of the AR(2) and Sargan OIR are not overwhelmingly rejected, confirming the absence of autocorrelation and validity of the instruments respectively. The estimated lags of endogenous KE dynamics and Wald statistics are also overwhelmingly significant. With the exception of absolute convergence in scientific publications, for the estimated initial values that meet the convergence criterion ($0<|\sigma|<1$), we proceed to compute the implied rate of convergence. For example, with an initial value of 0.789, the rate of convergence is 39.45% ((0.789/2)*100) and the time needed to achieve full convergence is 5.06 years (200%/39.45%). Hence, 5.06 years is required to achieve a 100% convergence for an estimated lagged value of 0.789.

Table 2: Information criteria

	Absolute Convergence (AC)				**Conditional Convergence(CC)**			
	Initial	AR(2)	OIR	Wald	Initial	AR(2)	OIR	Wald
Educatex	0.789***	-1.314	11.734	164.827***	0.751***	-1.155	3.563	1704.7***
	(0.000)	(0.188)	(0.946)	(0.000)	(0.001)	(0.247)	(1.000)	(0.000)
ICTex	0.824***	-1.026	20.995	903.90***	0.830***	-0.717	13.973	2753.3***
	(0.000)	(0.304)	(0.742)	(0.000)	(0.000)	(0.473)	(0.973)	(0.000)
Tradex	0.774***	0.775	17.169	45.921***	0.609***	0.870	5.763	480.33***
	(0.000)	(0.438)	(0.841)	(0.000)	(0.001)	(0.384)	(0.998)	(0.000)
Creditex	0.931***	-1.098	14.853	539.37***	0.632*	-1.230	8.448	1380.7***
	(0.000)	(0.272)	(0.960)	(0.000)	(0.092)	(0.218)	(0.999)	(0.000)
Scientific Pub.	1.024***	0.261	20.584	12190***	0.984***	0.144	9.397	2599.8***
	(0.000)	(0.793)	(0.360)	(0.000)	(0.000)	(0.885)	(0.966)	(0.000)
FDI inflows	0.550***	-0.809	20.978	8.754***	0.216*	-1.008	15.086	37.183***
	(0.000)	(0.418)	(0.743)	(0.003)	(0.078)	(0.313)	(0.955)	(0.000)

***,**,*: significance levels of 1%, 5% and 10% respectively. P-values in brackets. AR(2): Second Order Autocorrelation test. OIR: Sargan Overidentifying Restrictions test. Initial: lagged endogenous estimated coefficient. Educatex is the first principal component of primary, secondary and tertiary school enrolments. ICTex: first principal component of mobile, telephone and internet subscriptions. Creditex: first principal component of Private credit and Interest rate spreads. Tradex: first principal component of Trade and Tariffs. Pub: Publications. FDI: Foreign Direct Investment.

Table 3 below presents the computed rates of convergence and corresponding period required to achieve full (100%) convergence. The results broadly show that, on average a feasible horizon for the harmonization of blanket policies is between 4 to 7.5 years[9].

Table 3: Future trajectories of KE

		Absolute Convergence (AC)			Conditional Convergence(CC)		
Dimensions of KE		AC	% of AC	Yrs to AC	CC	% of CC	Yrs to CC
Education	Educatex	Yes	39.45%	5.06 Yrs	Yes	37.55%	5.32 Yrs
ICT	ICTex	Yes	41.20%	4.85 Yrs	Yes	41.50%	4.81 Yrs
Economic Incentives	Tradex	Yes	38.72%	5.16 Yrs	Yes	30.45%	6.56 Yrs
	Creditex	Yes	46.57%	4.29 Yrs	Yes	31.60 %	6.32 Yrs
Innovation	Scientific Pub.	No	---	---	Yes	43.86%	4.55 Yrs
	FDI inflows	Yes	26.80%	7.46 Yrs	Yes	10.80%	18.51 Yrs

Yrs: Years. Educatex is the first principal component of primary, secondary and tertiary school enrolments. ICTex: first principal component of mobile, telephone and internet subscriptions. Creditex: first principal component of Private credit and Interest rate spreads. Tradex: first principal component of Trade and Tariffs. Pub: Publications. FDI: Foreign Direct Investment.

3.2 Discussion of results, policy implications and caveats

The results have broadly shown that, common policies in the process of creation and diffusion of knowledge are feasible among SSA and MENA countries. Accordingly, as convergence in education, ICTs, innovation and economic incentives have been instrumental for the European Union's Lisbon treaty, common policies across the sampled countries could also lead to a convergence club within the project horizon of full convergence (4 to 7.5 years).

[9] It is interesting to highlight that, the convergence rates of between 10-40% are far higher than the 2% from the pioneering works (Barro & Sala-i-Martin, 1992, 1995). We have several explanations for this difference. First of all, we are not the first to have arrived at such double digit convergence rates. Narayan et al. (2011) have used the same methodology in financial markets on a sample of 120 countries and found the rate of convergence to be between 20% and 30% for the most part. The convergence interval of Narayan et al. (2011) is consistent with those from recent African convergence literature (Asongu, 2013cdef). Secondly, it has never been really clear what was driving the 2% (i.e in Barro & Sala-i-Martin) which is most often simply discussed as a statistical artifact. Thirdly, the concepts are very different. Comparing convergence in GDP per capita with convergence in KE dynamics is not quite feasible for several reasons. (1) GDP per capita growth is very much contingent on population growth. Given the very high rate of demographic change in developing countries relative to the developed world, it is normal that the GDP per capita growth in developing countries is limited by the demographic factor. (2) Citizens in developing countries have embraced ICTs without a corresponding change in GDP per capita. It has been substantially documented that, many households maybe willing to cope with unpleasant sacrifices (such as reduction in food consumption or sanitation in the perceived short-term) in the hope that, ICTs would improve their opportunities with income and jobs in the long-term.

While the dynamics are encouraging, in order to facilitate the convergence criteria, the progressive build-up of KE calls for increased capacity for research, technological development, innovation and economic incentives in the sampled countries.

We now discuss some specifics in the trajectories. Firstly, results of Education and ICT demonstrate that countries with low levels of education and ICT are catching-up with their counterparts with higher levels. Hence, it could be inferred that: (1) the objectives of the United Nations Educational, Scientific and Cultural Organization (UNESCO) are yielding fruits within Africa and the Middle East; (2) cross-countries differences in internet penetration, telephone subscriptions and mobile phone usage is substantially decreasing. Secondly, the absence of absolute convergence in scientific publications may also imply that UNESCO's objectives on knowledge convergence are still hard to come-by from a research perspective[10]. This broadly implies that sampled countries may not have the same fundamental characteristics in scientific publications. Thirdly, convergence in trade and credit facilities should be treated with caution given the limited nature of sampled countries. Hence, since the 22 countries used in the analysis are not broadly representative of MENA and SSA countries, the findings should not be generalized for two main reasons: (1) integration in trade may simply communicate the need for more intra-trade among sampled countries that has been substantially documented (Longo & Sekkat, 2004; Askari et al., 2003) and: (2) convergence in credit facilities may also reflect the substantially documented surplus liquidity issues in African financial institutions (Saxegaard, 2006). Hence, the results may also indicate the feasibility of and timelines for common policies that mitigate cross-countries differences in factors determining trade integration and financial allocation efficiency.

In the pursuits of more integrated KE strategies; the results broadly have policy implications for regional integration, credit facilities and support for regional research and

[10] For further details, see: '*Towards a convergence of knowledge acquisition and skills development*', a UNESCO report of education reform (Iwamoto, 2005).

innovation. Firstly, though integration may be occurring from the results, the findings could also point to convergence in the status quo of bad policies and the need for more intra-regional trade, which ultimately begs the question of whether policies implemented by African and Middle East countries to promote intra-regional trade have had the desired effects. Secondly, surplus liquidity issues could be tackled by: (1) increasing regional investment banks and investment funds that could substantially mitigate cross-country differences in credit facilities and; (2) addressing the plethora of documented issues that oblige banks to voluntarily or involuntarily hold bank reserves in excess of requirements (Saxegaard, 2006). Thirdly, support for regional research and innovation could be enhanced by: encouraging and validating activities targeting local and regional initiatives to promote development of new innovating businesses and 'transfer and exchange' of best practices as well as the establishment of an environment more conducive to innovation. Put in other words, policy should: support the development of regional and scientific infrastructure; develop research training networks, knowledge transfer and fellowships (to target more and better scientific and technical human resources) and; improve communication between experts and policy makers by supporting the establishment of joint work and communication platforms between them at the regional level.

Two main caveats are worth discussing: the purely empirical character of the study and draw-backs in the choice of the convergence approach. Firstly, using econometrics to accomplish more than just testing theory is not without shortcomings. We have been consistent with Costantini & Lupi (2005) and Narayan et al. (2011) in the assertion that applied econometrics has other tasks than the mere validation or refutation of economic theories. Secondly, the Beta convergence approach used has a number of limitations. Beta-convergence (detection of possible catching-up processes) is a necessary but not a sufficient condition for Sigma-convergence (reduction in disparities among regions in time). While the

latter has been described as more revealing (principally because it does not rely on random shocks and different country-specific steady states), the former is valid within our empirical framework for two main reasons: it is consistent with our data structure and, catching-up processes are genuine basis for policy harmonization

4. Conclusion

This paper has projected the future of knowledge economy (KE) in SSA and MENA countries using the four components of the World Bank's Knowledge Economy Index (KEI): economic incentive, education, ICTs and innovation. The empirical evidence has provided the speeds of integration as well as the time necessary to achieve full integration. Findings broadly indicate SSA and MENA countries with low levels in KE will catch-up their counterparts with higher levels in a horizon of 4 to 7.5 years.

Appendix 1: Variable definitions

Variables	Signs	Variable definitions	Sources
Panel A: Dimensions in Knowledge Economy (KE)			
Primary School Enrolment	PSE	Log of PSE	World Bank (WDI)
Secondary School Enrolment	SSE	Log of SSE	World Bank (WDI)
Tertiary School Enrolment	TSE	Log of TSE	World Bank (WDI)
Education in KE	Educatex	First PC of PSE, SSE & TSE	PCA
Internet Users	Internet	Log of Internet	World Bank (WDI)
Mobile Cellular Subscriptions	Mobile	Log of Mobile	World Bank (WDI)
Telephone lines	Tel	Log of Tel	World Bank (WDI)
Information & Infrastructure in KE	ICTex	First PC of Internet, Mobile & Tel	PCA
Trade Openness	Trade	Exports plus Imports of Commodities (% of GDP)	World Bank (WDI)
Tariff Barriers	Tariff	Tariff rate, most favored nation, weighted mean, all products (%)	World Bank (WDI)
1st Economic Incentive dimension in KE	Tradex	First PC of Trade & Tariff	PCA
Private domestic credit	Credit	Private domestic credit (% of GDP)	World Bank (WDI)
Interest rate spread	Spread	Lending rate minus deposit rate (%)	World Bank (WDI)
2nd Economic Incentive dimension in KE	Creditex	First PC of Credit and Spread	PCA
1st Innovation dimension in KE	Journals	Log of Number of Technical & Scientific Journals	World Bank (WDI)
2nd Innovation dimension in KE	FDI	Net Foreign Direct Investment (% of GDP)	World Bank (WDI)
Panel B: Control variables			
Rule of Law	R.L	Rule of Law (estimate)	World Bank (WDI)
Government Expenditure	Gov. Exp.	Government final consumption expenditure (% of GDP)	World Bank (WDI)
Inflation	Infl.	Consumer Price Index (annual %)	World Bank (WDI)
Economic Prosperity	GDPg	GDP growth rate (annual %)	World Bank (WDI)
Financial Depth	M2	Broad Money Supply (% of GDP)	World Bank (FDSD)

WDI: World Bank Development Indicators. FDSD: Financial Development and Structure Database. GDP: Gross Domestic Product. PC: Principal Component. PCA: Principal Component Analysis. Log: logarithm.

References

African Development Bank (2007, December). "Growing a Knowledge Based Economy: Evidence from Public Expenditure on Education in Africa", *Economic Research Working Paper Series* No. 88.

Amavilah, V. H., (2009). "Knowledge of African countries: production and value of doctoral dissertations," Applied Economics, 41,(7-9), pp. 977-989.

Andrés, A. R., & Asongu, S. A., (2013). "Fighting software piracy: which governance tools matter for Africa?", *Journal of Business Ethics*. http://link.springer.com/article/10.1007%2Fs10551-013-1620-7 (accessed: 15/01/2013).

Arellano, M., & Bond, S., (1991). "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations". *The Review of Economic Studies*, 58, pp. 277-297.

Arellano, M., & Bover, O., (1995). "Another look at the instrumental variable estimation of error-components models", *Journal of Econometrics*, 68, pp. 29-52.

Askari, H., Atie, R., & Khouri, N., (2003). "Intra-middle eastern trade: why is it so low?", *BNL Quarterly Review*, No. 226, pp. 1-32.

Asongu, S. A., (2012a). "Harmonizing IPRs on Software Piracy: Empirics of Trajectories in Africa", *Journal of Business Ethics*: Forthcoming. http://link.springer.com/article/10.1007%2Fs10551-012-1552-7?LI=true#page-1 (accessed: 26/12/2012).

Asongu, S. A., (2012b). "Fighting software piracy in Africa: how do legal origins and IPRs protection channels matter?" *Journal of the Knowledge Economy*: Forthcoming. http://link.springer.com/article/10.1007/s13132-012-0137-0 (accessed: 26/12/2012).

Asongu, S. A., (2012c). "Financial sector competition and knowledge economy: evidence from SSA and MENA countries", *Journal of the Knowledge Economy*: Forthcoming. http://link.springer.com/article/10.1007/s13132-012-0141-4 (accessed: 26/12/2012).

Asongu, S. A., (2013a). "'The Knowledge Economy'-finance nexus: how do IPRs matter in SSA and MENA countries?", *Economics Bulletin*, 33(1), pp. 78-94.

Asongu, S. A., (2013b). "Software piracy, inequality and the poor: evidence from Africa", *Journal of Economic Studies*: Forthcoming.

Asongu, S. A., (2013c). "African Stock Market Performance Dynamics: A Multidimensional Convergence Assessment", *Journal of African Business*: Forthcoming.

Asongu, S. A., (2013d). "African Financial Development Dynamics: Big Time Convergence", *African Journal of Economic and Management Studies*: Forthcoming.

Asongu, S. A., (2013e). "Are Proposed African Monetary Unions Optimal Currency Areas? Real, Monetary and Fiscal Policy Convergence Analysis", *African Journal of Economic and Management Studies*: Forthcoming.

Asongu, S. A., (2013f). "Real and Monetary Policy Convergence: EMU Crisis to the CFA Zone", *Journal of Financial Economic Policy*: Forthcoming.

Aubert, J. E., (2005). "Knowledge economies: A global perspective", In A. Bonfour & L. Edvinsson (Eds.), *Intellectual capital for communities*. Elsevier, Oxford.

Barro, R. J., & Sala-i-Martin, X., (1992). "Convergence", *Journal of Political Economy*, 100, pp. 223-251.

Barro, R. J., & Sala-i-Martin, X., (1995). *Economic Growth*. The MIT Press, Cambridge, MA.

Bizri, O., (2009). "The Knowledge economy and the Arab Countries: current climate and future prospects in education, innovation and technology", Carthage High Level International Conference on Building Knowledge Economies for job creation, increased competiveness and balanced development. December, 1-3, 2009.

Blundell, R., & Bond, S., (1998). "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Econometrics*, 87(1), pp.115-143.

Bond, S., Hoeffler, A., & Tample, J., (2001). "GMM Estimation of Empirical Growth Models", University of Oxford.

Britz, J. J., Lor, P. J., Coetzee, I. E. M., & Bester, B. C., (2006). "Africa as a knowledge society: A reality check", *The International Information & Library Review*, 38, pp. 25-40.

Chandra, D. S., & Yokoyama, K., (2011). "The role of good governance in the knowledge-based economic growth of East Asia – A study on Japan, Newly Industrialized Economies, Malaysia and China", Graduate School of Economics, Kyushu University.

Chavula, H. K., (2010). "The Role of Knowledge in Economic Growth. The African Perspective", ICT, Science and Technology Division (ISTD),United Nations Economic Commission for Africa (UNECA).

Costantini, M., & Lupi, C., (2005). "Stochastic Convergence among European Economies", *Economics Bulletin*, 3(38), pp.1-17.

Fung, M. K., (2009). "Financial development and economic growth: convergence or divergence?", *Journal of International Money and Finance*, 28, pp. 56-67.

Karagiannis, S., (2007, February). "The Knowledge-Based Economy, Convergence and Economic Growth: Evidence of the European Union", Center of Planning and Economic Research. *Working Paper* No. 91.

Islam, N., (1995). "Growth Empirics: A Panel Data Approach", *The Quarterly Journal of Economics*, 110, (4), pp. 1127-1170.

Iwamoto, W., (2005). “Secondary Education Reform: Towards a Convergence of Knowledge Acquisition and Skills Development”, UNESCO, ED-2005/WS/37.

Lightfoot, M., (2011). “Promoting the Knowledge Economy in the Arab World”, London Knowledge Lab, Institute of Education.

Longo, R., & Sekkat, K., (2004). “Economic Obstacle in Explaining Intra-African Trade”, *World Development*, 32 (8), pp. 1309-1321.

Jolliffe, I. T., (2002). *Principal Component Analysis* (2nd Ed.), New York: Springer.

Kaiser, H. F., (1974). “An index of factorial simplicity”. *Psychometrika,* 39, pp. 31–36.

Makinda, S. M., (2007). “How Africa can benefit from knowledge”, *Futures*, 39, pp. 973-985.

Narayan, P. K., Mishra, S., & Narayan, S., (2011). “Do market capitalization and stocks traded converge? New global evidence”, *Journal of Banking and Finance*, 35, pp. 2771-2781.

Saxegaard, M., (2006). “Excess liquidity and effectiveness of monetary policy: evidence from Sub-Saharan Africa”, *IMF Working Paper*, No. 06/115.

Weber, A. S., (2011). “The role of education in knowledge economies in developing countries”, *Procedia Social and Behavioral Sciences*, 15, pp. 2589-2594.

World Bank, (2007). “Building Knowledge Economies. Advanced Strategies for Development”, World Bank Institute.