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2 January 2013

Online at <https://mpra.ub.uni-muenchen.de/47801/>  
MPRA Paper No. 47801, posted 24 Jun 2013 19:56 UTC

# The ‘Knowledge Economy’-finance nexus in SSA and MENA countries

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## **Abstract**

**Purpose** – This paper assesses dynamics of the knowledge economy (KE)-finance nexus using the four variables identified under the World Bank’s knowledge economy index (KEI) and seven financial intermediary dynamics of depth, efficiency, activity and size.

**Design/methodology/approach** – Principal Component Analysis is used to reduce the dimensions of KE components before dynamic panel GMM estimation techniques are employed to examine the nexuses.

**Findings** – Four main findings are established. (1) Education improves financial depth and financial efficiency but mitigates financial size. (2) But for a thin exception (trade’s incidence on money supply), economic incentives (credit facilities and trade) are not consistently favorable to financial development. (3) ICT improves only financial size and has a negative effect on other financial dynamics. (4) Proxies for innovation (journals and FDI) have a positive effect on financial activity; journals (FDI) have (has) a negative (positive) effect on liquid liabilities and; journals and FDI both have negative incidences on money supply and banking system efficiency respectively.

**Practical Implications** – As a policy implication, the KE-finance nexus is a complex and multidimensional relationship. Hence, blind and blanket policy formulation to achieve positive linkages may not be successful unless policy-making strategy is contingent on the prevailing ‘KE specific component’ trends and dynamics of financial development. Policy makers should improve the economic incentive dimension of KE that overwhelmingly and consistently deters financial development, owing to surplus liquidity issues.

**Originality/value** – As far as we have reviewed, this is the first paper to examine the KE-finance nexus with the plethora of KE dimensions defined by the World Bank’s KEI and all the dynamics identified by the Financial Development and Structure Database (FDSD).

*JEL Classification:* G21; O10; O34; P00; P48

*Keywords:* Financial development; Knowledge Economy

## 1. Introduction

Europe and North America have mastered the dynamics of knowledge economy (KE) and are inexorably driving development in the global and international arena. Other regions like Asia and South America are reacting in strategic and calculated steps that underpin the role of KE in the current pursuit of national, regional and international initiatives. The Newly Industrialized Economies (Korea, Taiwan, Hong Kong & Singapore), Malaysia and China led by Japan are currently moving towards knowledge-based economies from the ‘product economies’ in the post-industrialization period. Intellectual property rights (IPRs) and KE have played quite a substantial role in the ‘East Asian miracle’ of industrial development (Chandra & Yokoyama, 2011; Asongu, 2012ab). In sub-Saharan African (SSA) and the Middle East & North African (MENA) countries, KE issues are also assuming central stage in discussions on development (Asongu, 2012c).

For close to two decades today, KE has emerged in the OECD<sup>1</sup> and World Bank reports as indispensable to 21<sup>st</sup> century development (World Bank, 2007; Peters, 2008; Weber, 2011). Hence, in policy making circles, knowledge created through innovation and advancement is key to long-run economic growth. Consistent with the recent weight of available empirical evidence, it has become abundantly clear that, for any country, region or continent to be actively involved in the global economy, it must be competitive. Competition stems from intellectual capital and KE, which are protected by IPRs laws and have recently been the focus of renewed interest in SSA and MENA countries; either through the fight against software piracy (Asongu & Andrés, 2012ab; Asongu, 2012ab) or via the incidence of financial sector competition (Asongu, 2012c). While the literature is flooding with theoretical and empirical assessments of the finance-growth nexus, the finance-KE nexus has been the object of limited scholarly research focus in developing countries. Cognizant of the crucial

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<sup>1</sup> Organization for Economic Co-operation and Development.

role of finance in economic prosperity, understanding the role of KE in financial development in developing countries is of policy relevance because, financial intermediation has been substantially documented as indispensable in channeling mobilized resources to economic operators. Unfortunately, much of the literature on KE has focused on the emerging economies of Latin America (Dahlan, 2007) and East Asia (Chandra & Yokoyama, 2011). As far as we have reviewed, but for a thin exception, SSA and MENA countries have not received the much needed scholarly attention (Aubert, 2005; Britz et al., 2006; Makinda, 2007; African Development Bank, AfDB, 2007; Chavula, 2010; Asongu, 2012abc; Asongu & Andrés, 2012ab).

In light of the above, this study's contribution to the literature is fivefold. Firstly, it deviates from mainstream literature by incorporating all financial dimensions identified in the Financial Development and Structure Database (FDSD) and provides an exhaustive assessment of the KE-finance nexus with financial dynamics of depth, efficiency, activity and size. Secondly, a substantial bulk of research has focused on developed countries and the emerging economies of Latin America and East Asia. Hence, the scope and positioning of this paper on SSA and MENA addresses an important missing dimension in the literature. Thirdly, most studies on KE have focused on one or two of its components. As opposed to mainstream literature, this paper employs all the four components in the World Bank's Knowledge Economy Index (KEI): economic incentive, innovation, education and information & communication technology (ICT). Fourthly, whereas some aspects of KE might have been investigated prior to the availability of the KEI for developing countries, the use of much recent data by this paper provides an updated account of the development nexuses with more focused policy implications. Fifthly, a motivation for this work also emanates from the debate on the 'East Asian miracle' in which some evidence suggests that the miracle could have been caused by strong policy focus on KE at the early stages of these nations'

development in addition to their accumulation of capital . Hence examining the debate within the framework of SSA and MENA countries could result in relevant policy recommendations.

The rest of the paper is organized as follows. Section 2 briefly examines the scope and positions the paper. Data and methodology are presented and outlined respectively in Section 3. Empirical analysis and corresponding discussion are covered in Section 4. Section 5 concludes.

## **2. Scope and positioning of the paper**

As we have highlighted earlier, much of the literature on KE in developing countries has focused on the emerging economies of Latin America (Dahlan, 2007; Asongu, 2012c) and East Asia (Chandra & Yokoyama, 2011). As far as we have reviewed, with the exception of Chavula (2010), the few SSA and MENA papers have assessed only a few dimensions of KE (Aubert, 2005; Britz et al., 2006; Makinda, 2007; African Development Bank, AfDB, 2007). There has also been a recent wave of growing literature on the enhancing of IPRs in Africa (Asongu & Andrés, 2012ab; Asongu, 2012ab) as means of creating conducive conditions for KE. In order to clearly position this paper, we shall discuss this section in three strands: policy issues, KE-growth nexus and how the present paper steers clear of past studies.

While Bizri (2009) has discussed the need for policy reforms towards KE in the MENA countries, as far as we have reviewed, Makinda (2007) provides one of the most detailed accounts of reforms required in SSA. Consistent with Makinda, in order to rectify this gap between SSA and the Western World, African policy makers need to: (1) define the type of knowledge their countries require; (2) establish conditions for nurturing strategic leaders who will in turn, seek right forms of knowledge to tackle Africa's problems; (3) build political and legal frameworks that encourage the absorption and application of scientific innovation and; (4) revamp universities, establish regional research centers and take capacity building more seriously. Much recently, Chavula (2010) has also concluded that African

countries need to direct policy efforts towards restructuring economic incentives that encourage the acquisition, adaptation and utilization of knowledge into productive use. Earlier, Britz et al. (2006) had investigated the question of whether Africa is moving towards a knowledge society and found that, Africa still had a long way to go down the road and the journey could be quickened with certain preconditions, amongst other: investment in human capital, effective stopping of brain drain, as well as effective development and maintenance of a physical infrastructure.

In the second strand, consistent with Asongu (2012c), the AfDB (2007) has assessed the impact of public expenditure on the education dimension of KE and found the following: (1) in the short-term, there is a positive relationship between public expenditure on education and economic growth in Africa, as well as on knowledge generation and human capital development, which have a potential to positively affect aggregate labor productivity and; (2) in the long-term however, public expenditure is negatively related to economic growth due to the often lack of capacity to retrain human capital and subsequent brain drain. Chavula (2010) has recently used panel data from 1990 to 2007 to assess the role of KE in economic growth. The results are consistent with the positive bearing of telephone lines, mobile subscribers, tertiary school enrolment and FDI inflows on per capita economic prosperity. In MENA countries, the United Arab Emirates thanks to Dubai (an internet and media city with world class standard created from scratch), shows the best performance (Aubert & Reiffers, 2003). Among other MENA countries which have demonstrated substantial improvement, it is worthwhile noting Jordan and Tunisia which have heavily invested in education and developed their ICT and/or electronic sectors. As for SSA countries, South Africa distinguishes itself quite remarkably and among low-income countries, some significant progress is noticeable in Uganda, Senegal, Rwanda, Mauritania...etc (Aubert, 2005).

In light of the above, the interest of the present study is to complement existing literature by assessing the incidence of KE on financial development dynamics. Its fivefold contribution to the literature has already been covered in the introduction.

### **3. Data and Methodology**

#### **3.1 Data**

We assess 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) over the period 1996-2010. Limitations to the time span and number of countries are constrained by KE data availability and the motivation of obtaining results with more updated policy implications.

##### *2.1.1 Dependent variables*

With regard to the choice of the dependent variables, contrary to mainstream literature in which only one or two measures of finance (for the most part) are employed, we exploit all the dimensions of finance indentified in the FDSD. These include financial intermediary dynamics of activity, efficiency, depth and size. This plethora of financial measures have been recently employed in the general context of Africa (Asongu, 2012d), in the assessment of potential monetary zones (Asongu, 2012e), existing monetary unions (Asongu, 2012f) or other macroeconomic strategies of economic development (Asongu, 2012g).

Firstly, from a financial depth perspective, we measure it both from overall-economic and financial system standpoints with indicators of broad *money supply* ( $M2/GDP$ ) and *financial system deposits* ( $FdgdP$ ) respectively. Whereas the former represents the monetary base ( $M0$ ) plus demand, saving and time deposits, the latter denotes liquid liabilities (or

deposits) of the financial system<sup>2</sup>. Secondly, credit is appreciated in terms of financial intermediary activity. Hence, the study seeks to lay emphasis on the ability of banks to grant credit to economic operators. We measure both *banking-system-activity* and *financial-system-activity* with “private domestic credit by deposit banks: *Pcrb*” and “private credit by deposit banks and other financial institutions: *Pcrbof*” respectively. Thirdly, financial efficiency<sup>3</sup> appreciates the ability of deposits (money) to be transformed into credit (financial activity). This third indicator measures the fundamental role of banks in transforming mobilized deposits into credit for economic operators. To this effect, we take into account indicators of *banking-system-efficiency* and *financial-system-efficiency* (respectively ‘bank credit on bank deposits: *Bcbd*’ and ‘financial system credit on financial system deposits: *Fcfd*’). Fourthly, *financial size* is measured in terms of deposit bank assets (credit) as a proportion of total assets (deposit bank assets plus central bank assets). The correlation matrices presented in Appendix 2 show that (but for financial size) the two measures adopted for each financial dynamic can be used to robustly check each another.

### 2.1.2 Independent and control variables

The exogenous variables are in line with recent KE literature (Chavula, 2010; Weber, 2011) and consist of the four dimensions of KE identified by the World Bank KEI: education, ICT, economic incentives and innovation. The procedure for selecting these variables is provided in Section 3.2.1 below.

Control variables include: *population growth*, *GDP growth*, *government expenditure*, *inflation* and *domestic investment*. Government expenditure and investment have been used in recent African finance literature (Asongu, 2012h) and could decrease financial

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<sup>2</sup> It is relevant to distinguish between these two aggregates of money supply because, since we are dealing exclusively with developing (SSA and MENA) countries, a great chunk of the monetary base does not transit via formal banking institutions.

<sup>3</sup> By financial efficiency in this context, we neither refer to the profitability-related concept (notion) nor to the production efficiency of decision making units in the financial sector (through Data Envelopment Analysis: DEA).

development if the budget allocated for investment is misallocated through corrupt practices (Ndikumana, 2000). Accordingly, GDP growth, population growth and domestic investment should naturally spur financial development. Whereas low and stable inflation rates generally provide a conducive environment for financial development, high inflation on the other hand, does quite the opposite. In addition, recent African finance literature has established a negative association between inflation and financial allocation efficiency (Asongu, 2012h).

The summary statistics (with presentation of countries), correlation analysis (showing the nexuses among key variables used in the paper), and variable definitions are detailed in the appendices. The ‘summary statistics’ (Panel A of Appendix 1) of the variables used in the panel regressions shows that, there is quite some variation in the data utilized so that one should be confident that reasonable estimated nexuses should emerge. Countries under investigation are presented in Panel B. The object of the correlation matrix (Appendix 2) is to mitigate issues resulting from overparametization and multicollinearity. From a preliminary examination of the correlation coefficients, there do not appear to be any serious issues in terms of the relationships to be estimated. Variable definitions and their corresponding sources are presented in Appendix 3.

## **3.2 Methodology**

### *3.2.1 Principal Component Analysis (PCA)*

Due to the high correlation between various indicators in each dimension of the KEI, one might criticize the redundancy of some information (data). Accordingly, we use principal component analysis (PCA) to reduce the dimensions of each constituent of the KEI. The PCA is a widely used statistical technique to reduce a larger set of correlated variables into a smaller set of uncorrelated variables called principal components (PC) that represent most of the information in the original data set. In choosing the PCs, the criteria applied to determine

how many common factors to retain are taken from Kaiser (1974) and Jolliffe (2002). Therefore, only PCs with an eigenvalue that exceed one are retained. It is interesting to note that, the first PCs are almost equal across dimensions. The results also show that one PC model is appropriate for KE dimensions in the sample. For example, as presented in Table 1, the first PC accounts for approximately 65% of the variation in all the four KE dimensions. *Educatex* for instance which represents 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 Economy dimensions		Component Matrix (Loadings)			First P.C	Eigen Value	Indexes
Education	School enrolment	PSE	SSE	TSE	0.771	2.313	Educatex
		0.535	0.620	0.574			
Information & Infrastructure	ICTs	Internet	Mobile	Telephone	0.705	2.115	ICTex
		0.653	0.661	0.371			
Economic Incentive	Trade & Tariffs	Trade	Tariffs	0.645	1.290	Tradex	
		-0.707	0.707				
Innovation	Credit & IR Spread	Private Credit	Interest rate spread	0.679	1.358	Creditex	
		-0.707	0.707				
	Scientific Journals 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.

### 3.2.2 Estimation technique

When compared with cross-country analysis, estimations with dynamic panel data have some important advantages and one disadvantage (Demirgüç-Kunt & Levine, 2008). From the positive side: (1) they makes use both of time-series and the cross sectional variations in the data; (2) in cross-country regressions, the unobserved country-specific effect is part of the error term, so that correlations between the error term and the exogenous

variables result in biased estimated coefficients. Additionally, in cross-country regressions, if the lagged explained variable is included among the explanatory variables, the country-specific effect is certainly correlated with the regressors. A measure of controlling for the presence of the unobserved country-specific effect is to first-difference the regression equation to eliminate the country-specific effect and, then make use of instrumental variables to control for endogeneity. This endogeneity issue is the second appealing side of dynamic panel data analysis. Uncontrolled endogeneity can significantly bias estimates and lead to misleading inferences and poor policy recommendations. Dynamic panel data analysis tackles this endogeneity issue by using lagged values of exogenous variables as instruments.

The principal unappealing dimension associated with dynamic panel data analysis is the use of data-averages over shorter time spans. By implication, the estimated results show shorter-run effects and not long-term impacts, which should be kept in mind when interpreting and discussing results. Within the framework of the current paper, this issue is overcome by the usage of ‘full data’ and not ‘averages’. It is interesting to note that, by so doing the condition for using dynamic system panel GMM ( $N > T$  or  $22 > 15$ ) is not violated.

The dynamic panel regression model is expressed as follows:

$$F_{i,t} = \sigma_0 + \sigma_1 F_{i,t-1} + \sigma_2 KE_{i,t} + \sigma_3 X_{i,t} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

Where ‘t’ stands for the period and ‘i’ represents a country.  $F$  is the measure for financial development;  $KE$  is the vector of knowledge economy components;  $X$ , is the vector of control variables;  $\eta_i$  is a country-specific effect,  $\xi_t$  is a time-specific constant and,  $\varepsilon_{i,t}$  an error term.

Estimates will be unbiased if and only if, the explaining variables above are strictly exogenous. Unfortunately, this is not the case in the real world because: (1) while they have a substantial effect on financial development, the reverse effect cannot be ruled-out because the level of financial development also affects the degree of KE (Asongu, 2012c); (2) the

regressors could be correlated with the error term ( $\varepsilon_{i,t}$ ) and; (3) country- and time-specific effects could also be correlated with other variables in the model, which is often the case with lagged dependent variables included in the equations. Consequently, we are confronted with an issue of endogeneity due to endogenous regressors. A way of addressing the problem of the correlation between the individual specific-effect and the lagged endogenous variables involves eliminating the individual effect by first differencing. Thus, Eq. (1) becomes:

$$F_{i,t} - F_{i,t-1} = \sigma_1(F_{i,t-1} - F_{i,t-2}) + \sigma_{2j}(KE_{i,t} - KE_{i,t-1}) + \sigma_{3j}(X_{i,t} - X_{i,t-1}) + (\xi_t - \xi_{t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad (2)$$

However Eq. (2) presents another concern; estimation by Ordinary Least Squares (OLS) is still biased because of a potential correlation between the lagged endogenous independent variable and the error term. In order to address this issue, we estimate the regression in differences jointly with the regression in levels using the Generalized Method of Moments (GMM) estimation. The estimation strategy uses lagged levels of the regressors as instruments in the difference equation, and lagged differences of the regressors as instruments in the level equation, hence, exploiting all the orthogonality conditions between the lagged dependent variables and the error term. Between the difference GMM estimator (Arellano & Bond, 1991) and the system GMM estimator (Arellano & Bover, 1995; Blundell & Bond, 1998), we prefer the latter strategy in accordance with Bond et al. (2001, 3-4)<sup>4</sup>.

In the specification of the dynamic panel system estimation, we opt for the *two-step* GMM because it corrects the residuals for heteroscedasticity. It should be noted that, in the *one-step*, the residuals are considered to be homoscedastic. The assumption of no auto-correlation in the residuals is crucial as past lagged variables are to be used as instruments for

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<sup>4</sup> “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 application. Hence we recommend this system GMM estimator for consideration in subsequent empirical growth research”. Bond et al. (2001, pp. 3-4).

the endogenous variable. Accordingly, the estimation depends on the hypothesis that the lagged values of the dependent variable and other explaining variables are valid instruments in the regression. 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:  $AR(2)$  should not be. The validity of the instruments is assessed with the Sargan over-identifying restrictions (OIR) test. In a nutshell, the main arguments for using the system GMM estimation are that: it does not eliminate cross-country variation, it mitigates potential biases of the difference estimator in small samples and, it can control for the potential endogeneity of all regressors (Asongu, 2012a).

#### **4. Empirical analysis**

##### **4.1 Presentation of results**

Table 3, Table 4, Table 5 and Table 6 below assess the effect of KE on financial dynamics of depth, efficiency, activity and size respectively. The findings of Tables 3-6 are summarized in Table 2 from which the following conclusions could be drawn. (1) Education improves financial depth and financial efficiency but mitigates financial size. (2) But for a thin exception (*Tradex's* incidence on money supply), economic incentives are not consistently favorable to financial development. (3) ICT improves only financial size and has a negative effect on other financial dynamics. (4) Proxies for innovation (journals and FDI) have a positive effect on financial activity; journals (FDI) have (has) a negative (positive) effect on liquid liabilities and; journals and FDI both have negative incidences on money supply and banking system efficiency respectively. Most of the significant control variables have the expected signs with domestic investment, population growth and government expenditure consistently exerting positive incidences on the financial dynamics.

**Table 2: Summary of results**

		Financial Depth		Financial Efficiency		Financial Activity		Fin. Size
		Money Supply	Liquid Liability	Banking Efficiency	Financial Efficiency	Banking Activity	Financial Activity	
Education	Educatex	+	+	na	+	na	na	-
Economic	Creditex	-	-	na	na	-	-	na
Incentive	Tradex	+	-	-	-	-	-	?
ICT	ICTex	?	-	-	na	-	-	+
Innovation	Journals	-	-	na	na	+	+	na
	FDI	na	+	-	na	+	+	na

? represents conflicting signs. na: not applicable due to insignificant estimate.

**Table 3: 'KE-financial depth' nexus (Two Step dynamic panel system GMM)**

		Dependent variable: Financial depth							
		Overall economic financial depth (M2)				Financial system depth (Liquid liabilities)			
Finance_1		<b>0.876***</b> (5.417)	<b>0.950***</b> (7.334)	<b>0.703**</b> (2.412)	<b>0.871***</b> (7.883)	<b>0.982***</b> (6.360)	<b>0.461**</b> (2.500)	<b>0.781***</b> (6.126)	<b>0.879***</b> (8.327)
Constant		0.088 (0.869)	<b>-0.406**</b> (-2.064)	0.290 (1.361)	<b>0.143*</b> (1.822)	<b>-0.263*</b> (-1.675)	<b>0.203**</b> (2.449)	<b>0.172***</b> (3.029)	<b>0.074*</b> (1.678)
Education	Educatex	<b>0.009</b> (0.759)	0.009 (0.734)	---	---	0.003 (0.711)	<b>0.033***</b> (4.656)	---	---
	Creditex	---	---	-0.076 (-1.313)	<b>-0.041*</b> (-1.760)	---	---	<b>-0.049**</b> (-2.509)	<b>-0.029*</b> (-1.700)
Economic	Tradex	-0.0091 (-0.562)	-0.010 (-0.814)	<b>0.011**</b> (2.497)	<b>0.013***</b> (2.970)	-0.003 (-0.241)	<b>-0.050**</b> (-2.507)	0.005 (1.208)	0.005 (0.912)
ICT	ICTex	0.003 (0.520)	<b>-0.026**</b> (-2.091)	<b>0.010**</b> (2.332)	0.002 (0.706)	<b>-0.016*</b> (-1.809)	-0.0001 (-0.010)	0.003 (1.031)	0.001 (0.578)
Innovation	Journals	---	<b>0.073**</b> (2.156)	<b>-0.03***</b> (-3.633)	<b>-0.02***</b> (-2.823)	<b>0.041*</b> (1.730)	0.045 (0.893)	<b>-0.02***</b> (-7.254)	<b>-0.014*</b> (-1.652)
	FDI	---	-0.003 (-1.041)	---	0.002 (1.498)	-0.001 (-0.668)	---	<b>0.002*</b> (1.948)	0.001 (1.152)
Population Growth		---	0.026 (1.127)	-0.006 (-0.883)	-0.004 (-1.083)	0.014 (0.934)	---	-0.003 (-1.275)	---
Inflation		-0.001 (-0.484)	---	---	---	---	---	---	---
Economic Prosperity		---	---	-0.003 (-1.070)	---	---	0.0006 (0.191)	---	---
Government Expenditure		0.0007 (0.876)	---	0.0007 (1.084)	---	---	0.001* (1.788)	---	---
Domestic Investment		---	<b>0.011**</b> (2.254)	---	---	<b>0.007**</b> (2.138)	---	---	<b>0.001*</b> (1.672)
Test for AR(2) errors		<b>1.353</b> [0.176]	<b>1.367</b> [0.171]	<b>-0.641</b> [0.521]	<b>-1.328</b> [0.183]	<b>0.920</b> [0.357]	<b>1.593</b> [0.111]	<b>-1.114</b> [0.265]	<b>-1.073</b> [0.282]
Sargan OIR test		<b>0.000</b> [1.000]	<b>0.129</b> [1.000]	<b>5.248</b> [1.000]	<b>7.618</b> [1.000]	<b>0.498</b> [1.000]	<b>0.470</b> [1.000]	<b>7.483</b> [1.000]	<b>6.693</b> [1.000]

\*,\*\*,\*\*\*: significance levels of 10%, 5% and 1% respectively. Z-statistics in parentheses. [ ]:P-values. OIR: Overidentifying Restrictions. 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.

**Table 4: ‘KE-financial efficiency’ nexus (Two Step dynamic panel system GMM)**

		Dependent variable: Financial efficiency							
		Banking system efficiency (BcBd)				Financial system efficiency (FcFd)			
Finance_1		<b>0.828***</b> (3.948)	<b>0.920***</b> (3.271)	0.449 (0.922)	0.257 (0.384)	<b>0.678***</b> (2.926)	<b>1.081***</b> (11.51)	0.755 (0.588)	0.224 (0.430)
Constant		-0.008 (-0.082)	0.072 (0.321)	0.542 (1.241)	0.602 (1.044)	0.336 (1.415)	-0.059 (-0.849)	0.200 (0.177)	0.197 (0.950)
Education	Educatex	---	---	---	0.025 (0.590)	---	---	0.007 (0.129)	<b>0.015***</b> (3.244)
	Creditex	---	-0.024 (-0.683)	-0.063 (-1.143)	---	-0.040 (-1.524)	0.002 (0.226)	---	---
Economic Incentive	Tradex	-0.010 (-0.698)	-0.009 (-0.680)	<b>-0.01***</b> (-3.280)	0.007 (0.271)	<b>-0.014*</b> (-1.782)	-0.002 (-0.236)	0.002 (0.072)	-0.001 (-0.409)
ICT Infrastructure	ICTex	0.001 (0.089)	-0.012 (-0.696)	<b>-0.016*</b> (-1.709)	-0.001 (-0.064)	-0.010 (-1.080)	0.009 (1.217)	-0.004 (-0.190)	-0.058 (-1.422)
	Journals	0.024 (0.636)	---	---	---	---	---	---	0.144 (1.461)
Innovation	FDI	<b>-0.003*</b> (-1.831)	-0.003 (-1.230)	<b>-0.003*</b> (-1.712)	0.002 (1.033)	-0.003 (-1.115)	-0.0008 (-0.534)	0.001 (0.474)	0.0008 (0.699)
Population Growth		---	---	0.011 (1.252)	---	<b>0.011**</b> (2.255)	---	---	---
Inflation		-0.0004 (-0.207)	0.0004 (0.674)	-0.0002 (-0.143)	0.001 (0.240)	-0.0006 (-0.480)	0.001 (1.261)	-0.000 (-0.001)	---
Government Expenditure		<b>0.002***</b> (2.925)	0.000 (0.122)	-0.000 (-0.107)	---	0.000 (0.018)	---	---	---
Domestic Investment		<b>0.003***</b> (2.771)	---	-0.008 (-1.238)	---	-0.005 (-1.400)	---	---	<b>0.005**</b> (2.192)
Test for AR(2) errors		<b>-1.482</b> [0.138]	<b>-1.379</b> [0.167]	<b>-0.706</b> [0.479]	<b>-1.011</b> [0.311]	<b>-1.206</b> [0.227]	<b>-1.194</b> [0.232]	<b>-0.380</b> [0.703]	<b>-1.100</b> [0.271]
Sargan OIR test		<b>10.403</b> [1.000]	<b>7.748</b> [1.000]	<b>4.975</b> [1.000]	<b>6.493</b> [1.000]	<b>6.093</b> [1.000]	<b>9.338</b> [1.000]	<b>6.137</b> [1.000]	<b>0.768</b> [1.000]

\*,\*\*,\*\*\*: significance levels of 10%, 5% and 1% respectively. Z-statistics in parentheses. [ ]:P-values. OIR: Overidentifying Restrictions. 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.

**Table 5: KE-financial activity nexus (Two Step dynamic panel system GMM)**

		Dependent variable: Financial activity							
		Banking system activity (Pcbrb)				Financial system activity (Pcrbof)			
Finance_1		<b>0.825***</b> (3.209)	<b>0.897***</b> (6.921)	<b>0.684***</b> (4.979)	<b>0.568***</b> (3.464)	<b>0.808***</b> (5.806)	<b>0.808***</b> (5.806)	<b>0.643***</b> (3.466)	<b>0.477**</b> (2.499)
Constant		<b>-0.210**</b> (-2.352)	0.063 (1.015)	<b>0.118***</b> (3.636)	<b>0.155***</b> (3.299)	<b>-0.376**</b> (-2.187)	<b>-0.376**</b> (-2.187)	<b>0.105***</b> (3.092)	<b>0.183***</b> (3.115)
Education	Educatex	0.003 (0.188)	0.010 (0.849)	---	---	0.004 (0.519)	0.004 (0.519)	---	---
	Creditex	---	---	<b>-0.05***</b> (-3.028)	<b>-0.07***</b> (-3.031)	---	---	<b>-0.060**</b> (-2.415)	<b>-0.08***</b> (-3.037)
Economic Incentive	Tradex	-0.023 (-1.536)	-0.011 (-1.119)	-0.011 (-1.355)	<b>-0.01***</b> (-2.619)	<b>-0.028**</b> (-2.020)	<b>-0.028**</b> (-2.020)	-0.017 (-1.497)	<b>-0.02***</b> (-3.022)
ICT Infrastructure	ICTex	<b>-0.022**</b> (-2.180)	0.0008 (0.194)	-0.0003 (-0.118)	-0.002 (-0.817)	<b>-0.032**</b> (-2.035)	<b>-0.032**</b> (-2.035)	-0.002 (-0.858)	-0.003 (-0.903)

Innovation	Journals	<b>0.070*</b> ( <b>1.826</b> )	---	0.0001 (0.010)	0.006 (0.613)	<b>0.102*</b> ( <b>1.790</b> )	<b>0.102*</b> ( <b>1.790</b> )	0.009 (0.515)	0.012 (0.824)
	FDI	0.001 (0.515)	---	<b>0.001**</b> ( <b>2.479</b> )	<b>0.001***</b> ( <b>2.679</b> )	0.0006 (0.627)	0.0006 (0.627)	<b>0.002***</b> ( <b>2.940</b> )	<b>0.003***</b> ( <b>4.822</b> )
Population Growth		---	---	---	<b>-0.006**</b> ( <b>-2.384</b> )	---	---	---	-0.004 (-1.432)
Inflation		---	-0.001 (-0.763)	---	0.000 (0.050)	---	---	---	-0.0009 (-1.472)
Economic Prosperity		---	---	-0.002 (-0.759)	-0.002 (-1.163)	---	---	-0.003 (-0.868)	<b>-0.003*</b> ( <b>-1.744</b> )
Domestic Investment		<b>0.006**</b> ( <b>2.533</b> )	---	0.0009 (1.374)	<b>0.001**</b> ( <b>2.525</b> )	<b>0.011**</b> ( <b>2.384</b> )	<b>0.011**</b> ( <b>2.384</b> )	0.001 (1.132)	<b>0.001**</b> ( <b>2.175</b> )
Test for AR(2) errors		<b>0.613</b> [ <b>0.539</b> ]	<b>-0.611</b> [ <b>0.540</b> ]	<b>-1.033</b> [ <b>0.301</b> ]	<b>-1.224</b> [ <b>0.220</b> ]	<b>1.118</b> [ <b>0.263</b> ]	<b>1.118</b> [ <b>0.263</b> ]	<b>-0.870</b> [ <b>0.384</b> ]	<b>-0.929</b> [ <b>0.352</b> ]
Sargan OIR test		<b>1.805</b> [ <b>1.000</b> ]	<b>3.982</b> [ <b>1.000</b> ]	<b>3.569</b> [ <b>1.000</b> ]	<b>1.891</b> [ <b>1.000</b> ]	<b>0.582</b> [ <b>1.000</b> ]	<b>0.582</b> [ <b>1.000</b> ]	<b>6.462</b> [ <b>1.000</b> ]	<b>3.212</b> [ <b>1.000</b> ]

\*,\*\*,\*\*\*: significance levels of 10%, 5% and 1% respectively. Z-statistics in parentheses. [ ]:P-values. OIR: Overidentifying Restrictions. 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.

**Table 6: KE-financial size nexus (Two Step dynamic panel system GMM)**

		Dependent variable: Financial size			
Finance_1		<b>0.945***</b> ( <b>18.83</b> )	<b>1.077***</b> ( <b>8.144</b> )	<b>0.971***</b> ( <b>16.13</b> )	<b>0.621***</b> ( <b>2.637</b> )
Constant		0.062 (1.375)	-0.093 (-0.761)	0.037 (0.329)	0.228 (1.280)
Education	Educatex	<b>-0.009***</b> ( <b>-3.197</b> )	---	<b>-0.009*</b> ( <b>-1.948</b> )	---
	Creditex	---	0.018 (1.343)	---	-0.010 (-0.530)
Economic Incentive	Tradex	<b>-0.002**</b> ( <b>-2.030</b> )	<b>0.012**</b> ( <b>1.986</b> )	0.0005 (0.103)	-0.003 (-0.397)
ICT Infrastructure	ICTex	0.003 (1.555)	0.007 (1.085)	0.004 (0.425)	<b>0.018**</b> ( <b>2.451</b> )
Innovation	Journals	---	---	0.001 (0.058)	---
	FDI	0.000 (0.076)	0.0003 (0.144)	0.0005 (0.792)	-0.006 (-1.475)
Inflation		---	<b>0.001*</b> ( <b>1.657</b> )	---	-0.001 (-1.283)
Government Expenditure		---	<b>0.002***</b> ( <b>4.062</b> )	-0.0003 (-0.141)	<b>0.002***</b> ( <b>6.407</b> )
Domestic Investment		---	---	---	<b>0.005**</b> ( <b>2.321</b> )
Test for AR(2) errors		<b>0.686</b> [ <b>0.492</b> ]	<b>-0.791</b> [ <b>0.428</b> ]	<b>0.523</b> [ <b>0.601</b> ]	<b>-0.472</b> [ <b>0.636</b> ]
Sargan OIR test		<b>4.637</b> [ <b>1.000</b> ]	<b>8.669</b> [ <b>1.000</b> ]	<b>2.490</b> [ <b>1.000</b> ]	<b>4.536</b> [ <b>1.000</b> ]

\*,\*\*,\*\*\*: significance levels of 10%, 5% and 1% respectively. Z-statistics in parentheses. [ ]:P-values. OIR: Overidentifying Restrictions. 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.

## 4.2 Further discussion of results

First and foremost, the positive incidence of education on financial dynamics of depth and efficiency are consistent with intuition. The educational process itself is object of a lot of borrowing and lending, payment of school fees is through formal financial institutions and, ultimately an educated person is more likely to have a bank account than an uneducated citizen. Secondly (but for a thin exception), the fact that economic incentives (that facilitate credit facilities and trade openness) have negative incidences on financial dynamics have a threefold explanation. (1) There is a substantially documented issue of surplus liquidity in African financial institutions (Saxegaard, 2006), such that policies towards favoring credit facilities still fall short of transforming mobilized deposits into credit for economic operators (inefficiency), which ultimately mitigate financial activity. (2) With trade openness, foreign financial institutions have the edge in financial services over their domestic counterparts, especially regarding the granting of credit (Asongu, 2012i). (3) The thin exception in the positive incidence of trade on money supply is logical because, M2 entails a great chunk of currency circulating outside financial institutions. Hence, with foreign financial services, we naturally expect the overall velocity of money to increase even when domestic financial institutions are negatively affected in terms of efficiency and activity. Thirdly, the fact that ICT are substantially exerting a negative incidence on financial development dynamics is consistent with the recent empirical evidence on the negative incidence of mobile phone penetration on traditional financial development indicators (Asongu, 2012h). Fourthly, the positive effect of FDI on financial dynamics of depth and activity is obviously logical, since FDI is a process of injecting funds into the economy through investment channels which ultimately stimulate financial activity and increase money velocity.

## **5. Conclusion and policy implications**

This paper has assessed dynamics of the knowledge economy (KE)-finance nexus using the four variables identified under the World Bank's knowledge economy index (KEI) and seven financial intermediary dynamics of depth, efficiency, activity and size. The following findings have been established. (1) Education improves financial depth and financial efficiency but mitigates financial size. (2) But for a thin exception (trade's incidence on money supply), economic incentives (trade and credit facilities) are not consistently favorable to financial development. (3) ICT improves only financial size and has a negative effect on other financial dynamics. (4) Proxies for innovation (journals and FDI) have a positive effect on financial activity; journals (FDI) have (has) a negative (positive) effect on liquid liabilities and; journals and FDI both have negative incidences on money supply and banking system efficiency respectively.

As a policy implication, the KE-finance nexus is a complex and multidimensional relationship. Hence, blind and blanket policy formulation to achieve positive linkages may not be successful unless policy-making strategy is contingent on the prevailing 'KE specific component' trends and dynamics of financial development. Policy makers should improve the economic incentive dimension of KE that overwhelmingly and consistently deters financial development, owing to surplus liquidity issues.

## Appendices

### Appendix 1: Summary statistics and presentation of countries

		Panel A: Summary Statistics				
		Mean	S.D	Min	Max	Obs.
Knowledge Economy	Educatex (Education)	-0.038	1.370	-4.344	1.858	126
	ICTex (Information & Infrastructure)	0.028	1.440	-3.750	3.183	310
	Tradex (First Economic Incentive)	-0.058	1.143	-2.901	2.635	161
	Creditex (Second Economic Incentive)	0.118	1.224	-2.296	3.488	193
	Scientific and Technical Journals	2.142	0.676	0.518	3.821	284
	Foreign Direct Investment Inflows	3.119	3.908	-4.025	33.566	319
Financial development variables	Overall economic depth (M2)	0.523	0.291	0.121	1.279	240
	Financial system depth (Liquid liabilities)	0.453	0.269	0.081	1.095	243
	Banking system efficiency (BcBd)	0.751	0.288	0.143	2.103	308
	Financial system efficiency (FcFd)	0.811	0.332	0.144	1.871	243
	Banking system activity (Pcrb)	0.348	0.245	0.041	1.006	243
	Financial system activity (Pcrbof)	0.375	0.256	0.041	1.002	243
Control variables	Financial system size (Dbacba)	0.851	0.216	0.124	1.609	261
	Population growth	2.759	2.668	-0.157	18.588	330
	Inflation	5.585	6.274	-9.797	43.073	296
	Government Expenditure	12.318	11.321	-34.88	80.449	295
	Economic Prosperity	4.689	3.450	-4.300	26.750	313
	Domestic Investment	20.531	6.910	-1.380	39.348	301

#### Panel B: Presentation of Countries

Algeria, Bahrain, Botswana, Cameroon, Egypt, Israel, Jordan, Kenya, Kuwait, Lebanon, Libya, Mauritius, Morocco, Nigeria, Oman, Qatar, Saudi Arabia, Senegal, Tunisia, United Arab Emirates, Yemen, Zambia.

S.D: Standard Deviation. Min: Minimum. Max: Maximum. Obs: Observations.

## Appendix 2 : Correlation analysis

Knowledge Economy						Financial (Fin) Development							Control Variables					
Educatex	ICTex	Tradex	Creditex	S& T Journals	FDI inflows	Fin. depth M2	Fin. depth fdgdp	Fin. efficiency BcBd	Fin. efficiency FcFd	Fin. activity Pcrb	Fin. activity Pcrbof	Fin Size Dbacba	Popg	Infl.	G.Exp	GDPg	D.Invt	
1.000	0.381	-0.388	-0.844	0.438	0.267	0.619	0.666	0.221	0.283	0.672	0.692	0.530	-0.241	-0.33	0.606	0.119	0.078	Educatex
	1.000	-0.221	-0.405	0.489	0.166	0.268	0.248	0.189	0.153	0.305	0.285	0.455	0.090	-0.15	0.179	0.050	0.013	ICTex
		1.000	0.490	0.161	-0.423	-0.33	-0.42	-0.22	-0.16	-0.45	-0.45	-0.317	-0.442	0.025	-0.28	-0.266	-0.18	Tradex
			1.000	-0.502	-0.147	-0.78	-0.78	-0.39	-0.43	-0.82	-0.82	-0.554	-0.081	0.460	-0.44	-0.114	-0.15	Creditex
				1.000	0.073	0.392	0.373	0.338	0.375	0.474	0.482	0.210	-0.101	-0.18	0.117	-0.105	-0.11	S&T Journals
					1.000	0.223	0.256	-0.03	-0.02	0.230	0.208	0.051	0.122	0.095	0.137	0.193	0.163	FDI inflows
						1.000	0.981	0.125	0.088	0.887	0.856	0.377	-0.135	-0.31	0.268	0.005	0.295	M2
							1.000	0.158	0.080	0.900	0.866	0.399	-0.097	-0.29	0.285	0.011	0.259	fdgdp
								1.000	0.812	0.501	0.519	0.336	0.168	-0.19	0.093	0.125	-0.14	BcBd
									1.000	0.348	0.527	0.215	0.036	-0.32	0.228	0.010	-0.12	FcFd
										1.000	0.968	0.398	-0.080	-0.31	0.289	0.031	0.207	Pcrb
											1.000	0.403	-0.054	-0.37	0.350	0.019	0.177	Pcrbof
												1.000	0.029	-0.37	0.215	0.084	0.279	Dbacba
													1.000	0.076	0.106	0.405	0.172	Popg
														1.000	-0.20	0.130	-0.15	Inflation(Infl)
															1.000	0.046	-0.03	G. Exp.
																1.000	0.153	GDPg
																	1.000	D.Invt.

S & T Journals: Technical & Scientific Journals. M2 :Money Supply. fdgdp: liquid liabilities. BcBd: Bank credit on bank deposit. FcFd: Financial credit on financial deposit. Pcrb: Private domestic credit by deposit banks. Pcrbof: Private domestic credit by deposit banks and other financial institutions. Dbacba: Deposit bank assets on deposit bank assets plus central bank assets. Popg:Population growth. Infl:Inflation. G. Exp: Government Expenditure. GDPg: Economic Prosperity. DInvt: Domestic Investment.

### Appendix 3: Variable definitions

Variables	Signs	Variable definitions	Sources
<b>Panel A: Dimensions in Knowledge Economy (KE)</b>			
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)
<b>Education in KE</b>	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)
<b>Information &amp; Infrastructure in KE</b>	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)
<b>1<sup>st</sup> Economic Incentive dimension in KE</b>	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)
<b>2<sup>nd</sup> Economic Incentive dimension in KE</b>	Creditex	First PC of Credit and Spread	PCA
<b>1<sup>st</sup> Innovation dimension in KE</b>	Journals	Log of Number of Technical & Scientific Journals	World Bank (WDI)
<b>2<sup>nd</sup> Innovation dimension in KE</b>	FDI	Net Foreign Direct Investment (% of GDP)	World Bank (WDI)
<b>Panel B: Financial Development</b>			
Financial system Depth	M2	Money Supply (% of GDP)	FDSD (World Bank)
Banking System Depth	Fdgdg	Liquid Liabilities (% of GDP)	FDSD (World Bank)
Banking System Efficiency	BcBd	Bank credit on Bank deposit	FDSD (World Bank)
Financial System Efficiency	FcFd	Financial credit on Financial deposit	FDSD (World Bank)
Banking System Activity	Pcrb	Private domestic credit by deposit banks (% of GDP)	FDSD (World Bank)
Financial System Activity	Pcrbof	Private domestic credit by deposit banks and other financial institutions (% of GDP)	FDSD (World Bank)
Financial System Size	Dbacba	Deposit bank assets on (Deposit bank assets plus Central bank assets)	FDSD (World Bank)
<b>Panel C: Control Variables</b>			
Government Expenditure	Gov. Exp.	Government final consumption expenditure (% of GDP)	World Bank (WDI)
Inflation	Infl.	Consumer Price Index (annual %)	World Bank (WDI)
Population Growth	Popg	Population Growth Rate (annual %)	World Bank (WDI)
Economic Prosperity	GDPg	GDP growth rate (annual %)	World Bank (WDI)
Domestic Investment	DI	Gross Domestic Investment (% of GDP)	World Bank (WDI)

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

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