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Knowledge Economy and Financial Sector Competition in African Countries

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Abstract

The goal of this paper is to assess how knowledge economy (KE) plays out in financial sector competition. It suggests a practicable way to disentangle the effects of different components of KE on various financial sectors. The variables identified under the World Bank's four knowledge economy index (KEI) are employed. An endogeneity robust panel instrumental variable fixed-effects estimation strategy is employed on data from 53 African countries for the period 1996-2010. The following findings are established. First, education and innovation in terms of scientific and technical publications broadly bear an inverse nexus with financial development. Second, the incidence of information and communication technologies is positive on all financial sectors but increases the non-formal sectors to the detriment of the formal sector. Third, economic incentives have positive implications for all sectors though the formal financial sector benefits most. Fourth, institutional regime is positive (negative) for the semi-formal (informal) financial sector. The findings contribute at the same time to the macroeconomic literature on measuring financial development and respond to the growing fields of informal sector importance, microfinance and mobile banking by means of KE promotion. Policy implications and future research directions are discussed.

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1. Introduction

Knowledge economy (KE) has emerged in the Organization of Economic Co-operation and Development (OECD) and World Bank reports (since the end of the 1990s) as key to the 21st century development (World Bank, 2007; Peters, 2008; Weber, 2011). Accordingly, it is now well documented that knowledge created through innovation and technological advancement is critical for long-term economic growth. While the finance-growth nexus has been abundantly assessed in theoretical and empirical literature, the finance-KE nexus has received very blur scholarly focus in developing countries (Asongu, 2014a). Understanding the role of KE in financial development is developing countries is crucial because financial intermediation has been substantially documented as indispensible in channeling mobilized resources to economic operators. Today the informal financial sector, a previously missing component in the IMF (2008) definition of the financial system can no longer be marginalized in developing countries because of the burgeoning phenomena of mobile banking, microfinance…etc (Asongu, 2014a; Tchamyou, 2014).

The goal of this paper is therefore to investigate the role of KE in financial sector competition. In so doing we are able to assess how recent advancements in KE in African countries have impacted the formal, semi-informal and informal financial sectors. This investigation is relevant because unlike in the developed world, the informal and semi-formal financial sectors play an important role in economic development (Demetriades & Hussein, 1996; Khumbhakar & Mavrotas, 2005; Ang & McKibbin, 2007; Abu-Bader & Abu-Qarn; 2008; Asongu, 2014b)[2]. The study has three main contributions to the literature: improving existing evidence on KE, complementing financial development trends and, uniting two streams of research.

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[2]Unlike developed countries, a substantial chunk of the monetary base (M0) in developing countries does not transit through the formal banking sector.

First, we improve existing KE literature in a fourfold manner. (1) The scarce evidence on the nexus between mobile phone and financial sector competition (Asongu, 2013a) is improved on three counts: (a) use of panel instead of cross-sectional data to assess nexuses beyond correlation; (b) employment of an endogeneity robust estimation technique and; (c) introduction of more KE variables. (2) Investigating the reverse link of current evidence in some causality flowing from financial sector competition to KE could also have relevant policy implications (Asongu, 2014a). (3) It deviates from previous research that does not incorporate all dimensions of KE and provides an exhaustive assessment with five KE dynamics. Hence, in contrast to mainstream approach to the phenomenon (which is premised for the most part on one or two dimensions of KE), this paper employs all the four components in the World Bank's Knowledge Economy Index (KEI): economic incentive, innovation, education and information infrastructure (Britz et al., 2006; Makinda, 2007; Lightfoot, 2011; Asongu, 2013b). (4) A great chunk of research on KE focuses on developed and the emerging economies of Latin America and East Asia. Thus, the scanty evidence of the assessment in African countries is a missing strand motivating this paper (Dahlan, 2007; Chavula, 2010; Chandra & Yokoyama, 2011; Asongu, 2013c; Andrés et al., 2014).

Second, the contribution to existing financial development literature is also quite interesting. Consistent with O'Toole (2012), many studies have been limited to more specific elements of the banking market structure like bank concentration, foreign bank participation and efficiency (Rajhi & Salah, 2012; Mlambo & Ncube, 2012; Zhao & Murinde, 2012; Mweda & Mutoti, 2012; Mwega, 2012; Biekpe, 2012; Poshakwake & Qian, 2012; Simpasa, 2012; Nguena & Tsafack, 2014). We steer clear of this mainstream approach by focusing on banking sector competition. Hence, we neither employ mainstream indicators of financial system performance (Bodie & Merton, 1998; World Bank, 2005, p. 19) nor the substantially documented proxies of financial system competition (Claesens, 2009, pp. 5-9) for two main

reasons. (1) The mainstream measures (inter alia, efficiency, liquidity and concentration) are based on a financial system definition that does not incorporate the informal financial sector (IFS, 2008)[3]. (2) In the same vein, the indicators do not fit the context of this study because of the recently documented positive (negative) correlation of information & communication technologies (ICTs) with the informal (formal) financial sector (Asongu, 2013a).

Third, the paper unites two streams of research. It contributes at the same time to the macroeconomic literature on measuring financial development and responds to the growing fields of informal sector promotion, micro finance and mobile banking by means of KE. It suggests a practicable way to disentangle the effects of different KE components on various financial sectors. Therefore it introduces indicators of absolute and relative 'informal financial sector importance' as well as concepts of financial sector informalization, non-formalization, semi-formalization and formalization, hitherto unexplored. Understanding these nexuses is crucial because information about the impact of growth on finance will influence the priority that policy makers and advisors attach to financial sector policies.

The rest of the paper is organized as follows. Section 2 reviews existing literature. 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. Literature review

2.1 Knowledge Economy and Financial Section Competition

2.1.1 Knowledge Economy

Consistent with recent African KE literature, the proliferation of ICTs in the continent can best be illustrated with the mobile phone (Asongu, 2013a, 2014c; Tchamyou, 2014). Indeed, the tale of soaring mobile phones and growth in communication technology in Africa is very interesting (Mbit & Weil, 2011). Whereas the continent was virtually not connected

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[3] Lines 24, 25 and 45 of the International Financial Statistics, October, 2008.

two decades ago, mobile phone coverage is in the neighborhood of 60% two decades later, with the mobile phones surpassing landlines tenfold (Aker & Mbiti, 2010). According to this narrative, there has been an impressive progress in the coverage of mobile phones over the last 20 years. To put these stylized facts into perspective, only 11% of Africans had mobile phone coverage in 1999 with a high concentration in Southern (South Africa & Kenya) and Northern (Algeria, Egypt, Tunisia, Libya & Morocco) countries. However approximately 477 million (about 60% of the population) had coverage by 2008 within a surface area that is equivalent to Argentina and the United Stated combined (about 11.2 million skms). Going by the same projections, it was estimated that by 2012 most African villages would have had mobile phone coverage. A case in point is Kenya that has undergone a considerable ICT revolution. According to Demombynes & Thegeya (2012, pp. 23-25) before the beginning of the third millennium, only about 3% of Kenyan households possessed a telephone with less than one per thousand adults owning a mobile phone. By 2011 however, close to 93% of households possessed a mobile phone.

For this paper to make a meaningful contribution, we provide some explanation to the following: knowledge as a quantitative or qualitative input in the production of financial services; the product state of knowledge; dealing with codified knowledge and; correlation or causality between ICT and KE. First, consistent with Smith (2000), all OECD countries are striving to become knowledge-based economies (KBE) because of the growing belief that knowledge is quantitatively and to some extend qualitatively more relevant as a factor of production, beside capital and labor. Therefore, compared to low-skilled labor, physical capital and natural resources, the role of knowledge is increasingly taking more significance.

Second, we are witnessing the proliferation in new forms of activities that are contingent on the trading of knowledge products due to the growing notion that knowledge is to some degree more relevant as a product (Smith, 2000). With growing economy-wide

aspects of knowledge use, there are sticky statistical issues in defining services and the perception that knowledge is more relevant as a product is based on claims about the significance of business services that are knowledge-intensive.

Third, codified knowledge is perceived as a significant component of KBE. While the use of codified knowledge in science and citations to basic science parts is rising, it is not yet clear whether this new trend represents some novel role for knowledge. Finally, there is a narrative that KE is based on ICT because innovation in new technologies has a substantial effect on the cost of collecting and disseminating information as well as physical constraints. Given the context of our study, we discuss this strand to elaborate detail in Section 2.2.2 below.

2.1.2 Financial sector competition (FSC)

According to the World Bank (2005, p. 18), competition in the financial system is the degree by which consumers can choose from a broad range of financial services a plethora of providers and the rate at which financial markets are contestable. This narrative postulates that competition is a desirable feature because it generally leads to financial efficiency, improves the range and quality of financial services and drives-down costs for clients (Asongu, 2014d). There is a substantial number of competition proxies, involving changes in market share, price of service, number of financial institutions, inter alia. Moreover, the rate at which the financial system is diversified could also proxy for competition. In essence, competition increases with the growth in instruments of the financial market or an expansion in financial institutions because consumers have access to more sources of financial services. In this light, in order to analyze financial system competition, a broad set of objectives are required which include, inter alia: efficiency, liquidity and concentration (World Bank, 2005, p. 19; Bodie & Merton, 1998). However, in accordance with O'Toole (2012) the scope of many studies has been restricted to these banking market structure specific elements such as

foreign bank participation and bank concentration. We deviate from this mainstream approach by investigating financial sector competition with new measures proposed and discussed in Section 2.3 below.

2.2 Nexus between Knowledge Economy and Financial Sector Competition

2.2.1 Theoretical highlights

In accordance with Fugazza & Fiess (2010) as purported by Asongu (2014b), a conventional perspective sustains that globalization and growing KE would bring about some growth in informality, the informal financial sector included. Whereas this consensus is still moderate, there is a more sustained believe that globalization (especially the advent of KE) increases competition among domestic producers of commodities (especially in financial services). Consistent with this narrative, as a mean to reduce production costs, domestic producers in order to gain the advantages of informal production would go for cheaper sources of inputs. Accordingly, the growing demand for goods and services that are produced in the informal sector increases with soaring KE. This thesis is broadly in line with recent KE literature (Asongu, 2013a).

2.2.2 KE and Financial Sector Competition (FSC)

According to Asongu (2013a), the nexuses between ICT and FSC can be discussed in three main strands: the role of mobile transactions, conception of savings and, link between banking and mobile phones.

We discuss the usefulness of ICT transactions in the first strand. We postulate that the choice of financial sectors for transactions (the store of value, conversion of cash and transfer of stored value) inherently has an incidence on the growth of one financial sector over another. As documented by Jonathan & Camilo (2008), ICT transactions in African countries accomplish three main objectives. (a) Store currency (value) in an account that is accessible

by various ICTs (e.g mobile phone). A bank account is opened for users without bank accounts. (b) Cash conversion, such that the users can visit banks or ICT kiosks to cash-in or cash-out. (c) Transfer of stored value such that users can transfer funds among accounts that are linked by ICTs. The three roles above have been particularly significant in, inter alia: the Philippines (Neville, 2006), Kenya (Vaughan, 2007; Ivatury & Mas, 2008) and South Africa (Ivatury & Pickens, 2006; Porteous, 2007).

In the second strand, we discuss how the financial sector in which savings are effectuated has some competitive advantage over other sectors. Such savings may be basic or partially integrated. (a) Basic ICT savings consists of using standard money mechanisms like M-PESA (M for money and PESA for money in Swahili). This form of savings which do not earn interests offer financial access to areas without formal bank branches. In this light, the outnumbering of bank branches by mobile agents in the provision of basic bank services is an indication of a competitive advantage in the informal banking sector of Kenya (Mas & Radcliffe, 2011). (b) 'Partially integrated' savings is employed in situations where access to a bank account by means of ICTs depends on the presence of a physical account at a traditional bank. Hence, in order to increase their bargaining leverage, banks are increasingly constructing their own ICT networks.

In the third strand, ICTs (e.g mobile phone) have been documented to be linked to mobile banking. Consistent with Ondiege (2010), financial sectors can compete for more territory in savings from four main perspectives. (a) The subscriber identity module (SIM) card in a mobile phone can be substituted for a bank card, such that bank and customer information are securely stored. Hence, the personal identification number (PIN) of the customer as well as the account number can be stored in the SIM card to play the same roles as the bank virtual card. (b) The point of sale (POS) terminal is also a function of mobile phones. Therefore, like in POS terminal, this ICT helps in communication and transaction

with financial institutions. (c) The mobile phones serves as an automatic teller machine (ATM) with the help of the POS, used to pay for commodities. (d) With growing internet connectivity, the mobile phone naturally also plays the role of a banking terminal by fundamentally performing two customer services: (i) remote payments and transfers and; (ii) instant access to bank accounts. In summary, with growing ICT, the formal, informal and informal financial sectors are naturally in competition to adapt to one burgeoning fact: wireless connectivity and the mobile phone device are serving as a mobile bank to otherwise unbank or partially banked customers.

As highlighted in the theoretical underpinnings above, the unexpected signs of the nexuses among other dimensions of KE (education, economic incentives, institutional regime and innovation) on financial sector competition are ambiguous at best, partly because of the absence of specific theoretical and empirical literature. This partly justifies the positioning of this paper.

2.3 Propositions and testable hypotheses

We tackle this section by first presenting existing measurements of financial sector competition, then covering their shortcomings in light of the problem statement and contexts of the study before finally discussing the propositions and testable hypotheses.

Claessens (2009, p. 5), has considered the nexuses between competition and three main dimensions: financial sector stability (i.e., when systematic perturbations with potential real sector impact are absent); financial sector development (involving the efficiency in the provision of financial services); and access to financial services for firms and household (i.e., availability or lack of low-cost and convenient financial services). Three approaches have also been proposed for the measurement of competition in empirical literature (Claessens, 2009, p. 8-9). The first which indirectly gauges bank's behavior entails factors such as the number of banks, Herfindahl indices and financial system concentration and depends on underlying

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nexuses between structure-conduct-performance. In the second approach, regulatory indicators are used to assess the contestability rate. Activity restrictions, entry requirements (informal and formal walls to entry for foreign and domestic banks), and innovations, time-dynamic changes to financial instruments (which could induce variations in competition) are considered. In the third approach, formal competition measures are employed like H-statistics (that measures how input prices affect output) are used. While they impose hypotheses on production and cost functions, these measures are well-motivated theoretically and have been employed in the non-financial industry. We have already discussed why these measures cannot be used in the introduction: second contribution of the paper to existing literature. Notably, they do not incorporate the informal financial sector that is capturing the burgeoning phenomenon of KE in African countries.

We propose financial sector competition measures that complement the definition, conception and measurement of the financial system & financial sector competition in two main dimensions. First, we disentangle the existing measurement of the financial system (IFS, 2008) into formal and semi-formal financial sectors. Second, we introduce a previously missing informal financial sector component. Table 1 below presenting the propositions is consistent with Asongu (2014ab). While Panel A shows GDP-based indicators, Panel B presents money supply oriented measures. While ameliorations in the shares of propositions in the second panel are relative to the supply of money, those in the shares of propositions in the first are relative to economic prosperity. Therefore, these indicators broadly appreciate financial sector importance (Asongu, 2013d). Propositions 4 & 8, 3 & 7, 2 & 6, 1 & 5 denote respectively non-formal (semi-formal & informal), informal, semi-formal and formal financial development.

Table 1: Summary of propositions

	Panel A: GDP-based financial development indicators		
Propositions	Name(s)	Formula	Elucidation
Proposition 1	Formal financial development	Bank deposits/GDP	Bank deposits[4] here refer to demand, time and saving deposits in deposit money banks.
Proposition 2	Semi-formal financial development	(Financial deposits – Bank deposits)/ GDP	Financial deposits[5] are demand, time and saving deposits in deposit money banks and other financial institutions.
Proposition 3	Informal financial development	(Money Supply – Financial deposits)/GDP	
Proposition 4	Informal and semi-formal financial development	(Money Supply – Bank deposits)/GDP	
	Panel B: Measures of financial sector importance		
Proposition 5	Financial intermediary formalization	Bank deposits/ Money Supply (M2)	From 'informal and semi-formal' to *formal* financial development (formalization)[6].
Proposition 6	Financial intermediary 'semi-formalization'	(Financial deposits - Bank deposits)/ Money Supply	From 'informal and formal' to *semi-formal* financial development (Semi-formalization)[7].
Proposition 7	Financial intermediary 'informalization'	(Money Supply – Financial deposits)/ Money Supply	From 'formal and semi-formal' to *informal* financial development (Informalisation)[8].
Proposition 8	Financial intermediary 'semi-formalization and informalization'	(Money Supply – Bank Deposits)/Money Supply	Formal to '*informal and semi-formal*' financial development: (Semi-formalization and informalization)[9]

N.B: Propositions 5, 6, 7 add up to unity (one); arithmetically spelling-out the underlying assumption of sector importance. Hence, when their time series properties are considered in empirical analysis, the evolution of one sector is to the detriment of other sectors and vice-versa.

Against the interesting background discussed above, the following hypotheses are tested in the empirical section.

Hypothesis 1: New insights into the effects of KE are obtained when formal finance is presented in terms of financial sector competition. Proposition 1 and Proposition 5 are used to assess this hypothesis.

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[4] Lines 24 and 25 of the International Financial Statistics (October, 2008).

[5] Lines 24, 25 and 45 of the International Financial Statistics (2008).

[6] In essence, in undeveloped countries, money supply cannot be equated to liquid liabilities or bank deposits. This equation is only valid in developed countries since the ratio of financial system deposits to money supply is almost equal to unity. This variable measures the rate at which money in circulation is absorbed by the banking system. Accordingly, 'financial formalization' is defined as the propensity of the formal banking system to absorb money in circulation.

[7] This variable appreciates the rate at which the semi-formal financial sector is growing to the detriment of formal and informal sectors.

[8] This proposition measures the rate by which the informal financial sector is growing at the expense of formal and semi-formal sectors.

[9] The variable appreciates the deterioration of the formal banking sector to the benefit of other financial sectors (informal and semi-formal). From logic and common sense, propositions 5 and 8 should almost have a perfect degree of substitution. This implies, the former (formal financial development to the detriment of other financial sectors) and the latter (formal sector deterioration) should display an almost perfect negative degree of correlation (See Appendix 3).

Hypothesis 2: Additional information is obtained on the impact of KE when semi-formal finance is measured in terms of financial sector competition. Proposition 2 and Proposition 6 are used to examine this hypothesis.

Hypothesis 3: Measuring informal finance in terms of competition within the financial sector substantially improves understanding of the KE-finance nexus. Proposition 3 and Proposition 7 are used to investigate this hypothesis.

Hypothesis 4: The informal and semi-formal financial sectors presented in terms of financial sector competition provide relevant new information on the KE-finance nexus. Proposition 4 and Proposition 8 are used to assess this hypothesis.

3. Data and Methodology

3.1 Data

We assess a panel of 53 African 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 based on constraints in KE data availability and the motivation of obtaining results with more updated policy implications.

Consistent with Asongu (2014a), the dependent variables of financial sector competition have been presented in Table 1 above. The inconsistency of traditional financial development indicators, (because their conception and definition of the financial system fail to take into account the informal financial sector) has been substantially documented in recent financial development literature (Asongu, 2014a, 2013a). For example, the informal financial sector component missing in the IFS (2008) definition of the financial system has been used in recent studies to explain the growing phenomenon of mobile banking in the African continent (Asongu, 2013a). And by natural inference we know that, this burgeoning

phenomenon is part and parcel of KE. Financial development could be seen from indirect (financial intermediary development via the banking sector) and direct (via financial markets) perspectives. The context of this study is restricted to the former type. Consistent with Beck et al. (1999), indirect indicators could further be classified into financial development dimensions of depth (M2), allocation efficiency[10], activity[11] and size[12]. Among these variables, M2 for financial depth is the most widely used in the finance-growth literature. By disentangling M2 into its inherent constituents and relaxing the IFS definition of the financial system, the propositions (or dependent variables) summarized in Table 1 are derived (Asongu, 2014a). Hence, the propositions are based on a rethinking of the IFS (2008) definition of the financial system. Therefore, the new definition integrates the previously missing informal financial sector component into the definition of the financial system[13].

In accordance with recent literature (Chavula, 2010; Weber, 2011; Andrés et al., 2013; Tchamyou, 2014), the independent variables employed in the study include those identified under the World Bank's four KEI components which include: economic incentives & institutional regime, innovation, education and, information infrastructure. More details about the independent variables are presented in Section 3.2.1 of the methodology below.

We control for inflation, government expenditure and economic prosperity. (1) While low and stable inflation rates generally provide a conducive environment for financial development, high inflation on the other hand, does quite the opposite (Asongu, 2013e). In addition, recent African finance literature has established a negative association between inflation and financial intermediary allocation efficiency (Asongu, 2013a). (2) Government expenditure could decrease financial depth if the budget allocated for investment is misallocated through corrupt practices (Ndikumana, 2000). A fact that has given rise to a

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[10] Bank credit on bank deposits.
[11] Private domestic credit on GDP.
[12] Deposit bank assets / Central bank assets plus deposit bank assets.
[13] Please see Asongu (2012ab) for an excellent insight into the propositions.

growing strand of investment needs in the continent (Anyanwu, 2007, 2009; Asongu, 2013f). (3) Economic prosperity should naturally improve financial development.

Details about the summary statistics (with presentation of the 53 countries), correlation analysis (showing the relationships between key variables used in the paper), and variable definitions are presented in the appendices. The 'summary statistics' (Appendix 2) 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 linkages should emerge. The purpose of the correlation matrix (Appendix 3) is to avoid issues resulting from overparametization and multicollinearity. Based on a preliminary assessment of the correlation coefficients, there do not appear to be any serious issues in terms of the relationships to be estimated. Appendix 1 provides definitions and corresponding sources of the variables.

3.2 Methodology

3.2.1 Principal Component Analysis (PCA) for independent variables

We are interested in empirically examining the impact of formal institutions on KE. One might also criticize the redundancy in the information provided for each dimension of the KEI (Tchamyou, 2014). Each dimension could be correlated with its component variables individually. Hence, we use principal component analysis (PCA). The PCA is a widely used statistical technique that is employed to reduce a larger set of correlated variables into a smaller set of uncorrelated variables called principal components (PC) that account for most of variation in the original data set.

Table 2: Principal Component Analysis (PCA) for Knowledge Economy Indicators

Knowledge Economy dimensions		Component Matrix (Loadings)						First PC	Eigen Value	Indexes
Education	School Enrolment	PSE		SSE		TSE		0.658	1.975	Educatex
		0.438		0.657		0.614				
Information & Infrastructure	ICTs	Internet		Mobile		Telephone		0.730	2.190	ICTex
		0.614		0.584		0.531				
Innovation System	Innovation	STJA		Trademarks		Patents		0.917	2.753	Innovex
		0.567		0.572		0.592				
Institutional regime	Institutional index	VA	PS	RQ	GE	RL	CC	0.773	4.642	Instireg
		0.383	0.374	0.403	0.429	0.443	0.413			

P.C: Principal Component. PSE: Primary School Enrolment. SSE: Secondary School Enrolment. TSE: Tertiary School Enrolment. PC: Principal Component. ICTs: Information and Communication Technologies. Educatex is the first principal component of primary, secondary and tertiary school enrolments. ICTex: first principal component of mobile, telephone and internet subscriptions. STJA: Scientific and Technical Journal Articles. Innovex: first principal component of STJA, trademarks and patents (resident plus nonresident).
VA: Voice & Accountability. RL: Rule of Law. R.Q: Regulation Quality. GE: Government Effectiveness. PS: Political Stability. CC: Control of Corruption. Instireg (Institutional regime): First PC of VA, PS, RQ, GE, RL & CC.

Without going into the depths of the PCA technique, as it can be seen from Table 2, the first principal component (PC) of education (Educatex) accounts for approximately 65% of the variation in all three constituents (PSE, SSE & TSE) . The criteria applied to determine how many common factors to keep are taken from Kaiser (1974) and Jolliffe (2002). Kaiser recommends dropping factors with an eigenvalue less than one. Note should also be taken on the fact that the weights in the first PCs are almost equal across dimensions. These results indicate that a one PC model is appropriate for each KE dimension in our sample.

In summary: the educational index (*Educatex*) represents primary school enrolment (PSE), secondary school enrolment (SSE) and tertiary school enrolment (TSE); the ICT index (*ICTex*) denotes telephone, mobile and internet penetration rates; the innovation index (*Innovex*) summarizes Scientific & Technical Journal Articles (STJA), trademarks and patents while institutional regime (*Instireg*) incorporates the six government quality dynamics of institutional governance (corruption-control and rule of law), political governance (voice & accountability and political stability) and economic governance (government effectiveness and regulation quality). This dimension of KE is critical for the emergence of African economies (Fosu et al., 2006; Fosu, 2013ab). It is important to highlight two issues. First, due to concerns in degrees of freedom for the trademark and patent components of *Innovex*

(Appendix 2) and considering the high degree of substitution between STJA and the two (Appendix 3), we use only SJTA to proxy for innovation. The economic incentive component in the KEI not represented in Table 2 is measured by private domestic credit (Andrés et al., 2014).

3.2.2 Estimation techniques

As discussed in the motivation (or the introduction), the shortcomings of Asongu (2013a) and reverse causality evidence documented by Asongu (2014a) necessitate the control for endogeneity. Hence to control for the potential endogeneity between KE and FSC we instrument the KE variables with their first lags (Ivashina, 2009, p. 301; Tchamyou, 2014). The estimation approach can be summarized in the following equations.

First-stage regression:

$$KE_{it} = \gamma_0 + \gamma_1 (Instruments)_{it} + \gamma_j X_{it} + \upsilon_{it} \tag{1}$$

Second-stage regression:

$$FSC_{it} = \beta_0 + \beta_1 (Educatex)_{it} + \beta_2 (ICTex)_{it} + \beta_3 (Innovex)_{it} + \beta_4 (Instireg)_{it} + \beta_5 (Econicent)_{it}$$
$$\beta_j X_{it} + \xi_t + \mu_{it} \tag{2}$$

In Eqs. (1) and (2), *X* is a vector of control variables which include: *inflation*, *government expenditure*, and *economic growth*. KE denotes education (*Educatex*), ICTs (*ICTex*), innovation (*Innovex*), institutional regime (*Instireg*) and economic incentives (*Econicent*). *FSC* symbolizing financial sector competition broadly represents the propositions in Table 1. Instruments are first lags of the endogenous variables in Eq. (1). While υ_{it} and μ_{it} respectively represent the error terms in Eq. (1) and Eq. (2), ξ_t is the time-specific constant.

In the first-stage, the KE dimensions are regressed separately on their first lags conditional on the control variables with robust Heteroscedascity and Autocorrelation

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Consistent (HAC) standard errors. We then use the fitted (instrumented) values from the first-stage regressions as exogenous variables in the principal or second-stage regressions. It should be noted that the first-stage regression merely aims to establish the prime condition of an instrument variables (IV) approach. Hence, the employment of one or more of the control variables in the first-stage is the sole discretion of the scholar and not an offense of professional incompetence requiring econometrics polices and arrest warrants. The second-stage regressions are also HAC and further robustness checks are ensured by: using alternative specifications of the same model and, controlling for the unobserved time-specific effects.

4. Empirical analysis

4.1 Presentation of results

This section aims to assess the following testable hypotheses discussed in Section 2.3. Table 4 and Table 5 below investigate respectively Hypotheses 1 & 2 and Hypotheses 3 & 4, while the summary of the findings is presented in Table 3. It can be observed from Table 3 that from a broad perspective, the four underlying hypotheses are valid. As concerns, specific findings, the following conclusions could be drawn. (1) Education and innovation in terms of STJA bear an inverse relation with financial development. The only exception to this conclusion is its positive role on financial sector formalization (Proposition 5) which suggests that the more people are educated, the more the revert to the formal banking sector at the cost of the semi-formal and informal financial sectors. (2) ICT generally has a positive incidence on all financial sectors but increases the non-formal sector to the detriment of the formal sector. (3) Economic incentives in terms of private domestic credit improve formal and semi-finance in both GDP- and M2-based perspectives; grows the informal and non-formal financial sectors in GDP terms but decreases them in M2 terms. This is understandable. (4)

The institutional regime is positive for semi-formal finance (relative to GDP and M2) but not informal and non-formal finance in GDP-based terms.

Table 3: Summary on effects of KE on financial sector competition

| | Hypothesis 1 | | Hypothesis 2 | | Hypothesis 3 | | Hypothesis 4 | |
| | Formal finance | | Semi-formal finance | | Informal finance | | Semi-formal and Informal finance | |
	Prop.1	Prop.5	Prop.2	Prop.6	Prop. 3	Prop.7	Prop. 4	Prop.8
Education (Educatex)	-	+	-	-	-	na	-	-
ICT (ICTex)	+	-	na	-	+	+	+	+
Econ. Incentive (credit)	+	+	+	+	+	-	+	-
Institutional regime (Instireg)	na	na	+	+	-	na	-	na
Innovation (STJA)	-	na	-	-	-	na	-	na

Educatex is the first principal component of primary, secondary and tertiary school enrolments. ICTex: first principal component of mobile, telephone and internet subscriptions. STJA: Scientific & Technical Journal Articles. Prop: Proposition. Econ: Economic. na: not applicable because of insignificant effect.

The control variables in Tables 4-5 have the expected signs. First, government expenditure is positive for formal and semi-formal financial development but not significant for the informal financial sector because of two main reasons: (1) the expenditure is channeled only through formal and semi-formal banks that are recognized by government and; (2) informal financial institutions are not legally registered and/or licensed at the national levels and hence not recognized by government. Second, inflation generally has a negative incidence on financial development (savings for example) because investors tend to withdraw their money and convert into more stable currencies or purchase less risky assets denominated in less volatile currencies. Third, economic growth could negatively impact financial development if the fruits of the economic prosperity are: (1) unevenly distributed such that only a tiny elite receives the lion share of the cake and; (2) the corrupt elites deposit their stolen share of the economic prosperity in foreign bank accounts. These scenarios have been substantially documented in African countries (Boyce & Ndikumana, 1998, 2001, 2003, 2011; Asongu, 2012, 2014e).

Table 4: Testing Hypotheses 1 & 2 (HAC Instrumental variable panel fixed effects)

	Hypothesis 1. Dependent variable: Formal financial development							
	Formal sector development (Prop.1)				Financial formalization (Prop.5)			
Constant	0.602***	0.422***	0.381***	0.379***	0.819***	0.778***	0.803***	0.835***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IVEducatex	-0.083	---	-0.083***	-0.089***	0.020	---	0.057**	0.039*
	(0.176)		(0.000)	(0.000)	(0.222)		(0.015)	(0.068)
IVICTex	---	0.009	0.044***	0.044***	---	-0.011**	-0.006	-0.010*
		(0.538)	(0.000)	(0.000)		(0.043)	(0.260)	(0.096)
IVCredit	---	0.338***	0.418***	0.394***	---	0.212***	-0.043	-0.048
		(0.000)	(0.000)	(0.000)		(0.008)	(0.350)	(0.294)
IVInstireg	-0.009	-0.007	-0.003	-0.0008	-0.006	0.002	-0.005	-0.007
	(0.708)	(0.519)	(0.713)	(0.951)	(0.344)	(0.719)	(0.357)	(0.280)
IVlogSTJA	-0.047	-0.057	-0.061***	-0.056***	0.0008	0.007	-0.002	0.006
	(0.224)	(0.229)	(0.000)	(0.008)	(0.948)	(0.656)	(0.861)	(0.699)
Inflation	-0.001*	-0.003*	0.000	0.000	-0.001	0.0009**	-0.0006	-0.001
	(0.050)	(0.064)	(0.711)	(0.856)	(0.243)	(0.020)	(0.371)	(0.186)
Gov. Exp.	-0.0001	0.0007**	-0.000	0.000	0.0001	0.0001	0.000	-0.0005
	(0.740)	(0.023)	(0.887)	(0.956)	(0.601)	(0.211)	(0.956)	(0.808)
GDPg	-0.002*	-0.003**	-0.0006	-0.0008	-0.0005	-0.0007	-0.0004	-0.0005
	(0.081)	(0.038)	(0.251)	(0.131)	(0.497)	(0.396)	(0.390)	(0.497)
Time effects	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Adjusted R²	0.981	0.973	0.993	0.993	0.982	0.987	0.982	0.982
Fisher	114.90***	146.47***	414.45***	303.17***	116.83***	304.04***	135.71***	113.18***

	Hypothesis 2. Dependent variable: Semi-formal financial development							
	Semi-formal sector development (Prop.2)				Financial semi-formalization (Prop.6)			
Constant	0.020***	-0.005	-0.007	0.001	0.049***	-0.003	-0.017	0.019*
	(0.000)	(0.305)	(0.304)	(0.822)	(0.000)	(0.729)	(0.336)	(0.076)
IVEducatex	-0.008**	---	-0.005***	-0.007***	-0.024***	---	-0.019**	-0.021***
	(0.021)		(0.000)	(0.000)	(0.006)		(0.018)	(0.000)
IVICTex	---	0.0009	0.0005	-0.0004	---	-0.0004	0.002	-0.003*
		(0.389)	(0.434)	(0.615)		(0.841)	(0.136)	(0.064)
IVCredit	---	0.015	0.049**	0.057***	---	0.020	0.105**	0.097***
		(0.156)	(0.016)	(0.000)		(0.229)	(0.017)	(0.000)
IVInstireg	0.002	-0.0002	0.004**	0.004**	0.007*	-0.0009	0.007**	0.006***
	(0.168)	(0.772)	(0.026)	(0.013)	(0.079)	(0.651)	(0.028)	(0.004)
IVlogSTJA	-0.006*	0.0006	-0.003	-0.005**	-0.010	0.002	-0.003	-0.005*
	(0.066)	(0.795)	(0.147)	(0.012)	(0.164)	(0.671)	(0.575)	(0.091)
Inflation	-0.000	0.000	-0.000	-0.0001**	-0.000	0.0001	0.0001	-0.0001
	(0.245)	(0.743)	(0.138)	(0.044)	(0.987)	(0.404)	(0.632)	(0.470)
Gov. Exp.	-0.000	0.000	0.000	0.00006*	-0.000	0.000	0.000	0.000
	(0.986)	(0.972)	(0.413)	(0.080)	(0.814)	(0.843)	(0.641)	(0.633)
GDPg	-0.0002*	-0.00004	-0.0002**	-0.0001**	-0.0002	-0.000	-0.0002	-0.0002
	(0.071)	(0.488)	(0.014)	(0.016)	(0.252)	(0.875)	(0.366)	(0.142)
Time effects	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Adjusted R²	0.809	0.725	0.857	0.910	0.859	0.725	0.842	0.943
Fisher	10.621***	11.506***	16.083***	21.961***	13.795***	11.339***	13.836***	33.729***

*,**,***: significance levels of 10%, 5% and 1% respectively. IV: Instrumented Variable. IVEducatex: Instrumented educational index. IVICTex: Instrumented ICT index. IVCredit: Instrumented credit. IVlogSTJA: Instrumented STJA. STJA: Scientific Journal Articles. Gov. Exp: Government Expenditure. GDPg: Gross Domestic Product. Prop: Proposition.

Table 5: Testing Hypotheses 3 & 4 (HAC Instrumental variable panel fixed effects)

	Hypothesis 3. Dependent variable: Informal financial development							
	Informal sector development (Prop.3)				Financial informalisation (Prop.7)			
Constant	**0.327*** (0.000)**	0.060 (0.263)	**0.290*** (0.000)**	**0.157*** (0.000)**	**0.131*** (0.000)**	**0.225*** (0.000)**	**0.214*** (0.000)**	**0.145*** (0.000)**
IVEducatex	**-0.185** (0.039)**	---	**-0.238*** (0.000)**	**-0.208*** (0.000)**	0.003 (0.858)	---	-0.037 (0.136)	-0.017 (0.416)
IVICTex	---	0.026 (0.126)	**0.054*** (0.000)**	**0.064*** (0.000)**	---	**0.012** (0.018)**	0.003 (0.555)	**0.013** (0.036)**
IVCredit	---	-0.0001 (0.998)	**0.330*** (0.000)**	**0.335*** (0.000)**	---	**-0.233*** (0.000)**	-0.061 (0.439)	-0.048 (0.352)
IVInstireg	-0.035 (0.163)	-0.022 (0.107)	**-0.041** (0.021)**	-0.026 (0.159)	-0.0004 (0.963)	-0.001 (0.816)	-0.001 (0.792)	0.0008 (0.906)
IVlogSTJA	-0.034 (0.457)	-0.018 (0.459)	**-0.078*** (0.001)**	**-0.058*** (0.000)**	0.009 (0.579)	-0.009 (0.557)	0.005 (0.668)	-0.0008 (0.955)
Inflation	**-0.005*** (0.000)**	**-0.003*** (0.000)**	**-0.003*** (0.000)**	**-0.003*** (0.000)**	0.001 (0.279)	**-0.001** (0.013)**	0.0004 (0.608)	0.001 (0.153)
Gov. Exp.	0.0001 (0.700)	0.0001 (0.587)	0.000 (0.852)	0.0006 (0.400)	-0.0001 (0.661)	-0.0001 (0.160)	-0.000 (0.874)	-0.000 (0.751)
GDPg	**-0.004*** (0.003)**	**-0.001 (0.287)**	**-0.001* (0.059)**	**-0.002*** (0.000)**	0.0007 (0.336)	0.0007 (0.375)	0.0007 (0.289)	0.0007 (0.350)
Time effects	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Adjusted R²	0.547	0.741	0.709	0.727	0.980	0.987	0.978	0.982
Fisher	**3.726***	12.378***	7.107***	6.501***	105.91***	312.38***	111.19***	109.96***

	Hypothesis 4. Dependent variable: Informal and Semi-formal financial development							
	Informal and semi-formal sector development (Prop.4)				Financial informalisation and semi-formalisation (Prop.8)			
Constant	**0.347*** (0.000)**	0.055 (0.318)	**0.283*** (0.000)**	**0.158*** (0.000)**	**0.180*** (0.000)**	**0.221*** (0.000)**	**0.196*** (0.000)**	**0.164*** (0.000)**
IVEducatex	**-0.193** (0.035)**	---	**-0.243*** (0.000)**	**-0.215*** (0.000)**	-0.020 (0.222)	---	**-0.057** (0.015)**	**-0.039* (0.068)**
IVICTex	---	0.027 (0.121)	**0.055*** (0.000)**	**0.064*** (0.000)**	---	**0.011** (0.043)**	0.006 (0.260)	**0.010* (0.096)**
IVCredit	---	0.015 (0.880)	**0.379*** (0.000)**	**0.393*** (0.000)**	---	**-0.212*** (0.000)**	0.043 (0.350)	0.048 (0.294)
IVInstireg	-0.032 (0.204)	-0.023 (0.108)	**-0.036** (0.036)**	-0.021 (0.237)	0.006 (0.344)	-0.002 (0.719)	0.005 (0.357)	0.007 (0.280)
IVlogSTJA	-0.041 (0.374)	-0.017 (0.491)	**-0.081*** (0.001)**	**-0.063*** (0.000)**	-0.0008 (0.948)	-0.007 (0.656)	0.002 (0.861)	-0.006 (0.699)
Inflation	**-0.005*** (0.000)**	**-0.003*** (0.000)**	**-0.003*** (0.000)**	**-0.003*** (0.000)**	0.001 (0.243)	**-0.0009** (0.020)**	0.0006 (0.371)	0.001 (0.186)
Gov. Exp.	0.0001 (0.707)	0.0001 (0.587)	0.000 (0.811)	0.0007 (0.365)	-0.0001 (0.601)	-0.0001 (0.211)	-0.000 (0.956)	-0.000 (0.808)
GDPg	**-0.004*** (0.003)**	-0.001 (0.285)	-0.001 (0.027)	**-0.002*** (0.000)**	0.0005 (0.497)	0.0007 (0.396)	0.0004 (0.390)	0.0005 (0.497)
Time effects	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Adjusted R²	0.545	0.737	0.712	0.726	0.982	0.987	0.982	0.982
Fisher	**3.708***	12.191***	7.206***	6.473***	116.83***	304.04***	135.71***	113.18***

*,**,***: significance levels of 10%, 5% and 1% respectively. IV: Instrumented Variable. IVEducatex: Instrumented educational index. IVICTex: Instrumented ICT index. IVCredit: Instrumented credit. IVlogSTJA: Instrumented STJA. STJA: Scientific Journal Articles. Gov. Exp: Government Expenditure. GDPg: Gross Domestic Product. Prop: Proposition.

4.2 Discussion and policy implications

From the educational nexuses, we have established that while citizens resort to more formal financial services as they become more educated, education in general does not

improve financial development. A possible explanation for this unexpected sign could be traceable to migration, such that a great proportion of the educated tends to seek employment opportunities and greener pastures abroad. This thesis is consistent with the recent literature on substantial emigration of skilled workers from Africa (Asongu, 2014f). As a policy implication, the benefits of education to financial development could be mitigated with massive emigration of skilled labour.

We have also observed that innovation in terms of STJA publications has a consistent negative effect on financial intermediary development. This unexpected sign has a threefold explanation. First, the process of scientific publications entails expenditure that warrant domestic researchers to withdraw incomes from their bank accounts and spent abroad by means of conferences/seminars/consortiums. Second, domestic researchers are mostly depending on their foreign bank account transactions for the scientific and technical publication processes. Third, foreign researchers who carry research abroad are affiliated to African universities. This is most often the case with post-doctoral research programs, inter-universities collaborations or trainings abroad due to domestic infrastructural and logistical issues. As a policy implication, the process of scientific research and contribution to knowledge should involve more domestic banks. This is broadly consistent with the recommendations of Amavilah (2009) for more domestic investment in the production of knowledge in African countries.

It has also been found that while ICTs generally have a positive effect on all financial sectors, they improve the informal financial sector to the detriment of other sectors. This finding is broadly consistent with those of Asongu (2013a) who has established a positive (negative) correlation between mobile phone penetration and the informal (formal) financial sector. Thus the initial findings on correlations could be extended to infer causality. The findings can be further supported by the manner in which the mobile revolution has

transformed the lives of the African population by facilitating financial access through storage and phone-based money transfer (Jonathan & Camilo, 2008; Demombynes & Thegeya, 2012). In essence, the proliferation of mobile telephony that has transformed cell phones into pocket-banks in the continent has provided opportunities for the poor (who predominantly depends on the informal financial sector) by bringing on board a substantial faction of the population that was previously excluded from formal financial services. As a broad policy implication, more emphasis should be placed at developing the hitherto unrecognized informal financial segments. This leads us to three more subtle implications: there is a burgeoning role of informal finance, ICTs may not be positively investigated at the macroeconomic level by mainstream (traditional) financial indicators and, there is an imperative for more scholarly research on proxies of informal financial development that are crucial in monetary policy orientation.

The finding that economic incentives in terms of private domestic credit generally improve the formal and semi-formal financial sectors (in both GDP- and M2-based terms), and grows the informal and non-formal financial sector (in GDP terms but not in M2 terms) was not unexpected. Accordingly, private domestic credit as measured by this study emanates from the financial system as defined by the Financial Development and Structure Database (FDSD) of the World Bank. In this definition, we have observed that the financial system is limited to the formal and semi-formal financial sectors. Hence, it is natural to expect a general positive correlation between economic incentives in credit terms and the financial sectors from which the credit is by definition expected to originate. In other words, if government were to provide credit to economic agents as an economic incentive, the financial transactions are limited to financial institutions that are formally registered and recognized by the government. Therefore going by definition, this incentive is to the detriment of the informal financial sector in money supply (M2) but not in GDP-terms because once the credit is

engaged in economic operations for general economic prosperity (GDP), the informal sector benefits directly or indirectly since it is part of the economy.

The last result has shown that the institutional regime is insignificant in the formal financial sector, has a consistent (relative to GDP and M2) positive incidence on the semi-formal financial sector but a negative effect on informal finance in GDP terms. A possible explanation to these signs is the following: informal finance strives in the absence of formal institutions while the semi-formal financial sector requires some form for regulation for its growth. As a policy implication, research should focus on how to adapt existing institutional regimes to the informal financial sector without compromising its development.

5. Conclusion

This paper has complemented exiting financial development and knowledge economy (KE) literature by investigation the role of KE in financial sector competition in Africa. It has suggested a practicable way to disentangle the effects of different components of KE on various financial sectors. Fundamentally, the paper has united two streams of research by contributing at the same time to the macroeconomic literature on measuring financial development and responding to the evolving fields of microfinance, informal sector promotion and mobile banking by means of KE. It has introduced hitherto unexplored indicators of absolute and relative 'informal financial sector importance' as well as concepts of financial sector informalization, non-formalization, semi-formalization and formalization. An endogeneity robust panel instrumental variable fixed effects estimation strategy has been employed on data from 53 African countries for the period 1996-2010. The following findings have been established. First, education and innovation in terms of scientific and technical publications broadly bear an inverse nexus with financial development. Second, the incidence of information and communication technologies is positive on all financial sectors but increases the non-formal sectors to the detriment of the formal sector. Third, economic

incentives have positive implications for all sectors though the formal financial sector benefits most. Fourth, institutional regime is positive (negative) for the semi-formal (informal) financial sector. Policy implications and future research directions have been discussed.

Appendices
Appendix 1: Variable definitions

Variables	Signs	Variable definitions	Sources
Panel A: Dimensions in Knowledge Economy (KE)			
Primary School Enrolment	PSE	School enrolment, primary (% of gross)	World Bank (WDI)
Secondary School Enrolment	SSE	School enrolment, secondary (% of gross)	World Bank (WDI)
Tertiary School Enrolment	TSE	School enrolment, tertiary (% of gross)	World Bank (WDI)
Education in KE	Educatex	First PC of PSE, SSE & TSE	PCA
Internet Users	Internet	Internet users (per 100 people)	World Bank (WDI)
Mobile Cellular Subscriptions	Mobile	Mobile subscriptions (per 100 people)	World Bank (WDI)
Telephone lines	Tel	Telephone lines (per 100 people)	World Bank (WDI)
Information & Infrastructure in KE	ICTex	First PC of Internet, Mobile & Tel	PCA
Economic Incentive dimension in KE			
Private domestic credit	Credit	Private domestic credit (% of GDP)	World Bank (WDI)
Institutional regime	Instireg	First PC of CC, RL, RQ, PS, GE & VA	PCA
Innovation dimension in KE	Journals	Log of Number of Scientific & Technical Journal Articles (STJA)	World Bank (WDI)

		Panel B: Financial Development	
		GDP Based Measures	
Formal Financial Development	Prop.1	Bank deposits/GDP. Bank deposits here refer to demand, time and saving deposits in deposit money banks (Lines 24 and 25 of International Financial Statistics (IFS); October 2008).	Asongu (2014ab)
Semi-formal financial development	Prop.2	(Financial deposits − Bank deposits)/ GDP. Financial deposits are demand, time and saving deposits in deposit money banks and other financial institutions. (Lines 24, 25 and 45 of IFS, October, 2008).	Asongu (2014ab)
Informal financial development	Prop.3	(Money Supply − Financial deposits)/GDP	Asongu (2014ab)
Informal and semi-formal financial development	Prop.4	(Money Supply − Bank deposits)/GDP	Asongu (2014ab)
		Measures of financial sector importance (M2-based)	
Financial intermediary formalization	Prop.5	Bank deposits/ Money Supply (M2). From 'informal and semi-formal' to *formal* financial development (formalization)	Asongu (2014ab)

Financial intermediary 'semi-formalization'	Prop.6	(Financial deposits - Bank deposits)/ Money Supply. From 'informal and formal' to *semi-formal* financial development (Semi-formalization)	Asongu (2014ab)
Financial intermediary 'informalization'	Prop.7	(Money Supply – Financial deposits)/ Money Supply. From 'formal and semi-formal' to *informal* financial development (Informalisation).	Asongu (2014ab)
Financial intermediary 'semi-formalization and informalization'	Prop.8	(Money Supply – Bank Deposits)/Money Supply. Formal to '*informal and semi-formal*' financial development: (Semi-formalization and informalization).	Asongu (2014ab)

Panel C: Control Variables

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)

WDI: World Bank Development Indicators. GDP: Gross Domestic Product. PC: Principal Component. PCA: Principal Component Analysis. Log: logarithm. Educatex is the first principal component of primary, secondary and tertiary school enrolments. ICTex: first principal component of mobile, telephone and internet subscriptions. P.C: Principal Component. VA: Voice & Accountability. RL: Rule of Law. R.Q: Regulation Quality. GE: Government Effectiveness. PS: Political Stability. CC: Control of Corruption. Instireg (Institutional regime): First PC of VA, PS, RQ, GE, RL & CC.

Appendix 2: Summary statistics and presentation of countries

Panel A: Summary Statistics

		Mean	S.D	Min	Max	Obs.
	Educatex (Education)	-0.075	1.329	-2.116	5.562	320
	ICTex (Information & Infrastructure)	0.008	1.480	-1.018	8.475	765
	Credit (Economic Incentive)	0.194	0.237	0.001	1.739	567
Knowledge Economy	Institutions (Institutional Regime)	0.105	2.075	-5.399	5.233	598
	Scientific and Technical Journal Articles(log)	1.235	0.906	-1.000	3.464	717
	Trademarks(log)	6.973	1.567	0.000	10.463	276
	Patentes(log)	5.161	2.077	1.386	9.026	121
GDP-based financial development indicators	Proposition 1	0.248	0.213	0.001	1.054	567
	Proposition 2	0.001	0.007	-0.027	0.097	795
	Proposition 3	0.046	0.056	-0.292	0.472	795
	Proposition 4	0.047	0.058	-0.290	0.472	795
	Proposition 5	0.730	0.171	0.175	1.456	564
Measures of financial sector	Proposition 6	0.007	0.031	-0.083	0.224	564
	Proposition 7	0.262	0.172	-0.457	0.824	564
	Proposition 8	0.269	0.171	-0.456	0.824	564
Control variables	Inflation	57.556	955.55	-100.00	24411	673
	Government Expenditure	4.392	12.908	-57.815	90.544	468
	Economic Prosperity	4.763	7.293	-31.300	106.28	759

Panel B: Presentation of Countries (53)

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Chad, Central African Republic, Comoros, Congo Democratic Republic, Congo Republic, Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Senegal, Sierra Leone, Somalia, Sudan, Rwanda, Sao Tomé & Principe, Seychelles, South Africa, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

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

Appendix 3: Correlation analysis

Educatex	ICTex	Credit	Instireg	STJA	TradeM	Patents	Prop1	Prop2	Prop3	Prop4	Prop5	Prop6	Prop7	Prop8	Infl.	G.Exp	GDPg	
Knowledge Economy							**Financial Development**								**Control Variables**			
							GDP based measures				Financial sector importance measures							
1.000	0.697	0.637	0.435	0.363	0.504	0.727	0.667	0.208	0.176	0.203	0.493	0.078	-0.511	-0.493	-0.089	0.035	0.003	Educatex
	1.000	0.566	0.435	0.201	0.372	0.580	0.800	-0.012	-0.005	-0.007	0.479	-0.054	-0.466	-0.479	0.002	-0.023	-0.048	ICTex
		1.000	0.554	0.483	0.579	0.761	0.686	0.137	-0.175	-0.152	0.595	0.037	-0.598	-0.595	-0.047	-0.041	-0.092	Credit
			1.000	0.310	0.179	0.502	0.606	0.100	0.015	0.028	0.596	0.054	-0.604	-0.596	-0.099	0.048	0.033	Instireg
				1.000	0.562	0.880	0.289	0.234	0.107	0.137	0.333	0.167	-0.361	-0.333	0.011	0.089	-0.125	STJA
					1.000	0.820	0.485	0.095	-0.166	-0.147	0.573	0.009	-0.584	-0.573	-0.019	-0.021	-0.004	TradeM
						1.000	0.676	-0.129	-0.187	-0.202	0.696	-0.208	-0.667	-0.696	-0.318	-0.081	-0.134	Patents
							1.000	0.077	0.149	0.159	0.588	-0.016	-0.581	-0.588	-0.053	-0.060	-0.101	Prop1
								1.000	0.080	0.214	-0.011	0.894	-0.149	0.011	-0.012	-0.017	-0.006	Prop2
									1.000	0.990	-0.535	-0.056	0.542	0.535	-0.041	0.008	-0.070	Prop3
										1.000	-0.529	0.099	0.508	0.529	-0.043	0.005	-0.069	Prop4
											1.000	-0.055	-0.983	-1.000	-0.056	0.007	0.011	Prop5
												1.000	-0.124	0.055	-0.007	-0.039	-0.024	Prop6
													1.000	0.983	0.058	-0.001	-0.006	Prop7
														1.000	0.056	-0.007	-0.011	Prop8
															1.000	-0.139	-0.057	Infl
																1.000	0.103	G. Exp.
																	1.000	GDPg

Educatex is the first principal component of primary, secondary and tertiary school enrolments. ICTex: first principal component of mobile, telephone and internet subscriptions. STJA: Scientific & Technical Journal Articles. TradeM: Trademarks. Prop: Proposition. Infl: Inflation. G.Exp. Government Expenditure. GDPg: GDP growth rate.

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