Software piracy and scientific publications: knowledge economy evidence from Africa

Asongu, Simplice

11 August 2014

AFRICAN GOVERNANCE AND DEVELOPMENT INSTITUTE

A G D I Working Paper

WP/14/018

Software piracy and scientific publications: knowledge economy evidence from Africa

Forthcoming: African Development Review

Simplice A. Asongu
African Governance and Development Institute,
Yaoundé, Cameroon.
E-mail: asongusimplice@yahoo.com

AGDI Working Paper

Research Department

Software piracy and scientific publications: knowledge economy evidence from Africa

Simplice A. Asongu[1]

August 2014

Abstract

This paper is an extension of the debate on the nexus between the strength of IPRs and prospects for knowledge economy. It assesses the relationships between software piracy and scientific publications in African countries for which data is available. The findings which reveal a positive nexus are broadly consistent with the school of thought postulating that, the East Asian miracle has been largely due to weaker IPRs regimes at the early stages of development. As a policy implication, less stringent IPRs regimes on scientific-related software (at least in the short-run) will substantially boost contributions to and dissemination of knowledge through scientific and technical publications in Africa. IPRs laws (treaties) on scientific-oriented software should be strengthened in tandem with progress in: scientific and technical publications and; knowledge spillovers essential for economic growth and development. More policy implications are discussed.

JEL Classification: A20; F42; O34; O38; O55
Keywords: Publications; Piracy; Intellectual property rights; Governance; Africa

[1] Simplice A. Asongu is Lead economist in the Research Department of the AGDI (asongus@afridev.org).

1. Introduction

Over the past decades, there has been a wide consensus on the crucial role that intellectual property rights (IPRs) protection play on the promotion of innovation processes, economic growth and development. Recent advancements in information and communication technologies (ICTs) have not only resulted in an increased availability of information and technology related products but also in the proliferation of technology used to copy and/or pirate such commodities. Accordingly, efforts are being placed on increasing and harmonizing the standards and enforcements of IPRs protection at the global level. Since the issue of IPRs consolidation and curtailment of the proliferation of pirated goods is more pronounced in developing countries, the concern over the effects of these efforts on development has been widely debated.

While some scholars have postulated that, increased protection of IPRs stimulate economic growth and development through the positive impact on factor productivity (Falvey et al., 2006; Gould & Gruben, 1996), some skeptics are of the stance that IPRs protection and adherence to international treaties (laws) may stifle, rather than stimulate economic growth in developing countries (Yang & Maskus, 2001). Proponents of less stringent IPRs argue that, because the existing technology in developing countries is more imitative and/or adaptive in nature (rather than suitable for the creation of new innovations), developing countries will be detrimentally affected by tight IPRs law regimes. Moreover, it is vehemently disputed that, weaker IPRs are necessary (at least on a temporal basis) for developing countries to obtain knowledge spillovers essential for growth and development. These skeptical positions have gained prominence in the debate over if 'permission' should be granted to enable the 'copying' of life-saving pharmaceuticals, especially those used in the management of HIV/AIDS in developing countries most affected and least likely to afford such treatments.

In light of the above, there is increasing relevance on the incidence of IPRs protection on technological advancement, promotion of innovation and economic development. While theoretical literature has addressed the concern to some extent, scanty scholarly focus has been devoted to empirical literature. A substantial bulk of empirical studies has examined the socio-economic determinants of piracy in several copyright industries (Andrés, 2006ab; Banerjee et al., 2005; Bezmen & Depken, 2006; Peitz & Waelbroeck, 2006; Goel & Nelson, 2009). On the contrary, very few empirical studies have investigated the impact of software piracy on economic prosperity (Bezmen & Depken, 2004; Andrés & Goel, 2012) and knowledge economy (KE).

The phenomenon of KE has been increasingly emphasized in with the growing relevance of IPRs. Since the 1990s, KE has been central in the reports of most organizations (inter alia, OECD, the World Bank), with strong emphasis on the capital role that knowledge (created through technological progress and innovation) is the wheel to long-run economic growth (World Bank, 2007; Weber, 2001). The interesting literature is consistently of the view that, Europe and North America have mastered the dynamics of IPRs in KE and are inexorably steering developments at the global and international arenas. Other regions like East Asia and Latin America are responding in calculated steps that underscore the imperative dimensions of KE and IPRs in their current quests of national, regional and international initiatives. Accordingly, the pattern of Japan has set the course for governments of the Newly Industrialized Asian Economies (China, Korea, Hong Kong, Singapore, Malaysia and Taiwan) which are playing a crucial role in the progress toward 'knowledge-based' economies from the 'product-based' economies (Chandra & Yokoyama, 2011). In Africa, IPRs and KE issues are also assuming central stage in discussions on development.

As far as we have reviewed, we currently know very little from the literature on KE and IPRs dynamics in Africa. The few studies that have assessed the phenomenon and

corresponding nexuses have been limited to economic growth for the most part (Chavula, 2010). While the growth-KE nexus is important, the debate has recently been centered on how African countries can replicate the 'East Asian Miracle'. As a matter of facts, it has become abundantly clear that, for African countries to be involved in the global economy, they must be competitive. Competition derives from KE and intellectual capital which are protected by IPRs laws and have very recently been the focus of renewed interest in the Africa: either through the fight against software piracy (Andrés & Asongu, 2013ab; Asongu, 2012ab), via dynamics in KE-finance nexuses (Asongu, 2012c; Asongu, 2013a), production value of doctoral dissertations (Amavilah, 2009) or pro-poor nexuses (Asongu, 2013b).

With this interesting background, the present paper complements the above literature that has epitomized concerns of policy makers in four main words: KE, IPRs, piracy and governance. It principally extends the debate on the nexus between the strength of IPRs and prospects for knowledge economy by assessing the relationship between software piracy and scientific publications in African countries for which data is available. Specifically, the study's contribution to existing literature is fourfold. Firstly, recent evidence has robustly established the pro-poor character of software piracy in Africa (Asongu, 2013b). Hence, extending the socio-economic flavor of the findings to a KE dimension could be of interesting policy relevance. Secondly, a considerable bulk of research on KE has focused on developed and the emerging economies of Latin America and East Asia (Dahlan, 2007; Chandra & Yokoyama, 2011). Hence, the scanty evidence of the phenomenon in African countries is a missing strand also motivating this paper. Thirdly, the role of governance in determining trajectories of KE has been crucial in the 'East Asian miracle' because; knowledge creation and diffusion processes depend on appropriate governance policies that are themselves the fruits of government quality. Hence, it would be interesting to assess how formal institutions

are instrumental in the nexuses we are investigating[2]. Fourthly, the study's positioning substantially steers clear of earlier (AfDB, 2007; Bizri, 2009; Aubert, 2005; Britz et al., 2006)[3] and recent[4] African KE literature in order to provide the much needed policy implications (Britz et al., 2006; Makinda, 2007; Lightfoot, 2011)[5].

The rest of the paper is organized as follows. Data and methodology issues are discussed in Section 2. Empirical analysis is covered in Section 3. Section 4 concludes.

2. Data and Methodology

We assess a panel of 10 African countries with data from African Development Indicators (WDI) of the World Bank (WB) for the period 1996-2010. Limitations to the time span and number of countries are constrained by software piracy data availability. The corresponding sampled countries are presented in Panel B of Appendix 1.

2.1 Data

The dependent variable is the number of scientific and technical journals published on a yearly basis. The independent variable is the software piracy rate, which is defined as "the unauthorized copying of computer software which constitutes copyright infringement for

[2] Fresh African literature has substantially documented institutional issues on the course to achieving KE in (Asongu, 2013a), especially by means of financial sector development (Asongu, 2012d) or transfer of technology through development assistance (Asongu, 2012e).

[3]For example, consistent with Asongu (2013a), the African Development Bank (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; (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.

[4] See discussion in the preceding paragraph.

[5]Britz et al. (2006) have examined the question of whether Africa is moving towards a KE and found that, Africa still has a far way to go down the road and the journey could be quickened with certain preconditions, amongst others: investment in human capital, effective stopping of brain drain, as well as effective development and maintenance of a physical infrastructure. In accordance with Makinda, in order to rectify the 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 (Makinda, 2007). This need for policy reforms draws from the Lightfoot (2011) conclusion that emphasizes the need for in-depth reforms as means to fulfilling the policy aspirations rather than speculating over progress through technology enriched futures.

either commercial or personal use" (SIIA, 2000). Software piracy may potentially take many avenues (e.g., organized copiers, piracy by individuals and commercial or business piracy), thus obtaining an accurate measure of the prevalence of software piracy remains a challenge in the literature. There are many types of software piracy. According to the Business Software Alliance (BSA), we can distinguish among: 1) downloading; 2) end user copying; and 3) counterfeiting. The level of software piracy is computed as the difference in demand for new software applications (estimated from PC shipments) and the legal supply of software. In the present paper, the measure of piracy employed is the percentage of software (primarily business software) in a country that is illegally installed (without a license) on an annual basis and is taken to capture the level of software piracy. This variable is presented in percentages, scaling from 0 % (no piracy) to 100 % (i.e., all software installed is of pirated origin). Piracy rates source from the Business Software Alliance (BSA, 2010). More information on measurement could be obtained from the BSA (2009)[6]. Though the BSA is an industry group, its data on software piracy is the best cross-country measure currently used in the literature.

The good governance instrumental variables from Kaufmann et al. (2010) are consistent with recent IPRs (Asongu, 2012b) and piracy (2013b) literature. As stated in the introduction, the role of governance has been crucial for the 'East Asian miracle'. This is essentially because; knowledge creation and diffusion processes depend on appropriate governance policies that are themselves the fruits of government quality. Indeed, the role of governance is straight forward; the institutional framework is crucial for gaining adequate flow of knowledge between scientific research and technological applications, as well as for a good information flow between knowledge users and researchers. Therefore, governments play a critical mission, because the creation of knowledge cannot be left to imperfect market

[6] Data from the BSA primarily measures the piracy of commercial software. See Png (2008) and Traphagan & Griffith (1998) for a discussion on the reliability of piracy data. This data has been widely used in the piracy literature (Marron & Steel, 2000; Banerjee et al., 2005; Andrés, 2006ab; Goel & Nelson, 2009; Asongu, 2012ab, 2013b; Andrés & Asongu, 2013ab).

mechanisms. The government quality instrumental variable can be grouped into three concepts. The first concerns the process by which those in authority are selected and replaced [Political Governance]: voice & accountability and political stability. The second is the capacity of government to formulate & implement policies and deliver services [Economic Governance]: regulatory quality and government effectiveness. The last, but by no means the least, concerns the respect for citizens and the state of institutions that govern the interactions among them [Institutional Governance]: rule of law and control of corruption.

We control for the literacy rate (secondary education and tertiary enrollment), ICTs (internet penetration and number of personal computer (PC) users) and innovation (foreign direct investment (FDI) and FDI inflows). We cannot control for more than three factors at the same time owing to: (1) constraints in the "Overidentifying Restrictions (OIR)" test for instrument validity[7] and; (2) concerns of overparametization and multicolinearity. Hence, we employ two specifications that contain one variable in the indentified categories above. Intuitively, we expect all the control variables to positively affect scientific publications. This is essentially because from common sense, increased literacy, ICTs and innovation should create a conducive climate for scientific and technical related activities that ultimately lead to publications of corresponding results in journals.

The summary statistics (with presentation of countries), correlation analysis (showing the nexuses among key variables used in the paper), and variable definitions (with corresponding sources) are presented in the appendices. The 'summary statistics' (Appendix 1) of the variables used in the estimations shows that, there is quite some variation in the data used so that one should be confident that reasonable estimated nexuses should emerge. The objective of the correlation matrix (Appendix 2) is to mitigate concerns of overparametization

[7]An OIR test is only applicable in the presence of over-identification, that is, the instruments must be higher than the endogenous explaining variables by at least one degree of freedom. In the cases of exact- identification (instruments equal to endogenous explaining variables) and under-identifications (instruments less than endogenous explaining variables) an OIR test is by definition impossible.

and multicolinearity. Based on an initial assessment of the correlation coefficients, there do not appear to be any serious concerns in terms of the relationships to be estimated. Definitions and corresponding sources of the variables are presented in Appendix 3.

2.2 Methodology

2.2.1 Endogeneity

The issue of endogeneity has two main justifications. Firstly, whereas scientific publications could be influenced by the degree of software piracy, the reverse effect cannot be ruled-out because as an economy grows in scientific knowledge, it tends to have better IPRs laws (on software piracy) hence, the concern of reverse-causality. Secondly, in the empirical IPRs literature, Bezmen & Depken (2004) have insisted that studies investigating the IPRs-development nexus are subject to potential endogeneity problems, because it is likely that a nation's level of development is a crucial factor in the choice of, or adherence to, a particular IPRs regime. This justifies an earlier position by Ginarte & Park (1997) which states that, the height of economic development explains the strength of patent protection provided by individual countries. Before addressing this endogeneity concern, we shall briefly examine its presence with the Hausman test and then employ an estimation technique compatible with the outcome of the test.

2.2.2 Estimation technique

A two-stage least squares (2SLS) instrumental variable (IV) estimation approach is adopted for two main reasons. Firstly, it is compatible with the problem statement that seeks to assess the instrumentality of governance tools in KE building (by means of scientific publications) through software piracy. Secondly, it deals effectively with the endogeneity concern thus, avoiding the inconsistency of estimates by Ordinary Least Squares (OLS) which arise when the exogenous variables are correlated with the error term.

The 2SLS estimation will entail the following steps:

First-stage regression:

$$Piracy_{it} = \gamma_0 + \gamma_{1i}(Instruments)_{it} + \gamma_{2i} X_{it} + v_{it} \quad (1)$$

Second-stage regression:

$$SP_{it} = \beta_0 + \beta_{1i}(Piracy)_{it} + \beta_{2i} X_{it} + u_{it} \quad (2)$$

In Eqs. (1) and (2), *Piracy* represents the software piracy rate. The instruments are government quality dynamics of: the rule of law, regulation quality, voice & accountability, government effectiveness, political stability/no violence and corruption-control. γ_{1i} are the estimated effects on *Piracy* of the instruments (described above in the data section). *SP* denotes scientific and technical publications and, β_{1i} are estimated impacts of *Piracy* on publications. *X* is a set of control variables (described above and defined in Appendix 3) and, β_{2i} (γ_{2i}) are their corresponding effects on *Piracy* (publications) of the control variables. In Eq. (1) and Eq. (2) respectively, *v* and *u* represent the error terms.

Consistent with recent IPRs and software piracy literature (Andrés & Asongu, 2013a), we adopt the following steps in the estimation procedure: (1) justify the choice of a 2SLS over an OLS estimation technique with the Hausman-test for endogeneity; (2) verify the instruments are exogenous to the endogenous components of the explaining variable (piracy channel) and; (3) ensure the instruments are valid and not correlated with the error-term in the main equation with an Over-identifying Restrictions (OIR) test. Further robustness checks are ensured with: (1) modeling with Heteroscedasticity and Autocorrelation Consistent (HAC) standard errors; (2) employment of restricted and unrestricted regressions and; (3) the use of an alternative set of control variables.

3. Empirical Results

3.1 Presentation of results

This section aims to examine two main issues: (1) the capacity of the exogenous components of the piracy channel to explain scientific publications and; (2) the ability of the instruments to explain publications beyond the piracy channel. Whereas the first issue is addressed by the significance and signs of estimated coefficients, the second is solved with the Sargan-OIR test. The null hypothesis of this test is the position that, the instruments explain publications only through the piracy mechanism, conditional on other covariates (control variables). Hence, a rejection of this null hypothesis is a rejection of the view that the instruments do not explain publications beyond the piracy channel. A Hausman test is performed prior to the 2SLS-IV approach. The null hypothesis of this test is the position that, estimated coefficients by OLS are efficient and consistent. Therefore, a rejection of this null hypothesis points to the concern of endogeneity due to inconsistent estimates and thus, lends credit to the choice of the IV estimation technique.

Table 1 below summarizes the findings. Panel A (B) entail the first (second) specification with a different set of control variables. For either panel, the first (second) halves are restricted (unrestricted) 2SLS with HAC standard errors. While the Hauman for endogeneity is overwhelmingly significant in Panel A, it is not for Panel B. As concerns the first issue, a positive piracy-publications nexus is overwhelmingly consistent across specifications and panels. For the second issue, the Sargan OIR is increasingly insignificant as the number of control variables increase. This implies, when the control variables are few, government quality instrumental variables explain publications beyond the piracy mechanism. However, when the degrees of freedom necessary for the OIR test are two (that is, six instruments and four explaining variables), the null hypothesis is rejected consistently across

the unrestricted specifications of both panels. This means the instruments are valid and not correlated with the error term in the equation of interest (Eq. 2).

Most of the significant control variables have the expected signs. Firstly, ICTs by means of internet penetration and proliferation in the number of PC users create favorable conditions for scientific publications. Secondly, innovation in terms of FDI increases knowledge spillovers as attempts by scientific bodies are made to explain, replicated and/imitate the imported know-how (technology). Thirdly, the negative nexus between tertiary education and publication has a fivefold justification: (1) the low rate of tertiary students pursuing education to research levels due to socio-economic and political reasons; (2) the absence of substantial government incentives for research purposes; (3) the disincentive to research because academic appointments are politically motivated (and not based on peer assessments), (4) academic brain drain and; (5) the culture of academic promotion based on teaching and oral examinations[8].

Table 3: Restricted and Unrestricted 2SLS

	Dependent variable: Scientific and Technical Journals Publications							
	Panel A: First Specification							
	Restricted HAC SE 2SLS				**Unrestricted HAC SE 2SLS**			
	Model 1	Model 2	Model 3	Model 4	**Model 1***	**Model 2***	**Model 3***	**Model 4***
Constant	---	---	---	---	**2.462*** (0.000)**	0.630 (0.538)	-0.332 (0.467)	**-4.337*** (0.000)**
Piracy	**3.722*** (0.000)**	**1.319** (0.014)**	-0.023 (0.958)	**-0.836** (0.034)**	-0.601 (0.568)	0.867 (0.480)	0.180 (0.638)	**0.441** (0.034)**
Tertiary Edu	---	1.548*** (0.000)	-0.680 (0.156)	**-1.151*** (0.003)**	---	**1.147*** (0.000)**	-0.526 (0.243)	**-0.877** (0.023)**
Internet	---	---	**1.044*** (0.000)**	**0.619*** (0.000)**	---	---	**1.071*** (0.000)**	**1.185*** (0.000)**
FDI	---	---	---	0.074 (0.202)	---	---	---	**0.154*** (0.007)**
Hausman	**5.842****	**14.407*****	**27.624*****	**8.698***	0.060	**4.698***	**28.417*****	**185.67*****
Sargan OIR	44.721*** (0.000)	27.168*** (0.000)	13.818*** (0.000)	24.176*** (0.000)	44.866*** (0.000)	30.325*** (0.000)	13.010*** (0.001)	**0.595 (0.742)**
Adjusted R^2	0.042	0.032	0.605	0.399	0.023	0.009	0.605	0.534
Fisher	---	---	**238.27*****	**202.47*****	---	**5.451*****	**12.888*****	**14.256*****
Chi^2	---	**269.35*****	---	---	0.324	---	---	---
Observations	53	42	42	40	53	42	42	40

[8] For example, university lecturers with an extensive teaching experience are more likely to pass the oral examination for promotion in CAMES (African and Malagasy Council for Higher Education).

	Panel B: Second Specification							
	Restricted HAC SE 2SLS				Unrestricted HAC SE 2SLS			
	Model 5	Model 6	Model 7	Model 8	**Model 5***	**Model 6***	**Model 7***	**Model 8***
Constant	---	---	---	---	**2.462*** **	**3.860*** **	**-5.743*** **	-9.870
					(0.000)	**(0.000)**	**(0.003)**	(0.165)
Piracy	**3.722*** **	0.582	0.199	0.335	-0.601	-0.607	**1.778*** **	**2.453** **
	(0.000)	(0.383)	(0.662)	(0.513)	(0.568)	(0.551)	**(0.009)**	**(0.044)**
Secondary Edu	---	**1.057*** **	-0.749	-0.567	---	-0.872	**1.225***	2.026
		(0.000)	(0.208)	(0.332)		(0.163)	**(0.078)**	(0.229)
PC Users	---	---	**1.341*** **	**1.231*** **	---	---	**2.006*** **	**2.858** **
			(0.001)	**(0.002)**			**(0.000)**	**(0.045)**
FDI inflows	---	---	---	-0.048	---	---	---	0.163
				(0.289)				(0.498)
Hausman	**5.842** **	4.601	4.645	4.073	0.060	1.000	**15.849*** **	**27.534*** **
Sargan OIR	44.721***	33.195***	30.624***	32.176***	44.866***	33.752***	15.593***	**4.444**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	**(0.108)**
Adjusted R^2	0.042	-0.013	0.505	0.527	0.023	-0.036	0.487	0.252
Fisher	---	---	**170.33*** **	**183.02*** **	---	0.972	**18.772*** **	**6.060*** **
Chi^2	---	**364.42*** **	---	---	0.324	---	---	---
Observations	53	44	44	44	53	44	44	44

Instruments	Constant; Corruption-Control; Voice & Accountability; Regulation Quality; Rule of Law; Political Stability; Government Effectiveness.

*;**;***: significance levels of 10%, 5% and 1% respectively. ( ): p-values. 2SLS: Two-Stage-Least Squares. HAC: Heteroscedasticity and Autocorrelation Consistent. SE: Standard Errors. OIR: Overidentifying Restrictions test.

3. 2 Discussion of results, policy implications and caveats

3.2.1 Discussion and policy implications

Our findings have broadly demonstrated that, software piracy is pro-scientific publications, which further indicate that good governance is not a sufficient condition for a negative piracy-publications nexus. Hence, it could be inferred that, formal institutions are instrumental in the friendly character of software piracy on scientific publications. Accordingly, this evidence is fairly logical because it is hard to reconcile the substantially high cost of software (related to scientific activity) with the low income of researchers in most African countries. From a global perspective, our results reflect the Chinese model of KE. Accordingly, though there has been a clear positive nexus between good governance and the upholding of IPRs imperative for KE in much of East Asia, China has largely remained an exception to this rule. China's success story in attracting FDI is attributed to its spectacular growth track record, relatively better executive power, good infrastructure, abundant educated labor force and, a large domestic market (Chandra & Yokoyama, 2011, p. 46). For now the

empirical evidence seems to indicate that African countries are in the same paradigm as China with respect to the impact of good governance measures on the piracy-publications nexus.

The results are also generally consistent with the Chinese model insofar as they are in line with studies on wealth-effects that have established the existence of a non-linear nexus between income-levels and IPRs (Kim, 2004; Maskus & Penubarti, 1995). These studies have documented that, patent protection tends to ameliorate as economies move from low- to middle-income platforms and that, this protection decreases with the ability to imitate new technologies. The kernel of the intuition here is that, IPRs are thought to be successful at spurring economic prosperity only after a nation has acquired sufficient human capital and technology infrastructure for creative imitation to occur. Hence, it could be inferred that, strong IPRs protection in the early stage of African industrialization (when knowledge and technology can be acquired via reverse engineering, duplication and/or imitation) could substantially hamper knowledge contribution and spillovers in sampled countries.

Looking at one of the ongoing debates that have partially motivated this paper, it has been well documented that, the 'East Asian miracle' has substantially been due to less tight IPRs at the early stages of economic development in the region. This documentation has supported the thesis that, the changing strength of IPRs regimes depends on the nation's level of development and/or current technological capacity. Further evidence has suggested that, this miracle has been largely due to this nation's ability to absorb, replicate and duplicate foreign innovations through some form of piracy. However, it has also been established that, as these countries became significant producers of new technologies and innovations, their IPRs regimes were tightened (Nelson & Pack, 1999). Hence, our findings are broadly consistent with the Nelson & Pack postulation that, as the assimilation of existing techniques and technologies was a critical component in the success of these Asian countries, their sampled African counterparts would have to give less significance to the Maskus (2000)

caution. Accordingly, Maskus has postulated that, weaker IPRs might not necessarily be beneficial to developing countries as it may cause them to become dependent on older and less efficient technologies.

Another line of interpretation is the manner in which the findings reconcile the debate. Accordingly, based on the results, it could be established that less tight IPRs regimes on 'scientific publication'-related software (at least in the short-run) would enable knowledge spillovers imperative for growth and development. However, as the sampled countries grow, adoption of tighter IPRs regimes will facilitate inflows of innovation and technology transfers (Lee & Mansfield, 1996), stimulate exports (Maskus & Penubarti, 1995) and, increase the likelihood of investment undertaken by multinational enterprises (Mansfield, 1994; Seyoum, 1996).

It will also be interesting to provide a 'down-to-earth' elucidation of the positive piracy-publication nexus. Given the relatively high cost of scientific-related software, many African scholars cannot afford to buy original software packages. Therefore illegal copying, unauthorized downloading and counterfeiting become the only options of obtaining the desired software package. By purchasing cheap pirated software, scholars can save money for other research utilities. Hence, this indirectly increases their exposure to research facilities that eventually lead to more publications. This interpretation is in accordance with the hypothesis that, the poor are more prone to using pirated software (Moores & Esichaikul, 2011, 1-2). Moores & Esichaikul have found a strong negative nexus between economic wealth and the level of software piracy, such that poorer countries tend to have higher levels of software piracy.

Apart from economic considerations, another factor that could explain the nexus established in the findings is African culture. Moores & Esichaikul (2011, 2) have also found that, countries with a more collectivist society also tend to have higher levels of software

piracy. Hence, the sharing culture in African academic institutions could also be a major factor for the positive relationship. This interpretation is consistent with a great bulk of the literature that has examined the determinants of the willingness to pirate software (by assessing the socio-economic factors that affect piracy). The conclusion drawn from these studies is that, countries with higher income and greater individualism have lower piracy rates (Maskus & Penubarti, 1995; Gould & Gruben, 1996; Thompson, 1996, 1999; Park & Ginarte, 1997; Rushing & Husted, 2000; Marron & Steel, 2000; Kranenberg & Hogenbirk, 2003; Kim, 2004; Depken & Simmons, 2004).

Examining the findings in light of very recent African IPRs literature is also essential. Asongu (2013b) has found software piracy to be pro-poor using almost the same sample. His conclusion is broadly consistent with the discussion in the preceding paragraph. This strand of discussion is also in accordance with Andrés & Asongu (2012) who have shown that, from the education dimension of KE, adoption of tight IPRs regimes may negatively affect human development by diminishing the literacy rate and restricting diffusion of knowledge. However, Andrés & Asongu have also documented that, adherence to international IPRs protection treaties (laws) may not impede per capita economic prosperity and could improve life-expectancy.

The major policy implication of this study is that, imposing very tight laws against software piracy by government institutions is not a sufficient condition for KE in the sampled countries. Hence, the Chinese model may be a better reflection of what is happening in this group of countries. Four main ethical implications are also worth noting: (1) the seller of pirated software thinks (S)he is right to continue her (his) business because the company may incur more expenses taking the matter to court; (2) users of pirated software think it is right to use pirated commodities because they are poor; (3) illegal copying might be based on interpersonal trust as those who either copy or share software with others must trust that the

software contains no viruses and; (4) moreover, individuals distributing illegal copies to others must trust these persons not to report to the police.

3.2.2 Caveats

Two main caveats have been retained: shortcomings in the measurement of software piracy and, the perception based good governance measures that may be subject to substantial bias owing to media propaganda.

Firstly, consistent with Asongu (2012b), on the measurement of software piracy, three points are relevant. Firstly, the 'piracy level is computed as the difference in demand for new software applications (computed from PC shipments) and the legal supply of software'. It is important to emphasize that, this metric defines piracy as the drop in demand of software products. Therefore, all pirated copies constitute lost sales. Secondly, it has also been substantially documented that, those who buy pirated copies do not always have the money to buy the true commodity. Therefore to consider the use of pirated products as diminishing demand for originals could be some kind of overstatement. Thirdly, the employment of the metric presupposes knowledge of the elasticity of demand for the original product. Otherwise, there will be a comparison of pirated commodities that constitute loss in sales with ones that do not. Thus, there is some upward bias in the software piracy estimate.

Government quality indicators are perception based measures that may be subject to a considerable degree of media propaganda. Nonetheless, as far as we have reviewed, there are no better government quality indicators than those available in the World Bank Development Indicators.

4. Conclusion

This paper has extended the debate on the nexus between the strength of IPRs and prospects for knowledge economy. It has assessed the relationships between software piracy

and scientific publications in African countries for which data is available. The findings which reveal a positive nexus are broadly consistent with the school of thought postulating that, the East Asian miracle has been largely due to weaker IPRs regimes at the early stages of development. As a policy implication, less stringent IPRs regimes on scientific-related software (at least in the short-run) will substantially boost contributions to and dissemination of knowledge through scientific and technical publications in Africa. IPRs laws (treaties) on scientific-oriented software should be strengthened in tandem with progress in: scientific and technical publications and; knowledge spillovers essential for economic growth and development. More policy implications have been discussed.

Appendices

Appendix 1: Summary statistics and presentation of countries

Panel A: Summary Statistics

		Mean	S.D	Min	Max	Obser.
Dependent Variable	Scientific & Technical Journals Articles	2.159	0.583	1.120	3.286	80
Independent Variable	Piracy rate	0.485	0.222	0.034	0.720	95
	Tertiary School Enrollment (TSE)	0.992	0.304	0.380	1.486	67
	Secondary School Enrollment (SSE)	1.656	0.219	1.201	1.948	74
Control Variables	Internet Penetration	2.822	0.809	1.301	4.727	110
	Personal Computer Users	2.535	0.448	1.699	3.553	110
	Foreign Direct Investment	2.626	2.893	-7.646	11.603	99
	Foreign Direct Investment Inflows	2.642	2.372	-0.610	11.603	110
	Rule of Law	-0.342	0.709	-1.657	1.053	100
	Regulation Quality	-0.250	0.524	-1.305	0.905	100
Good Governance	Government Effectiveness	-0.252	0.546	-1.038	0.801	90
Instrumental Variables	Voice & Accountability	-0.371	0.659	-1.256	1.047	100
	Corruption-Control	-0.371	0.638	-1.236	1.086	100
	Political Stability (No Violence)	-0.432	0.872	-2.094	0.996	100

Panel B: Presentation of Countries

Algeria, Botswana, Cameroon, Egypt, Kenya, Mauritius, Morocco, Nigeria, Senegal, Zambia.

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

Appendix 2: Correlation analysis

Piracy	Education		Control Variables ICT		Innovation		Government Quality		Instrumental Variables				S&T	
	TSE	SSE	Internet	PC	FDI	FDI I	CC	GE	RL	RQ	V&A	PolS	JA	
1.000	-0.43	-0.44	-0.010	-0.33	0.031	0.018	-0.31	-0.44	-0.55	-0.47	-0.15	-0.26	-0.17	Piracy
	1.000	0.655	0.484	0.517	0.169	0.296	0.257	0.288	0.385	0.076	-0.04	0.039	0.249	TE
		1.000	0.078	-0.01	0.001	-0.03	0.542	0.566	0.575	0.593	0.387	0.408	-0.01	SE
			1.000	0.873	-0.02	0.080	-0.39	-0.28	-0.31	-0.39	-0.50	-0.54	0.696	Internet
				1.000	-0.07	-0.01	-0.36	-0.19	-0.25	-0.35	-0.52	-0.56	0.807	PC
					1.000	0.874	0.178	0.116	0.182	0.147	0.142	0.287	-0.05	FDI
						1.000	0.102	0.065	0.149	0.060	0.079	0.239	-0.08	FDI I
							1.000	0.951	0.907	0.855	0.773	0.784	-0.39	CC
								1.000	0.930	0.918	0.795	0.750	-0.34	GE
									1.000	0.888	0.732	0.824	-0.40	RL
										1.000	0.815	0.781	-0.48	RQ
											1.000	0.739	-0.72	V&A
												1.000	-0.66	PolS
													1.000	S&T JA

TSE: Tertiary School Enrollment. SSE: Secondary School Enrollment. Internet: Internet Penetration. PC: PC Users. FDI: Foreign Direct Investment. FDI I: Foreign Direct Investment Inflows. CC: Corruption-Control. GE: Government Effectiveness. RL: Rule of Law. RQ: Regulation Quality. V&A: Voice & Accountability. PolS: Political Stability. S&T J A: Scientific & Technical Journal Articles.

Appendix 3: Variable definitions

Variables	Signs	Variable definitions	Sources
		Panel A: Dependent and Independent Variables	
Scientific Publications	S&T JA	Logarithm of Scientific and Technical Journal Articles	World Bank (WDI)
Piracy	Piracy	Logarithm Piracy rate (annual %)	BSA
		Panel B: Control Variables	
Tertiary Enrollment	TSE	Logarithm of Tertiary School Enrollment	World Bank (WDI)
Secondary Enrollment	SSE	Logarithm of Secondary School Enrollment	World Bank (WDI)
Internet Penetration	Internet	Logarithm of Internet Users per 1000	GMID
Personal Computer Users	PC	Logarithm of Personal Computer Users per Capita	GMID
Foreign Direct Investment	FDI	Net Foreign Direct Investment (% of GDP)	World Bank (WDI)
FDI Inflows	FDI I	Foreign Direct Investment Inflows (% of GDP)	World Bank (WDI)
		Panel C: Good Governance Instrumental Variables	
Rule of Law	RL	Rule of law (estimate): captures perceptions of the extent to which agents have confidence in and abide by the rules of society and in particular the quality of contract enforcement, property rights, the police, the courts, as well as the likelihood of crime and violence.	World Bank (WDI)
Regulation Quality	RQ	Regulation quality (estimate): measured as the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	World Bank (WDI)
Government Effectiveness	Gov. E	Government effectiveness (estimate): measures the quality of public services, the quality and degree of independence from political pressures of the civil service, the quality of policy formulation and implementation, and the credibility of governments' commitments to such policies.	World Bank (WDI)
Voice & Accountability	V&A	Voice and accountability (estimate): measures the extent to which a country's citizens are able to participate in selecting their government and to enjoy freedom of expression, freedom of association and a free media.	World Bank (WDI)
Control of Corruption	CC	Control of corruption (estimate): captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests.	World Bank (WDI)
Political Stability (No Violence)	PolSta	Political stability/no violence (estimate): measured as the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional and violent means, including domestic violence and terrorism.	World Bank (WDI)

WDI: World Bank Development Indicators. BSA: Business Software Alliance. GDP: Gross Domestic Product. GMID: Global Market Information Database.

References

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

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

Andrés, A. R., (2006a). "Software piracy and income inequality", Applied Economic Letters, 13 (2), pp. 101-105.

Andrés, A. R., (2006b). "The relationship between copyright software protection and piracy: Evidence from Europe", *European Journal of Law and Economics*, 21, pp. 29–51.

Andrés, A. R., & Goel, R. K., (2012). "Does software piracy affect economic growth? Evidence across countries", *Journal of Policy Modeling*, 34, pp. 284-295.

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

Andrés, A. R., & Asongu, S. A., (2013b). "Global trajectories, dynamics and tendencies of software piracy: benchmarking IPRs harmonization" *African Governance and Development Institute Working Paper*.

Andrés, A. R., & Asongu, A. S., (2012). "The Impact of Software Piracy on Human Development: Evidence from Africa", *INESAD Working Paper*.

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

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

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

Asongu, S. A., (2012d). "Government quality determinants of stock market performance in African countries", *Journal of African Business*, 13(2), pp. 183-199.

Asongu, S. A., (2012e). "On the effect of foreign aid on corruption", *Economics Bulletin*, 32(2), pp. 2174-2180.

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

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

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

Banerjee, D., Khalid, A. M., & Sturm, J.-E., (2005). "Socio-economic development and software piracy. An empirical assessment", *Applied Economics*, 37, pp. 2091–2097.

Bezmen, T. L., & Depken, C. A., (2006). "Influences on software piracy: Evidence from the various United States", *Economics Letters*, 90, pp. 356-361.

Bezmen, T. L., & Depken, C. A., (2004). "The impact of software piracy on economic development", *Working Paper*. Francis Marion University.

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

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

Business Software Alliance: BSA, (2009). What is Software Piracy? http://www.bsa.org/Piracy%20Portal.aspx, accessed May 2012.

Business Software Alliance: BSA, (2010). Seventh Annual BSA/IDC Global Piracy Study. http://portal.bsa.org/globalpiracy2009/studies/09_Piracy_Study_Report_A4_final_111010.pdf (accessed: 15/01/2013).

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

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

Dahlan, C., (2007). "The Challenge of the Knowledge Economy for Latin America", *Globalization, Competitiveness and Governability Journal*, 1(1), pp. 18-46.

Depken, C. A., & Simmons, L., (2004). "Social Construct and the Propensity for Software Piracy", *Applied Economics Letters*, 11, pp. 97-100.

Falvey, R., Foster, N., & Greenway, D., (2006). "Intellectual property rights and economic growth", *Review of Development Economics*, 10, pp. 700-719.

Ginarte, J. C., & Park, W. G., (1997) "Determinants of Patent Rights: A Cross-National Study," *Research Policy,* pp. 283-301.

Goel, R. K., & Nelson, M. A., (2009). "Determinants of software piracy: economics, institutions and technology", *Journal of Technology Transfer*, 34, pp. 637–658.

Gould, D. M., & Gruben, W. C., (1996) "The Role of Intellectual Property Rights in Economic Growth", *Journal of Development Economics,* 48, pp. 323-350.

Husted, B. W., (2000). "The Impact of National Culture on Software Piracy", *Journal of Business Ethics,* 26, pp. 197-211.

Kaufmann, D., Kraay, A & Mastruzzi, M., (2010). "The Worldwide Governance Indicators: Methodology and Analytical Issues". *World Bank Policy Research Working Paper* No 5430.

Kim, L., (2004). "The Multifaceted Evolution of Korean Technological Capabilities and its Implications for Contemporary Policy", *Oxford Development Studies*, 32(3), pp. 341-63.

Kranenburg, H. L., & Hogenbirk, A. E., (2003). "Determinants of Multimedia, Entertainment, and Business Software Copyright Piracy: A Cross-national Study," mimeo, Department of Organization and Strategy, University of Maastricht.

Lee, J., & Mansfield, E., (1996). "Intellectual Property Protection and U.S. Foreign Direct Investment", *The Review of Economics and Statistics,* 78(2), pp. 181-86.

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

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

Mansfield, E., (1994). *Intellectual Property Protection, Foreign Direct Investment, and Technology Transfer,* (Washington D.C.: International Finance Corporation).

Marron, D. B., & Steel, D. G., (2000). "Which Countries Protect Intellectual Property? The Case of Software Piracy", *Economic Inquiry,* 38(2), pp. 147-74.

Maskus, E. K., (2000). "Intellectual Property Rights and Economic Development", University of Colorado, Boulder.

Maskus, K. E., & Penubarti, M., (1995). "How Trade Related are Intellectual Property Rights?"*Journal of International Economics,* 39, pp. 227-248.

Moores, T. T., & Esichaikul, V., (2011). "Socialization and software piracy: A study", *Journal of Computer Information Systems*, pp. 1-9.

Nelson, R. R., & Pack, H., (1999). "The Asian Miracle and Modern Growth Theory," *Economic Journal,* 109, pp. 416-36.

Park, W., & Ginarte, J., (1997). "Intellectual Property Rights and Economic Growth", *Contemporary Economic Policy,* 15, pp. 51-61.

Peitz, M., & Waelbroeck, P., (2006). "Piracy of digital products: A critical review of the

theoretical literature", Information Economics and Policy, 18, pp. 449–476.

Png, I., (2008). *On the reliability of software piracy statistics*. Mimeo: National University of Singapore.

Rushing, F., W., & Thompson, M. A., (1996). "An Empirical Analysis of the Impact of Patent Protection on Economic Growth", *Journal of Economic Development,* 21(2), pp. 61-79.

Rushing, F., W., & Thompson, M. A., (1999). "An Empirical Analysis of the Impact of Patent Protection on Economic Growth: An Extension", *Journal of Economic Development,* 24(1), pp. 67-76.

Seyoum, B., (1996). "The Impact of Intellectual Property Rights on Foreign Direct Investment", *Columbia Journal of World Business*, 31(1), pp. 50-59.

SIIA. (2000). *SIIA report on global software piracy 2000*. Washington, DC: Software and Information Industry Association.

The World Bank (2007). *Building Knowledge Economies. Advanced Strategies for Development*. World Bank Institute Development Studies. Washington DC.

Traphagan, M., & Griffith, A., (1998). "Software piracy and global competitiveness: Report on global software piracy", *International Review of Law, Computers & Technology*, 12, pp. 431–451.

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

Yang, G., & Maskus, K. E., (2001). "Intellectual Property Rights, Licensing, and Innovation in an Endogenous Product-Cycle Model", *Journal of International Economics,* 53, pp. 169-187.