European Journal of Science and Theology, June 2014, Vol.10, No.3, 131-147

WHERE DO IDEAS COME FROM? THE RELATION BETWEEN BOOK PRODUCTION AND PATENTS FROM THE INDUSTRIAL REVOLUTION TO THE PRESENT

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(Received 8 November 2013, revised 11 March 2014)

Abstract

Recently, more and more use is made from book production as a measure of the long-run development of human capital. However, its relation with technology and growth is often found to be small and changing over time. In this paper we try to establish the link between book production and the spread of 'ideas' as proxied by patents both over time and between regions. Two mechanisms may be distinguished. First, in the initial phase of economic development, the production of books may stimulate the accumulation of knowledge already present in society. After such an accumulation is complete, books may advance a common research focus within a certain geographic space. Indeed, applying this to the case of England, we find that books had a significant role on the number of patents during the second Industrial Revolution. However, when education became increasingly important, the role of books eventually broke down in the second half of the twentieth century. This pattern does not hold true for less developed regions where, due to the lack of efficient education, linguistic fragmentation, an overwhelmingly oral culture, and a structural different kind of knowledge, book production stagnated and no knowledge could be imported (for example, via translated books).

Keywords: book production, patents, ideas, education, economic development

1. Introduction

The importance of ideas and knowledge for growth and development has been widely recognized [1-9]. Yet, this knowledge and these ideas also needed

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to be spread through society in order to have an effect. Ernst Curtius [10] asserted that the use of 'artificial script', as the invention of printing was first referred to, created a complex system of transmitting tradition to present and future generations, i.e. permitting the accumulation of knowledge that had hitherto been transferred in largely oral (or single copy manuscript) form. Printing, as an urban invention, promoted an active accumulation of human capital and played an important role in the evolution of business practices [11-13].

Indeed, books may be considered a primary means of communicating ideas and knowledge. However, there are many theories regarding the way in which books affect 'ideas' and, ultimately, economic development. For example, Eisenstein argued the invention of the printing press led to the accumulation of knowledge in the form of books (before that time the number of hand written manuscripts was too low to effectively spread knowledge) which, in turn enhanced the spread of knowledge [12]. In a path breaking study, Baten and van Zanden found a positive effect of book production on real wage growth [14]. Their argument is that book production is a proxy for literacy. Using this basic relation, they find that the effect of book production on growth is very strong in the period up to 1800 in both Asia and Europe. Yet, since in much of Asia book production was much lower, this implies that per capita income was lower as well. However, many other studies argue for a broader relation between book production and human capital (and via human capital with 'ideas'). For example, Dittmar considers that "between 1500 and 1800, European cities were seedbeds of the ideas, activities, and social groups that launched modern, capitalist economic growth … (the) movable type print technologies had very substantial effects in European economic history through their impact on cities" [15]. Likewise, Buringh and van Zanden argue that the number of printed books is a complex measure of economic performance and societal capabilities and, in this sense, is a valuable guide to the study of long-term economic change [16]. The production of books is therefore linked to a number of variables used in new growth theory, such as human capital and knowledge production [1, 17, 18].

It remains to be seen, however, if the relationship between books and human capital accumulation actually holds over time. Rather, it is likely that, after an initial phase where the books play an important role in the accumulation of knowledge, education and other possible media of knowledge exchange are gaining in importance. Indeed, whereas after the Industrial Revolution endogenous growth may have come into existence which emphasized the accumulation of 'ideas' via education, in the early modern period little evidence of such endogenous relations can be found. Rather a hybrid form (depending on the level of development) of modern and Malthusian type growth exists. Indeed, Foldvari, van Leeuwen and van Zanden found for one of the most modern societies that there was no direct relation between human capital and per capita income and they conclude that "[w]ithout this final link, economic growth was finally dependent on exogenous factors affecting human capital accumulation" [19]. This contradicts Houston who argued that increased literacy enabled people

to read contracts and, in this way, fostered economic growth in per capita terms [20].

However, this does not mean that human capital is not accumulated via other channels than book production. Following Kremer [21] and Galor [22], we may argue that, consistent with historical evidence, increased population leads to an increase in the number of people that invest in education. Using this preposition, Galor and Weil [23] argue that increased population and/or a small increase in the level of education (due to the fact that schooled people have more surviving children) increase the amount of technical progress. Yet, for the early modern period this effect must have been small due to the insignificant relation between education and GDP per capita found by Foldvari, van Leeuwen and van Zanden [19]. Hence, it is more likely that the invention of the printing press led to the accumulation of knowledge in the form of books [12]. This enhanced the spread of knowledge and, hence, created faster technological progress than would have been possible without the invention of the printing press

Human capital thus apparently affects economic growth (either endogenously or exogenously). However, before the Industrial Revolution, it seems to have happened largely via book production (which accumulated existing knowledge), after the Industrial Revolution it was education that (directly or via other media) affected 'ideas' and per capita GDP. One needs to add one more element to this story though. In her seminal work on this topic, Eisenstein only looked at how the printing press changed the accumulation of knowledge. However, it also changes the rhetoric and thought: it promotes the sharing of similar frameworks for research and (academic) debate. This is related to, as pointed out by Heckel "shifts in consciousness (…) attributable in part to the growing interiorization of the printed text as a model for intellectual activity" [24]. And this implies that more people can start working on comparable problems sharing accumulated knowledge. However, this only works in relatively homogenous societies. For example, in Europe, which, notwithstanding all linguistic, ethnic and religious divides was relatively homogenous, a single research paradigm could emerge. However, this research paradigm could not be exported to, for example, Africa which had a completely different demand for technology, a lack of integration, and an overwhelmingly oral culture [25].

In this paper, we aim to look at the relationship between book production and the realization of 'ideas' (in this context proxied by patents), i.e. how the accumulation of knowledge via books may lead to increasing technological development and, ultimately, economic growth. We hypothesize that:

- Before the Industrial Revolution books had relatively insignificant direct role in productive knowledge. Also, other channels of productive knowledge transfer were more important than printed books, like verbal transfer and learning by doing,
- During Industrial Revolution, books may have some limited positive relationship with patents but traditional spread of knowledge still retains its importance. It is only during the second phase of the Industrial Revolution

that the existing knowledge needs to be accumulated and spread over the wider society. This is when education multiplies the efficiency of knowledge recording by books. We therefore expect that both books and education are positively related to patents,

- During the 20th century, especially in the developed world, alternative forms of knowledge recording and idea-related communications arise which reduce the importance of printed books (some of the knowledge is not even printed as it is not made available to the public, electronic documents, unpublished texts not included in the dataset, internet, emails) that most likely are the main sources of communication leading to patents). Education should, however, remain important as education makes the processing of knowledge possible,
- During the 20th century in the developing world, alternative forms of knowledge recording are much less important. In addition, we expect that there is little transfer across world regions concerning book production and ideas given the non-homogenous nature of knowledge (i.e. the African local knowledge is not equal to European local knowledge). Hence, it is difficult to import accumulated knowledge from other continents. As a consequence, we expect that countries which hitherto largely had an oral culture, like in Africa, still have higher gains from the accumulation knowledge via books than more advantaged countries.

In order to analyze these hypotheses, in the next section we will discuss the data. Section 3 analyzes the pre- and post 1900 periods respectively. Section 4 discusses the results and we end with a brief conclusion.

2. Data and model

In order to test above hypotheses, we require data on education, annual number of new book titles, number of patents, population and GDP per capita. For the twentieth century, these data have been derived from the UNESCO Statistical Yearbooks (1963-1999), UNESCO Statistical reports on book production in various countries (1935-1950), UNESCO international survey of book production (1951-1977). In total, we cover a set of 59 countries: Austria, Belgium, Bulgaria, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Hungary, Italy, Malta, Netherlands, Norway, Poland, Portugal, Romania, URSS/Russia, Spain, Sweden, Switzerland, United Kingdom, Estonia, Latvia, Lithuania, Yugoslavia/Serbia, Croatia, Slovenia, Macedonia, Algeria, Egypt, Tunisia, Morocco, Kenya, Nigeria, South Africa, Australia, New Zealand, Argentina, Brazil, Chile, Mexico, Canada, United States of America, China, India, Israel, Japan, Jordan, South Korea, Malaysia, Philippines, Thailand, Saudi Arabia, Turkey, United Arab Emirates and Indonesia. The countries were subdivided into regions using information from CEPII [T. Mayer and S. Zignago, CEPII Working Paper 2011-25, online at http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6#sthash.EmubuHid.dpuf]. GDP per capita and population were obtained from Maddison [26] and the levels of

average years of education were taken from Barro and Lee [R. Barro and J-W Lee, NBER Working Paper No. 15902, 2010], Foldvari, van Leeuwen and van Leeuwen-Li [27], and van Leeuwen, van Leeuwen-Li and Foldvari [P. Foldvari and B. van Leeuwen, Cliometrica, 2014, forthcoming]. Finally, patents were obtained from the World Development Indicators (WDI, World Bank, 2011).

Obviously, these data only go back to the 1930s at best. In order to explore the development of the relation between book titles and ideas over time, we added additional data for England going back to 1600. In this way, we obtained a running series between 1600 and 2008. The number of book titles per year data were obtained from Baten and van Zanden [14], added with new estimates of the number of book titles in the United Kingdom in the 19th and 20th century from Sandra DePleijt [CGEH working paper no.21, 2011]. Patents were used from the work of Diebolt and Pellier [C. Diebolt and K. Pellier, *La cliométrie du brevet, Rapport de recherche: Projet Exploratoire*, Premier Soutien (PEPS) du CNRS, janvier 2010], updated with data from the World Development Indicators. Average years of education were acquired from DePleijt [CGEH working paper no.21, 2011], Foldvari et al. [Cliometrica, 2014, forthcoming] and van Leeuwen et al [27]. GDP was achieved from Broadberry et al [28] and Maddison [26], the data on population were obtained from Wrigley and Schofield [29], Wrigley et al [30] and Maddison [26].

Using these data, we are able to test if and how book production affects 'ideas'. This is done by testing the hypotheses summarized in the previous section. In order to make them clearer, these hypotheses are graphically represented in Figure 1.

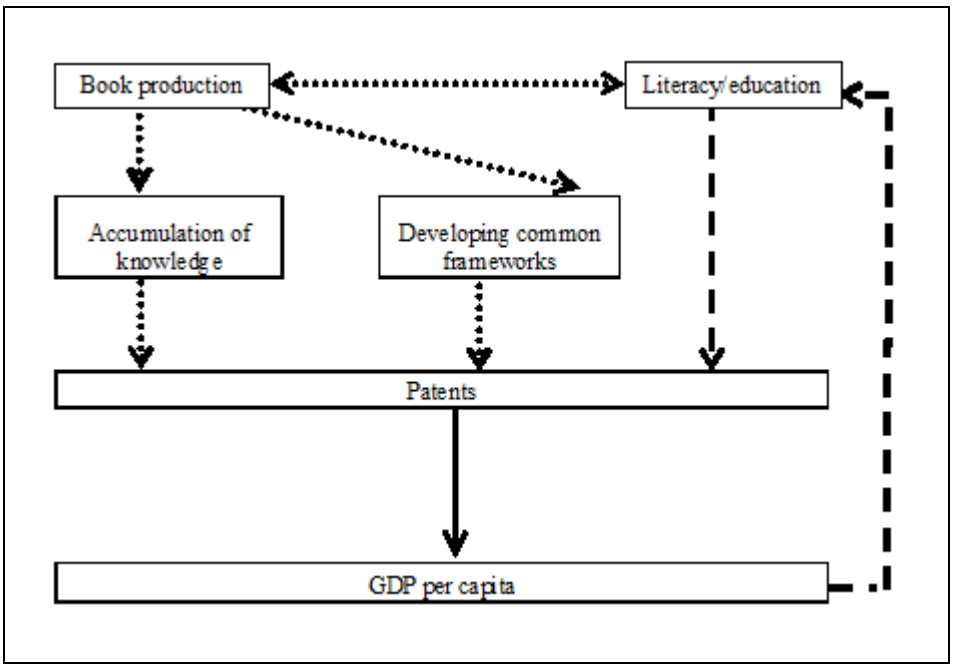

Figure 1. Effect of books on 'ideas'.

In all cases, one can see that patents affect GDP per capita. This is obvious, since increased technology leads to economic growth [1, 31, 32]. The other relations are less straightforward though. The dotted lines represent the relations as might exist before the period of modern (i.e. sustained) economic growth: education does not affect per capita income, and it is only via the number of books that, indirectly via the accumulation of knowledge and the development of a common research and thought framework, the number of patents is influenced. Yet, over time the effect of books receded since all existing knowledge was accumulated and new knowledge had to be generated. Also, technologies became increasingly complex. This led to a shift away from the role of books to the role of education (the dashed lines). Hence, education affected technology, and also technology the GDP per capita. Also, since more per capita GDP led to an increase in education, we arrived at the endogenous growth theories as proposed by Lucas [33] and Romer [1], which are important explanations of sustained per capita growth witnessed in the twentieth century.

3. An analysis of the relation between books and ideas

3.1. Books and development: a long-run view

England, being one of the first economic developers, provides a case in point when analyzing the relation between books and ideas overt time. In the Early Modern period, book production was already quite considerable in England, while patents only started to increase during the Industrial Revolution. Indeed, Figure 2 shows that the relative gap between patents and book titles clearly declined until the mid-19th century, after which they more or less grow together.

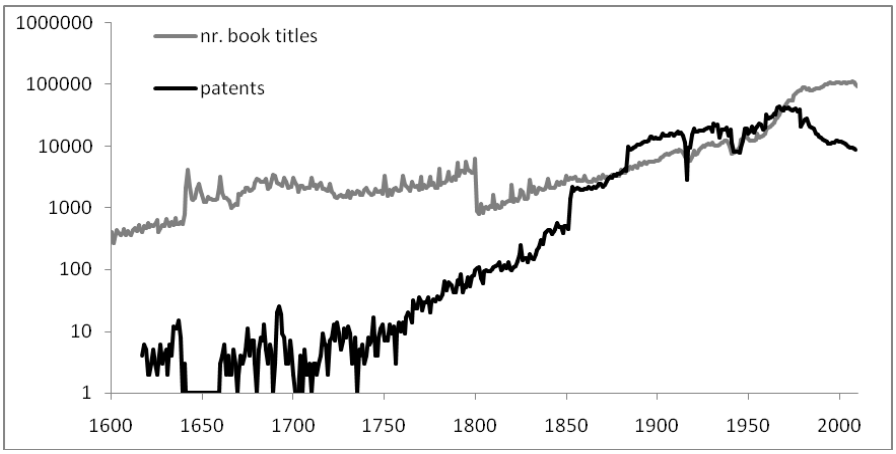

Figure 2. Number of book titles and patents in England, 1600-2010, source*:* number of book titles is obtained from Baten and van Zanden [14] and DePleijt [CGEH working paper no.21, 2011], while patents from Diebolt and Pellier [*La cliométrie du brevet, Rapport de recherche: Projet Exploratoire*].

This seems to indicate that patents did profit from books until at least the mid-19th century. The things changed though, during the second half of the twentieth century, when full literacy combined with other modes of communication drove patents and books apart again.

The way to test the relationships from Figure 1 is to run a regression between patents and number of book titles and average years of education. To this, we add GDP per capita to correct for the reverse effect of per capita income on patents. Hence, the equation becomes (1):

$$patents_t = \alpha_0 + \alpha_1 patents_{t-1} + \alpha_2 titles_t + \alpha_3 lnGDP/capita_t + \alpha_4 Education_t + u_t$$

Yet, as outlined in Figure 1, these relations may change over time. Hence, we start with running the Quandt-Andrews unknown breakpoint test [34, 35]. Using the first and the last 15% of observations, this is a test for whether a breakpoint exists.

Table 1. Quandt-Andrews unknown breakpoint test for patents in England, ca.1600-2008 (Note: probabilities calculated using Hansen's (1997) method).

	Year	1618-2008	1618-1978	1618-1940	1618-1907	1618-1850	1618-1789
Maximum LR F-statistic	1979	16.619 .(0.000)					
	1941		14.579 .(0.000)				
	1908			45.761 .(0.000)			
	1852				4.036 .(0.024)		
	1790					17.466 .(0.000)	
	1762						8.110 .(0.000)
Exp LR F-statistic		2.762 .(0.000)	2.761 .(0.000)	17.925 .(0.000)	0.792 .(0.258)	7.169 .(0.000)	2.144 0.001
Ave LR F-statistic		1.541 .(0.084)	2.143 .(0.012)	5.427 .(0.000)	1.512 .(0.114)	10.464 .(0.000)	3.125 0.001
No. of breaks compared		352	288	258	203	164	121

The results for patents per capita, i.e. the dependent variable, are reported in Table 1. Basically, we tested from big to small, i.e. the whole period and then reducing the sample size to test for alternative breakpoints. In this way, we identified six breakpoints: 1979, 1941, 1908, 1852, 1790, and 1762.

In the next step, we ran regression 1 for each sub-period (see Table 2). The results are quite interesting: up to the Industrial Revolution, neither education nor books affected the number of patents. Only after 1760 we find that books become significant. This finding is not very surprising. After all, the invention of printing meant an increasingly rapid circulation of ideas via the

printed book. This fact increased the possibilities to spread around religious and political information but, at the same time, there was the risk of books being spread around with, according to the political elite, undesirable content. Therefore, a system of official licensing for books, pamphlets and other materials was created. Formal copyright law, however, started in the 18th century and was largely applicable to printed books. This was formalized in the Copyright Act of 1709 which gave the exclusive right of printing books to the authors and not to printers as had been customary before. Indeed, book production can in many ways be compared with patent law, "If a literary composition was essentially a collection of ideas, why should copyrights be treated differently from patents? The basis of patent law had long since been established by the Jacobean Statute of Monopolies, which strictly limited patent grants, providing a fourteen-year-term for new inventions and a twenty one-year term for patents already in existence. Indeed, the fourteen- and twenty one-year terms established by the Statute of Anne were evidently modelled on those provided for patents." [36]

Table 2. Effect of books on patents in England, 1618-2008.

Dependent variables: Patents per capita						
	1618-1760	1760-1850	1851-1907	1908-1940	1941-1978	1979-2008
C	0.000 .(-0.854)	0.000 .(-4.513)	0.000 .(0.747)	0.006 .(3.594)	0.000 .(-0.092)	0.007 .(2.491)
Patents per capita (t-1)	0.585 .(6.901)	0.495 .(5.387)	0.860 .(14.529)	-0.008 .(-0.082)	0.460 .(3.967)	0.297 .(1.431)
Books per capita	-0.0004 .(-0.828)	0.003 .(2.364)	0.128 .(0.611)	1.300 .(2.653)	-0.184 .(-2.013)	-0.136 .(-1.223)
lnGDP per capita	0.000 .(0.797)	0.000 .(4.336)	0.000 .(-0.830)	-0.001 .(-3.564)	0.000 .(-0.709)	-0.001 .(-2.393)
AvYears	0.0000 .(0.459)	0.0000 .(0.848)	0.0000 .(1.710)	0.0001 .(3.356)	0.0003 .(4.992)	0.0001 .(1.917)
R^2	0.410	0.929	0.987	0.685	0.917	0.852
N	143	91	57	33	38	30

This changed around the 1760s as obviously, this situation was unsatisfactory to printers and book sellers. The controversy that thus arose was not solved until the cases of Hinton v Donaldson in Scotland (1773) and Donaldson v Beckett in England (1774), in which the duration of the copyright law was limited [37]. This massively increased the amount of printed books and, hence, the circulation of knowledge. Yet, since education remains insignificant, a common phenomenon during the first phase of the Industrial Revolution [38, 39], this suggests that books work via a common framework or accumulation of knowledge rather than via education. However, where, from the second phase of the Industrial Revolution onwards education increases in importance, the same relationship is not true for books. After 1941, we can see that the coefficient of per capita book titles published become insignificant.

In sum, only after an initial phase of economic development where the accumulation of knowledge is important, books are important for the spread of ideas. When technology becomes increasingly complicated, education increases in importance and starts to have direct effects on patents and, ultimately, on per capita income. But does this imply that for developing economies, where technology and education are less developed, the accumulation of knowledge via books still remains an important way to develop 'ideas'? Or, can they import 'knowledge' from Western countries and, as such, do not require an increase in the number of books as important means to accumulate knowledge? This will be tested in Section 3.2.

3.2. The 20th century - world overview

As our previous example of England shows, the situation in the twentieth century changed considerably. First, at least for the developed countries, an endogenous relationship between education and GDP per capita came into existence [1, 31, 33].

However, this does not necessarily apply for the developing economies. First, it remains to be seen if they experience endogenous growth. Many countries, also fast growing Asian Tigers, experienced perspiration factors (i.e. accumulation of physical capital) rather than inspiration factors (i.e. knowledge), implying a lack of endogenous growth [40]. Second, knowledge used in developing countries is most likely different from those in developed economies. Hence, books produced in Europe are often of little use in for example Africa. Therefore, the accumulation of knowledge in these largely oral societies still continues, which it makes possible that there still is a link between patents and book production.

Table 3. Granger causality test panel ca. 1950-2000 (Note: lag length determined with Akaike information criterion. We used a fixed effect within regression).

	p-value	**Verdict**
Patents cause books	0.602	No
Books cause patents	0.180	No
Patents cause books (including GDP per capita as independent variable)	0.365	No
Books cause patents (including GDP per capita as independent variable)	0.075	Yes
Patents cause GDP per capita	0.116	No
GDP per capita causes patents	0.012	Yes

In order to test this, we must prove that there is a reverse causation between patents and GDP per capita, which suggests an endogenous system of growth. Also, there should be no relation between book production and GDP per capita. To test this, we use the data on patents, books, and GDP per capita as discussed in section 2. These data contain 59 countries with more than 2,000 observations of the number of book titles.

To test causality, we apply a Granger causality test. Basically, this test consists of regressing a variable on its own lags and the lags of a variable that is supposedly having a causal relationship.

Since the future cannot determine the past, a significant relationship is indicative of causality. The results of the Granger causality test panel are reported in Table 3, where we used the first difference of the variables to correct for non-stationary process. We find that there is indeed a reverse causation between patents and GDP per capita, confirming the existence of some sort of endogenous system (possibly, via education).

Table 4. Panel regression between patents and number of book titles.

Dependent variable: Patents per capita						
	Panel coefficient	t-value	Panel IV coefficient	z-value	Panel IV Coefficient	z-value
Constant	-0.143	-0.31				
Nr titles per capita	-0.152	-1.54	-0.166	-4.85	-0.177	-4.90
Titles per capita* Africa					1.197	3.07
Titles per capita* America					0.038	1.15
Titles per capita* Pacific					0.246	3.67
Titles per capita*Asia					0.303	2.21
ln GDP per capita	0.240	1.72	0.227	4.31	0.214	4.27
lnPop	-0.172	-1.6	-0.187	-4.14	-0.195	-4.34
Effects	Fixed effects		Fixed effects		Fixed effects	
Hansen J-statistic (p-value)	NA		0.215		0.508	
Instrumented			Nr titles per capita		Nr titles per capita, titles per capita*Africa, titles per capita* America, titles per capita* Pacific, titles per capita*Asia	
Included instruments			ln GDP/cap, lnPop		ln GDP per capita, lnPop	
Obs.	1,125		948		948	
R^2	0.060		0.101		0.103	

On first sight, books do not seem to affect GDP per capita. After including GDP per capita (since it is possible that both patents per capita and book titles per capita are affected by economic development), we find that books do affect per capita patents, even though it is only just significant. Likewise, we find that GDP per capita causes patents, while the reverse relationship is just rejected at

10%. This seems to suggest that in poorer countries (with a lesser economic development), the relationship between per capita books and patents might be higher, while their technology is still largely exogenous.

However, in order to test that, we need to disentangle the effects of book production on patents using a panel regression.

Since the system may be, at least partially, endogenous we have to use lags of the independent variables as instruments. The results are reported in Table 4. In both a panel and an instrumental variable panel regression, we find that the effect of population and GDP per capita is remarkably identical. More interesting is the coefficient of the number of book titles per capita. We find, when splitting up by continent, that the coefficient of Europe is negative while that of most developing regions is positive. Indeed, in our long-run analysis for England in the previous section, we already concluded that the effect of books may turn insignificant, or even negative, in the latter part of the twentieth century. This confirms our previous statement that book production loses ground when education and endogenous growth become increasingly important.

Theoretically, this knowledge may spill-over to developing economies as well, also reducing their coefficients of book titles to zero. However, apparently this is not the case since we find the effect of books on growth to remain large with a coefficient for Africa of no less than 1.2. One possible reason why such flows of knowledge do not seem to have any effect might be that the character of useful knowledge in Africa is different. This will be discussed in the next section.

4. Knowledge accumulation in developing economies

The question why the relation between books and patents breaks down, at least in the developed world, has been implicitly discussed by Eisenstein [12], as well as by other studies that argue that new information technology and the increasingly knowledge - and education - intensive character of the technological development requires an increasing amount of education [41-43]. Nevertheless, we might shed some more light on the question as to why this relationship apparently did not break down in the developing countries, more specifically in some countries in Africa.

Eisenstein [12] argued that in the first years of the rise of book production, knowledge started to accumulate. In order for a similar argument to be applicable for the 20th century Africa, we need three ingredients:

- Education is exogenous in economic development and uncorrelated with book production. This must be the case, or otherwise, an endogenous system driven by education comes into existence like in most of the developed world. However, this can only happen if there is a real market for scientific knowledge.
- The development of book production in Africa is relatively small and recent. If this were not true, knowledge would already have been accumulated before.

- There is little transfer of knowledge via books from the Western world to Africa. In other words, Western knowledge cannot/is not applied in Africa). If this were not the case, knowledge could easily have been imported.

One way of addressing these issues is to look at causality again. Table 5 reports that there are indeed no causal relations between number of book titles and education. Interestingly, education also does not cause GDP per capita. Even though this may be surprising from a human capital point of view, it has to be kept in mind that only useful knowledge actually affects growth and we have to consider that years of education is not human capital *per se*. This can be easily seen from multiple papers from Heyneman who gives multiple examples of failed UNESCO schooling projects in Africa [44, 45]. A similar argument has been brought forward by Pritchett, who argued that schooling was highly inefficient in many developing economies [46].

Table 5. Granger causality test for Africa, ca. 1950-1990.

	p-value	**Verdict**
Books cause education	0.844	No
Education causes books	0.487	No
Books cause patents	0.929	No
Patents cause books	0.094	Yes
GDP per capita cause education	0.001	Yes
Education causes GDP per capita	0.202	No

Table 6. Test for number of book titles per capita in Europe and Africa, ca. 1940-2000.

Book titles per million inhabitants		
	Africa	Europe
1940s		321.9
1950s	27.8	343.2
1960s	38.0	430.4
1970s	28.2	570.6
1980s	39.8	702.9
1990s	39.0	751.7

A second precondition for the continued importance of books in a developing region like Africa is that knowledge accumulation is not yet complete (in the form of books). This means that teaching process as such is impaired, if there is not enough local accumulated knowledge or misuse of it. This can also be seen if we look at the absolute number of books titles as reported in Table 6. This table is calculated using a dummy variable regression

to interpolate missing observations. It is clear though that in per capita terms the total number of titles published in Africa is much lower. Add to this that the total population in Europe is, on average, about three times as large as in Africa; it means the gap in total number of titles published is even larger.

Of course, this lack of production of books may be remedied by importing them from other regions, either within or outside Africa. However, within Africa a low volume of knowledge is disseminated since, if any knowledge was accumulated at all, it was local and did not spread to other parts of the African continent due to its large ethnolinguistic fractionalization. A counter argument might be that the same lack of spread of books and knowledge occurred in Europe since not all books here are read by all Europeans given the strong language barriers between them. Still, the literature so far seems to indicate that this barrier is less significant in Europe than it is in Africa. Indeed, looking at coefficients of linguistic fractionalization [47], we find that Africa has a Gini of 0.61 versus only 0.24 for Europe.

Table 7. Number of titles translated from a European language into a local language by continent per million inhabitants (source: UNESCO Index Translationum).

	Pacific	**Africa**	**America**	**Asia**	**Europe**
1980	3.49	0.30	2.12	1.06	22.10
1985	1.31	0.20	3.97	1.23	26.37
1990	3.24	0.11	3.34	0.97	27.38
1995	1.11	0.03	2.65	1.71	45.20
2000	1.66	0.47	3.68	1.59	45.24
2005	2.10	0.43	1.86	4.51	53.92

A similar argument on the spread of knowledge may also be made about the imports of books from other continents, i.e. the lack of accumulation in Africa might overcome by imports of knowledge (i.e. books) from other (more developed) regions. Yet, the lack of economic development, the small role of education, and the fact that any useful knowledge is written in a language that is often known to a small share of its population, it makes difficult for Africa to straightforward import this kind of knowledge. Rather, we may argue, following Ouane and Glanz, that the transfer of knowledge is not just a simple top-down process from centre to periphery; instead, it is a complex network of multi-facets flows of information [48]. Indeed, the few studies that look in the spread of knowledge across regions suggest that in Europe mobility was relatively high [49], while in Africa the introduction of European books titles was extremely low, with only 0.3 book titles per million inhabitants (see Table 7). In comparison, the lowest other continent is Asia, with about 1 translated book per million inhabitants. Obviously, this has something to do with language: Spanish and Portuguese in South America, English in the United States and Canada, but also French and English are used in parts of Africa. In any case, Table 7 suggests a limited flow of books from the Western world to Africa.

It is also interesting to see that there is a strong flow within Europe, which is not completely caused by linguistic homogeneity. After all, many different languages are spoken throughout Europe as well. Instead cultural and/or knowledge homogeneity may be part of the reason for these flows of books. By times, large parts of the European continent were under influence of similar religions or were part of the same empire. Likewise, we can see that the fall of socialism around 1990 caused a large increase in book translations within Europe. This is largely caused by increased translations of Western books in Eastern Europe, which increased with a factor of five. However, most translated titles were in more subjective titles as religion and philosophy [49].

It is thus clear that in Eastern Europe largely books from Humanities, such as religion and Philosophy, were translated. If this is the same for Africa, this brings us to a final reason of the low mobility of books from Europe to Africa, in the form of translations or otherwise, i.e. that in Africa another kind of knowledge was demanded. One obvious way of acknowledging that is that Western books about religion often discuss Christianity, which is probably not in high demand in Muslim Northern Africa. However, besides such factors, knowledge in Africa is generally rather local. Lack of written culture, local disease environment, etc. makes even the spread of books within Africa limited. This can be assessed by looking at the subjects that were printed. For Europe, we see a strong tendency towards social sciences and geography, whereas applied sciences used to be more popular in the 1940s. This is a bit the same for Africa today, whereas still some focus is on religion and Philology, two topics that are of quite some use even in modern day Africa (Table 8). Yet, the lack of applied sciences is hampering modern day industry.

Table 8. Division of book titles by UDC classes.

	Europe		**Africa**
	1950	1995	1995
Generalities	3.2%	4.2%	2.9%
Philosophy/Psychology	2.4%	3.9%	1.6%
Religion	4.9%	4.4%	9.6%
Social sciences	16.8%	21.2%	22.3%
Philology	2.4%	2.5%	8.7%
Pure sciences	6.3%	6.5%	6.4%
Applied sciences	26.7%	15.5%	16.0%
Arts and recreation	5.9%	7.7%	4.8%
Literature	24.4%	23.7%	21.5%
Geography and history	7.1%	10.3%	6.2%

In sum, the main reason why the effect of books on 'ideas' remained strong throughout the twentieth century in many developing regions was that they did not manage to modernize its economy and generate endogenous growth based on education and applied technologies. Likewise, imports of knowledge from other regions or continents turned out impossible as well due to the different kinds of knowledge demanded as well as the large ethnolinguistic fractionalization that burdened especially the African continent.

5. Conclusions

Recently, book production has been assigned an indicator of human capital even though most studies see it as an indicator of literacy only.

In this paper we asses this relationship over time and across regions. We find that books started to affect the accumulation of 'ideas', proxied by patents, in the first phase of the Industrial Revolution. Partly, however, for the later period this relation is shattered when new information technologies appear and new inventions became increasingly education-intensive. In the late 20th century, the role of education became endogenised via familiar channels of (new) growth theory. For developing economies, especially Africa, this is not the case and books continue to affect 'ideas'.

The reason for this continued relation between books and patents in Africa is that education is not yet endogenised, meaning that education and alternative information technologies did not take over the role of books. Likewise, due to linguistic fragmentation, an overwhelmingly oral culture, and a structural different kind of knowledge, book production stagnated, and no knowledge could be imported (for example via translated books). This means that there still is a relation between books and 'ideas' in many developing regions.

Acknowledgement

This paper was supported by the Fundamental Research Fund for the Central Universities in China (Jinan University).

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