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University-industry linkages' literature on Sub-Saharan Africa: systematic literature review and bibliometric account

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Abstract As a result of the growing interest on University-Industry Linkages (UIL)' research, systematic literature reviews and bibliometric studies have been undertaken to describe the state-of-the-art and provide a quantitative overview of the literature on UILs. However, these reviews have mainly enhanced the visibility of UILs' literature targeting developed countries. UILs' literature focusing on developing countries, particularly on Sub-Saharan Africa (SSA), is generally less visible. This paper seeks to fill this gap and to enhance the visibility of UILs' focusing on SSA, by undertaking a systematic literature review and displaying its bibliometric portrait. More specifically, the paper addresses the evolution, sources, main research questions, units of analysis, methods, countries researched, the influence of this literature, as well as its main findings. Based on Web of Science, Scopus and Google Scholar, 230 relevant articles have been identified and analysed. The paper's findings demonstrate that, while SSA continues to be an under-research terrain, the quantity of literature targeting this continent seems to be substantial and higher than it is often portrayed. The findings also demonstrate the dominance of South Africa, Nigeria and developed countries, both as knowledge producers and consumers of literature focusing on SSA. African poor countries seem to suffer from a double neglect: they are under-researched, but also ignored when research on them is produced. The paper argues, therefore, for the need to reconsider the place of African low-income countries in UILs' research, both as empirical fields and as incipient knowledge producers.

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Introduction

From 1980s onwards, innovation studies have emerged as a new field that explores innovation systems and their impact on socio-economic transformation (Nelson 1993; Freeman 1995; Fagerberg and Verspagen 2009; Lundvall et al. 2009). Underlying the emergence of this field was the rise of the knowledge economy (Nelson and Winter 1982). The reliance of this economic paradigm on generation, transfer and use of knowledge and technology has driven some innovation scholars to examine university-industry linkages (UILs) (Cohen et al. 2002).

For over two decades, UILs' literature in the field has increased remarkably and unveiled the different mechanisms through which universities and industry collaborate in several countries with different stages of development and maturation of national innovation systems (NIS). As a result of the growing interest on UILs, systematic literature reviews and bibliometric studies have been undertaken. These studies describe the state-of-the-art and provide a quantitative overview of the literature on UILs (Teixeira and Mota 2012; Perkman et al. 2013). By and large, the literature shows that empirical research on innovation studies tends to focus mainly on developed countries (Teixeira 2013).

In general, there is dearth of innovation studies in developing countries, since they have also been neglected as empirical sites of research. The rationale underpinning this neglect is at least twofold: on one hand, the claim that developing countries, particularly the low-income, had no innovation, but fledgling technology systems (Lall and Pietrobelli 2002). On the other, the monolithic view of innovation as consisting of new-to-the-world science and technology, produced through Research and Development (R&D) or what has been christened as Science and Technology mode of Innovation (STI) (Jensen et al. 2007; Lundvall et al. 2009).

Further research has shown that developing countries, including the low-income, do have innovation, albeit of a distinct nature (Lorentzen and Mohamed 2009; Williams and Woodson 2012; De Beer et al. 2014). In developing countries, innovation may consist of building personal and organisational competences to adopt, adjust or imitate science and technology produced elsewhere,—the often referred to as Doing, Using and Interacting (DUI) mode of innovation (Lundvall et al. 2009), rather than of producing new-to-the-world knowledge.

The recognition that developing countries do have innovation, despite perhaps being of a distinct character, has triggered empirical research on innovation and UILs in countries beyond the frontier. While systematic literature reviews on innovation studies focusing on developing countries have been undertaken (Lorentzen and Mohamed 2009; Zanello et al. 2015), no such reviews examined the UILs literature in particular. The need to fill this knowledge gap is even essential as far as Sub-Saharan Africa (SSA) is concerned. Available systematic literature reviews substantially traced UILs' studies targeting Latin America and Asia, but studies on UILs in SSA remain scarce (Teixeira and Mota 2012). Leading academic journals in the field (e.g. *Research Policy, Technovation, Science and Public Policy*) tend to publish research from developing countries and emerging economies, e.g. Chin, Brazil, South Korea; Lee and Lim 2001; Albuquerque et al. 2015).

There is an emerging interest and research on UILs in SSA. However, no systematic literature review has been undertaken. Furthermore, in the global systematic literature

reviews on UILs, SSA is almost absent (see Teixeira and Mota 2012; Perkman et al. 2013). SSA's underrepresentation can be explained partially through Nwagwu's (2010) notion of 'social cybernetics' which accounts for the bias of scientific data and rankings that mostly give advantage to developed countries.

The main objective of the article is to undertake a systematic review of UIL's literature focusing on SSA. In addition, the paper portrays a bibliometric portrait of the networks of collaboration amongst authors writing on UILs in SSA. The paper draws from previous systematic reviews on innovation studies and UILs (Lorentzen and Mohamed 2009; Teixeira and Mota 2012; Teixeira 2013; Zanello et al. 2015), to describe the evolution, bibliographical sources and influence of UILs' literature targeting SSA. The paper also reviews the state of the theory and main findings of UILs' literature focusing on SSA, regarding three patterns of UILs (Cohen et al. 2002; O'Brien and Bortagaray 2015): (1) the determinants of UILs, (2) the modes or channels of interactions and (3) the outcomes of UILs. The paper is organised in four sections. The Sect. 2 describes the methodology used for the study, Sect. 3 presents and discusses the findings and Sect. 4 presents the conclusions.

Methodology

For this study, we have undertaken a systematic literature review focusing on UILs in SSA. The review was based on similar methodologies used in studies by Teixeira and Mota (2012), Perkman et al. (2013), Teixeira (2013), Zanello et al. (2015).

The literature review was done in five phases. The first phase consisted of searching extensively all relevant peer-reviewed articles, published by January 16th 2017, in the main scientific databases, namely Web of Science, Scopus and Google Scholar. The search for titles and abstracts was made by combining the following keywords: (a) university-industry linkages; (b) university-industry collaboration, (c) university-industry partnerships; (d) academic and firms/companies collaboration; (e) university knowledge and technology transfer; (f) firms' innovation and universities; (g) commercialisation of university knowledge; (h) university spin-offs; university-industry relations/relationships; (i) university-industry and academic consulting; (j) university-industry and academic engagement; (k) university-industry and academic entrepreneurship; (l) university-industry and contract research.

Since the focus of the study is limited to SSA, the words Sub-Saharan Africa and the individual names of all 49 SSA countries (e.g. South Africa; Cape Verde) were used in combination with the above-mentioned words as searching keywords. Given the linguistic diversity of SSA, the equivalent searching keywords were translated into French and Portuguese and used to search relevant publications.

A search of the issues published in the main academic journals in the field, such as *Research Policy, Scientometrics, Science and Public Policy, Industry and Higher Education*, was done. The search also included journals with a focus on SSA such as *The African Journal of Science; Technology, Innovation and Development* and *South African Journal of Science*. A backward and forward search was undertaken in the Web of Science, Scopus and Google Scholar to trace all relevant cited references and citations made to the articles found.

The second phase consisted of reading the titles and abstracts, including skimming the full texts whenever necessary, to filter the relevant articles that meet the objective and

criteria of the study. In order to be considered, an article had to meet the following criteria: (1) having been published by peer-reviewed journals, including journals that are not indexed by Web of Science and Scopus;[1] relevant books and book-chapters were also considered, provided that they had not been published under the form of research articles; (2) focusing on a research question on UILs, for instance, determinants, channels, benefits and outcomes of UILs; (3) having been conducted through an empirical research in one or several SSA countries; comparative studies between SSA and non-African countries were also considered; (4) scientometric studies focusing on national, regional or continental systems of science, technology and innovation. A total of 230 articles were found to fit the study criteria.

The third phase consisted of reading carefully the full texts of the 230 articles and classifying them according to the kind of research questions addressed, the unit of analysis observed, methodology used and country (ies) researched. According to O'Brien and Bortagaray (2015), the main research questions addressed by the UILs' literature targeting developing countries may be grouped into three categories: (1) *determinants of UILs*: motivations and incentives driving firms, universities and researchers to collaborate; structural characteristics and conditions of firms and universities influencing when, where and who participate in interactions; influence of meso and macro-institutional contexts; (2) *modes of interaction*: channels used, their extent and variation across location, firms/universities' characteristics and academic disciplines; (3) *outcomes*: benefits, obstacles, including different perspectives of benefits. O'Brien and Bortagaray's (2015) approach was used to classify the research questions addressed by the 230 articles.

Teixeira and Mota's (2012) classification was adopted and adjusted for the analysis. According to these authors, UILs' literature can address the following topics: (1) characteristics of researchers; (2) characteristics of firms; (3) characteristics of universities; (4) knowledge transfer channels, (5) intermediaries (6) location and regional spillovers and (7) scientific and technological policies. These topics suggest that UILs' literature can address five main units of analysis: researchers, universities, firms (or both), intermediaries, and scientific and technological policies and indicators; a sixth unit of analysis was also considered, namely informal actors, to incorporate the emergence of literature addressing inclusive innovation and processes of knowledge transfer between African universities and informal sector (Kruss and Gastrow 2016; Kawooya 2014).

Teixeira and Mota (2012) and O'Brien and Bortagaray (2015)'s insights were combined to draw five classifications of methodologies: firstly, studies based on official statistics and documents, particularly addressing national or cross-national scientific and technological policies and indicators; secondly, studies based on formal methodologies, i.e. on mathematical logic and modelling; thirdly, studies based on surveys to researchers, universities, firms, and government officials; fourthly, articles based on single or multiple case studies; fifthly, articles based on mixed methods (e.g. mixing surveys with cases studies, mixing formal modelling with cases studies and surveys). Concerning the researched country (ies), studies can target single or several countries, regional blocks, the whole continent or African countries as compared with non-African countries.

In the fourth phase, we examined the nature of journals in which articles were published. We disclosed the bibliographical sources and influence of the UILs' literature

[1] Google Scholar was used to trace African and non-African journals normally not indexed by Web of Science and Scopus, the two most reliable scientific databases. However, non-scientific reliable materials indexed by Google Scholars were not considered (e.g. predatory journals, teaching materials, unpublished technical reports, etc.).

focusing on SSA. We identified the most prolific authors by counting the number of citations made to the relevant literature. We also examined the most cited articles and journals, and identified the institutional affiliations of most cited authors. Google Scholar's citations were used to obtain the total number of citations of the 230 publications (for rationale and caution observed in using Google Scholar, see footnote 1 above). Scopus was used to count citations of the most influential works, i.e. works with 5 or more citations. 69 most cited works were found.

In the fifth phase and last, a social network analysis (SNA) was conducted. SNA was undertaken to examine the social structure of the scientific community producing the most influential research. SNA is based on the idea that scientific collaboration, through the form of co-authorship, is one of the hallmarks of modern science. SNA usually uses co-authorships to measure scientific communities as social networks and to reveal patterns of scientific collaboration and social ties between members of these communities (Martin 1997). While citations illustrate the influence, magnitude and unintentional connections between members of a specific scientific community, they do not enable to measure and visualize the social structure of scientific groups, their intentionality to collaborate and their social ties. SNA allows identifying the structure of the network, by investigating the intentional relationship between two or more authors and by reliably measuring practices of knowledge sharing and co-production between co-authors (Hanneman and Riddle 2005). SNA was therefore undertaken to complement the analysis of citations.

SNA technique was used to examine relationship pattern among the authors and institutional affiliations. SNA consists of measuring and visualizing social network composed of nodes (authors or institutions) and edges (relationship between authors or institutions). SNA involves collecting, extracting, normalizing and examining data (Bordin et al. 2014). The 69 most cited UILs' publications focusing on SSA (see Table 3) produced from 1996 to 2016 were selected and examined, based on the following variables: authors' name, co-authors, type of publication (e.g. article, books or book-chapters) and institutional affiliations. Scopus database was used to retrieve information of these variables. We identified 94 authors and co-authors who published the 69 articles. Data was stored in Excel CSV format and in *Paj.extension* to allow importing and reading through the *SocNetV 2.3*.[2] Data was processed through *SocNetV 2.3* data analysis software. Two databases were generated. The first consisted of a list of nodes (vertices), standing for authors or institutions, with an identifier (Id) and a label. The second consisted of a list of all the edges of the network, i.e., the relationship of co-authorship and relationship of institutional affiliations. Finally, a co-authorship network and an institutional network were generated.

Centrality measures were used to identify the most prominent actors (authors and institutions) in the network. Centrality shows how important an actor or group of actors is in a given network (Borgatti and Everett 2006). Two of the most important measures of centrality were used. The first, *degree of centrality,* shows an actor's position, influence and power in the network. More powerful actors have higher degree of centrality. The second measure, *between-ness*, shows the degree to which an actor works as an intermediary among different actors in the network. If an actor has a higher score of *between-ness*, s/he is in a position of controlling the flow of resources, assets and information in the network (Erfanmanesh et al. 2012).

Apart from the above-mentioned measures, the *degree of density* was used to measure the strength or weakness of connectivity among actors of the network. The value of density varies from 1 to 0. The density score of 1 means that all potential connections in a network

[2] http://socnetv.org/.

are actual connections; 0 is when there is no single tie in the network (Hanneman and Riddle 2005).

Findings and discussion

Sub-Saharan Africa's economic, scientific and technological background

To contextualize the features of UILs' literature in SSA, the paper begins by making a brief account of SSA's economic, scientific and technological background. SSA refers to a group of 49 countries located in south of the Sahara Desert. By mid-twentieth century, these countries were British, French and Portuguese colonies, hence the usual division into Anglophone, Francophone and Lusophone Africa. Most SSA economies still rely on subsistence agriculture and unprocessed natural resources; industry accounts for less than 10% in SSA's GDP (Filmer and Fox 2014). The structure of employment is dominated by informal sector: in 2010, about 80% of the labour force was engaged in informal sector and only 16% had "wage jobs", 3% of which belonged to industrial sector (Filmer and Fox 2014).

The SSA's innovation environment is critical. The specific indexes of technological capabilities (e.g. World Bank's Knowledge Economy Index, Global Competitiveness Index) place SSA at the bottom (World Bank 2012; Schwab 2014). Literature identifies three phases in growth of innovation systems and SSA's characteristics fit into the initial phase—named *low-level equilibrium trap*—, during which threshold conditions for innovation system have to be established (UNIDO 2005; Sercovich and Teubal 2008). UNIDO (2016, 2005) demonstrates empirically that knowledge-driven catch-up has been decisive in different countries over the human history, but this was not the case in SSA, despite potential.

SSA's performance in higher education, global science and technology is also challenging. Despite ongoing revitalizing trends, SSA is the only region where higher education has expanded without massification and where most countries continue to have "elite" higher education systems, with less than 15 percent of gross enrolment (Mohamedbhai 2014). Enrolments tripled or quadrupled in some countries, but funding remained significantly the same, i.e., less than 1% of GDP. According to UNESCO (2015), from 2007 to 2013, SSA's share in world's gross expenditure on R&D was between 1.1 and 1.3% (South Africa represented 0, 4%), compared to, for example, 3.1—3.4% in South Asia and Latin America.

Inadequate funding has undermined SSA's scientific outlook. According to UNESCO (2015), from 2007 to 2013, SSA's average share in global researchers was 1% (South Africa accounted for 1/3 of this share), compared to 3.6% for Latin America and 3.2% for South Asia. During 2008–2014 period, SSA's accounted for 1.2–1.4% in world's scientific publications (South Africa accounted for 50–70% of this share), while Latin America contributed with 4.9–5.1%, South Asia with 4–4.9%. During the same period, SSA's share in world's patent submission was 0.1%, compared to 0.3 in Latin America, 0.5–1.2% in South Asia, 52% in North America, 28% in Southeast. In the main universities' ranking league tables, SSA is placed at the bottom: only about 4–5 South African universities (e.g. University of Cape Town, Stellenbosch University, Witwatersrand University) tend to be

ranked in the top-500 in, e.g., *Times Higher Education* and *Shanghai Jiao Tong Ranking* (Cloete et al. 2015).

These SSA's weaknesses are critical to fostering UILs. As recent reports by the Association of African Universities show (Ssebuwufu et al. 2012; Sá 2015), while governments recognize the role of UILs in fostering national development, most SSA countries lack specific UILs' policies. This background contributes to SSA's underrepresentation in UILs' global literature (Teixeira and Mota 2012). However, as our findings show, while SSA conditions are unfavourable to fostering UILs, there is nevertheless non-negligible research targeting this region.

Evolution and sources

Evolution of publications

Figure 1 shows that a total of 230 articles were published during 1996–2017. From this total, 221 were published during 2005–2017. By 2004, only nine relevant articles had been published (Oyelaran-Oyeyinka et al. 1996; Oyebisi et al. 1996; Pouris and Richter 2000; Ojewale et al. 2001; Sanni et al. 2001; Adeoti 2002; Ilori et al. 2002; Pouris 2003; Konde 2004). From 2005 onwards, the number of publications has consistently increased. As Kruss et al. (2015a, p. 1) refer, before 2005, UILs' literature has mainly targeted developed countries. The year of 2005 coincides with the launching of the first cross-continental and comprehensive research project intended to systematically examine the patterns and particularities of UILs in developing countries from Latin America, SSA and Asia, sponsored by the International Development Research Centre (IDRC) (Albuquerque et al. 2015). The project produced relevant findings, compiled in 15 research reports, 40 conferences articles, 28 articles in peer-reviewed journals, 2 special issues in specialized journals and three books (Kruss et al. 2015a). This project was an influential academic embryo, as it triggered researchers directly involved to produce further research and influenced other researchers working on UILs in developing countries, including SSA.

The figure shows consistency regarding the trends of global literature on UILs. According to Teixeira and Mota (2012), the global literature on UILs is recent and has mainly been published from 2000s onwards. However, in contrast to Teixeira and Mota (2012), Fig. 1 reveals that the quantity of literature targeting SSA is higher that it is portrayed. While endorsing Teixeira and Mota (2012)'s claims that developed countries dominate the field, SSA does not seem to be so unexplored. During 1986–2011, Teixeira and Mota (2012) identified 10 publications on UILs in SSA. These articles include countries such as Zambia, Nigeria and South Africa. The number of 10 is by far lower than 83 articles published by 2011, displayed in Fig. 1 below. This discrepancy is partly related to the fact that Teixeira and Mota (2012) only limited their search on Web of Science and Scopus databases, whereas we also considered non-indexed journals. However, Teixeira and Mota's search may also have been biased, since we identified more than 10 articles published by 2011 in WoS and Scopus-indexed journals (e.g. Oyelaran-Oyeyinka et al. 1996; Oyebisi et al. 1996; Ojewale et al. 2001; Adeoti 2002; Adeoti and Adeoti 2005; Konde 2004; Kahn and Blankley 2005; Cooper 2005; Kahn 2006; Oyelaran-Oyeyinka 2006; Kahn et al. 2007; Kruss 2005, 2006a, b, 2008a, b; Szogs 2008; Lorentzen 2009; Cusmano et al. 2010; Giuliani et al. 2010).

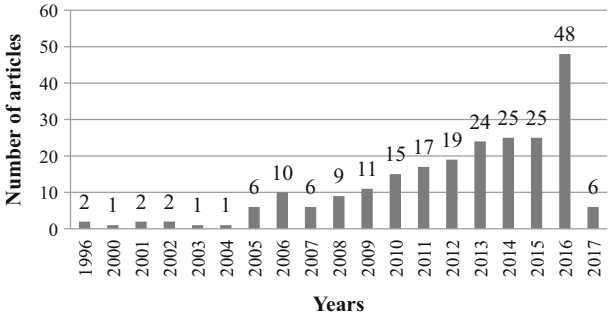

Fig. 1 Evolution of number of publications *Source*: author's computations based on Web of Science, Scopus and Google Scholar

Academic journals and publishers

The 230 articles were published by a total of 104 journals and 9 book publishers. 30 journals and 4 book publishers have published more than 1 paper. *Scientometrics* is the leading journal in number of publications, with 25 articles, followed by the *African Journal of Science, Technology, Innovation and Development, with* 14 articles, by the *South African Journal of Science*s, with 14 articles, by *Industry and Higher Education,* with 8 articles and *Technovation,* with 7 articles. Three journals, namely *Science, Technology and Society, Science and Public Policy,* and *Innovation and Development,* have each published 5 articles. 1 journal, the *South African Review of Sociology*, and 1 book publisher, the *Cape Town University Press,* have produced 8 publications (4 publications each). 8 journals, namely Technological *Analysis and Strategic Management; Technology Management and Social Change; International Journal of Educational Development; Mousaion; Development Southern Africa; Journal of Higher Education in Africa*; *Innovation: Management, Policy and Practice; International Journal of Technology Management,* and 1 book publisher, *Palgrave*, have altogether produced 24 publications (3 publications each). *Research Policy* and *Journal of Informetrics,* two of the leading journal in the field, both in impact factor and in concentration of UILs articles (Teixeira and Mota 2012), have only published 2 articles on SSA. The same number of papers has been published by *International Journal of Innovation Management; International Journal of Technology Policy and Management; Procedia-Social and Behavioural Sciences*; *International Journal of Technology Management*; *Local Economy; Perspectives in Education; Technology in Society; Education and Training; World Patent Information; Journal of Business and Management Sciences; Asian Research Policy; Springer-Book Publisher,* Cape Town-based Book-Publisher *African Minds* and *the Association of African Universities*. Each of the 74 remaining journals and 5 book-publishers has published only 1 paper. UILs' literature targeting SSA is rather published by internationally recognised journals and book publishers. Table 1 shows that 32 of the 104 journals have an impact factor. Figure 2 shows that (1) 67 (59%) of the journals have been published by internationally recognised publishers, such as Routledge, Elsevier, Sage, Springer, Palgrave, (2) 12 (11%) journals or publishers are South African-based and (3) only 34 (30%) are African and non-African non-indexed journals. The knowledge producers and publishing market of UILs' literature targeting SSA reflects the hegemonic international scientific landscape, dominated by developed countries outside the continent and by South Africa inside the continent.

Table 1 Number of publications (PUB) per Journal/Book Publisher and Journals' 2015 Impact Factor (IF) (total of 194 Publications). *Source*: Author's computations based on Web of Science, Scopus and Google Scholar

Name of the journal	PUB	IF	Name of the journal	PUB	IF	Name of the journal	PUB	IF
Scientometrics	25	2.1	*Journal of Knowledge Management*	1	1.7	*COLLNET Journal of Scientometrics and Information Management*	1	0
African Journal of Science, Technology, Innovation and Development	14	0	*Cambridge Journal of Economics*	1	1.3	*The Journal of Technology Transfer*	1	2.2
South African Journal of Science	14	0.9	*South African Journal of Information Management*	1	0	*Book-chapter-SensePublishers*	1	0
Industry and Higher Education	8	0	*Book-Evergreen Publishers*	1	0	*Studies in Higher Education*	1	1.2
Technovation	7	2.5	*Journal of Higher Education Policy and Management*	1	0	*Policy Futures in Education*	1	0
Science, Technology and Society	5	0.4	*First Monday*	1	0	*Journal of Asian and African Studies*	1	0.3
Science and Public Policy	5	1.2	*Institutions and Economics*	1	0	*Journal of Adult and Continuing Education*	1	0
Innovation and Development	5	0	*International Journal of Business and Social Sciences*	1	0	*The Social Work Practitioner-Researcher*	1	0
Book chapter—Cape Town University Press	4	0	*Book-chapter Sarua*	1	0	*African Education Review*	1	0
South African Review of Sociology	4	0	*African Journal of Business Management*	1	0	*International Journal of Higher Education*	1	0
International Journal of Educational Development	3	1.1	*International Journal of Technology Intelligence and Planning*	1	0	*Education Policy Analysis Archives*	1	0
Palgrave Communications	3	0	*Current Science*	1	0.8	*Journal of International and Intercultural Communication*	1	0
Mousaion	3	0	*South African Journal of Economic and Management Sciences*	1	0	*The Journal for Transdisciplinary Research in Southern Africa*	1	0
Development Southern Africa	3	0	*Inkanyiso: Journal of Humanities and Social Sciences*	1	0	*Learned Publishing*	1	1
Journal of Higher Education in Africa	3	0	*Educational Research and Reviews*	1	0	*Online Information Review*	1	1.1

Table 1 continued

Name of the journal	PUB	IF	Name of the journal	PUB	IF	Name of the journal	PUB	IF
Innovation: Management Policy and Practice	3	0.6	*African, Technology, Development Forum Journal*	1	0	*New Review of Information Networking*	1	0
International Journal of Technology Management	3	0.9	*Journal of Scientometric Research*	1	0	*Research Evaluation*	1	1.1
Technology Analysis and Strategic Management	3	0.8	*African Journal of Library, Archives & Information Science*	1	0	*Journal of Balkan Libraries Union*	1	0
Technological Forecasting & Social Change	3	2.7	*International Journal of Research, Innovation and Commercialisation*	1	0	*The Electronic Library*	1	0.4
Book-African Minds	2	0	*Journal of Commercial Biotechnology*	1	0	*Quality & Quantity*	1	0.9
International Journal of Innovation Management	2	0	*Revista Brasileira de Inovação*	1	0	*Current Sociology*	1	1.6
Association of African Universities	2	0	*International Journal of Technological Learning, Innovation and Development*	1	0	*International Journal of Sociology*	1	0
International Journal of Technology, Policy and Management	2	0	*Africa Review*	1	0	*Social Science & Medicine*	1	2.8
Procedia-Social and Behavioural Sciences	2	0	*Minerva*	1	1	*Information, Communication & Society*	1	0
Journal of Informetrics	2	2.4	*The African Journal of Information and Communication*	1	0	*International Journal Innovation Science*	1	0
Research Policy	2	3.5	*Emerald Publishing (Book-chapter)*	1	0	*Southern African Business Review*	1	0
Local Economy	2	0	*Triple Helix*	1	0	*African Journal of Plant Science and Biotechnology*	1	0
Perspectives in Education	2	0	*Canadian Journal of Information and Library Service*	1	0.2	*Journal of Scholarly Publishing*	1	0
Technology in Society	2	1	*International Journal of technology and Globalisation*	1	0	*The Bottom Line*	1	0

Table 1 continued

Name of the journal	PUB	IF	Name of the journal	PUB	IF	Name of the journal	PUB	IF
Book chapter Springer	2	0	*Publishing Research Quarterly*	1	0	*Research Journal of Applied Sciences*	1	0
Education and Training	2	0	*Book-Chapter ICG Global Publisher*	1	0	*Environmental Economics*	1	0
World Patent Information	2	0	*African Higher Education Review*	1	0	*Management*	1	0
Journal of Business and Management Sciences	2	0	*Journal of International Development*	1	0.7	*International Journal of Innovation, Management and Technology*	1	0
Asian Research Policy	2	0	*Higher Education Research and Development*	1	0.9	*African Journal of Economic and Management Studies*	1	0
World Development	1	2.4	International Journal of Technology Transfer and Commercialisation	1	0	*International Journal of Energy Sector Management*	1	0
Journal of Developmental Enterpreneurship	1	0	*Journal of Open Innovation: Technology, Market, and Complexity*	1	0	Procedia-Engineering	1	0
Tertiary Education and Management	1	1	*International Journal of Innovation Science*	1	0	Joumal of Management Research	1	0
Acta Universitatis Danubius Œconomica	1	0	*International Journal of Business Innovation and Research*	1	0	*Journal of technology management & innovation*	1	0
			European Journal of Training and Development	1	0	*Journal of Development Studies*	1	0.9

Journals' academic fields

The academic fields of the journals are eclectic and can be classified into seven main clusters: (1) innovation, R&D and technology transfer-focused journals (e.g. *Scientometrics; Research Policy; African Journal of Science, Technology, Innovation and Development*; *Industry and Higher Education; Science, Technology and Society; Science and Public Policy, Technological Forecast and Social Change*); (2) development studies journals (e.g. *Development Southern Africa, Journal of Development Studies)*; (3) Management and business-oriented journals (e.g. *Cambridge Journal of Economics, South African Journal of Economic and Management Sciences; Institutions and Economics*); (4) information systems journals (e.g. *African Journal of Library, Archives & Information*

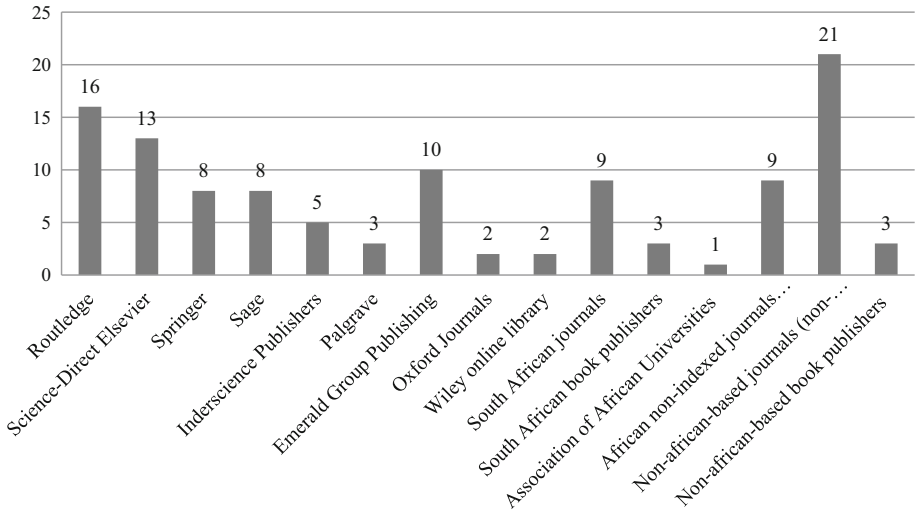

Fig. 2 Number of journals/book-publisher per type/origin of publisher

Sciences, Journal of Informetrics); (5) education and higher education journals (e.g. *International Journal of Educational Development, Minerva, Journal of Higher Education Policy and Management, Journal of Higher Education in Africa*), (6) Sociology journals (e.g. *South African Review of Sociology*) and (7) multidisciplinary journals (e.g. *South African journal of Science*). The eclectism of these sources is a testament to the multidisciplinary nature of research on UILs focusing SSA, a nature also demonstrated by previous systematic literature review on global literature (Teixeira and Mota 2012).

Glenda Kruss, from the South African Human Science Research Council (HSRC), is the most prolific author (17 relevant publications), both as a single author, leading author or co-author with other colleagues from the same institution (e.g. Michael Gastrow, Petersen II-haam) or from other institutions (e.g. John Adeoti, Dani Nabudere, Eduardo Albuquerque) (Kruss 2005, 2006a, b, 2008a, b; Kruss and Petersen 2009; Gastrow and Kruss 2012; Kruss 2012a, b; Kruss et al. 2012, 2015b, 2016; Britto et al. 2013; Gastrow et al. 2016, 2017; Kruss and Gastrow 2016; Kruss and Visser 2017). Glenda Kruss is followed (1) by Anatastassios Pouris, from the University of Pretoria, South Africa, with 13 publications (Pouris and Richter 2000; Pouris 2003, 2010, 2011, 2012a; Lubango and Pouris 2007, 2009, 2010; Pouris and Pouris 2009; Jeenah and Pouris 2008; Inglesi-Lotz and Pouris 2013; Pouris and Ho 2014; Makhoba and Pouris 2016); (2) by Radhamany Sooryamoorthy from the University of KwaZulu-Natal, South Africa, with 11 publications (Sooryamoorthy 2009a, b, 2010, 2011, 2013, 2014; 2015, 2016a, b, 2017; Schubert and Sooryamoorthy 2010); (3) by Matthew Olugbemiga Ilori, from Obafemi Awolowo University, Nigeria, with 10 publications (Oyebisi et al. 1996; Ojewale et al. 2001; Sanni et al. 2001; Ilori et al. 2002; Abereijo et al. 2009; Jegede et al. 2012, 2013; Oluwale et al. 2013; Sobanke et al. 2014; Adelowo et al. 2015); (4) by Abiodun Egbetokun, from the National Centre for Technology Management-Federal Ministry of Science and Technology, Nigeria, with 9 publications (Egbetokun et al. 2008, 2010, 2016, 2017; Egbetokun 2015a, b; Siyanbola et al. 2011; Sobanke et al. 2014; Oluwatope et al. 2016); (5) by Willie Owulabi Siyanbola, from Obafemi Awolowo University, Nigeria, with 9 publications (Siyanbola et al. 2013; Egbetokun et al. 2008, 2010, 2016; Adelowo et al. 2015; Siyanbola

et al. 2011, 2012; Jegede et al. 2012, 2013), by the Eustache Mêgnigbêto, from the University of Antwerp-Belgium, with 5 publications (Mêgnigbêto 2013a, b, c, 2014, 2015); (6) by John Adeoti, from the Nigerian Institute for Social and Economic Research, with 4 publications) (Adeoti 2002; Adeoti and Adeoti 2005; Kruss et al. 2012; Adeoti et al. 2010); (7) by Louis Mitondo Lubango, from the University of Pretoria and United Nations Economic Commission for Africa, with 4 publications (Lubango and Pouris 2007, 2009, 2010; Lubango 2015); (8) by Sikiru Adigun Sanni, from Obafemi Awolowo University, Nigeria, with 4 publications (Sanni et al. 2001; Ilori et al. 2002; Egbetokun et al. 2008; Oluwatope et al. 2016); (9) and by Oluseye Oladayo Jegede, from Obafemi Awolowo University, with 4 publications (Jegede et al. 2012, 2013; Egbetokun et al. 2016, 2017). In SSA, South Africa and Nigeria are therefore the main research hubs on UILs, and home of leading authors. In South Africa, prominent scholars (e.g. Glenda Kruss, Anatastassios Pouris, Radhamany Sooryamoorthy) are mainly affiliated to institutions like HSRC, University of Pretoria and University of KwaZulu-Natal. In Nigeria, most prominent scholars (e.g. Matthew Olugbemiga Ilori, Abiodun Egbetokun, Willie Owulabi Siyanbola, John Adeoti) are mainly affiliated to institutions like Federal Ministry of Science and Technology, Obafemi Awolowo University and Nigerian Institute for Social and Economic Research.

Research questions addressed, units of analysis observed, methods used and countries researched

As stated in the methodology, according to O'Brien and Bortagaray (2015), the main research questions addressed by UILs' literature targeting developing countries can be grouped into three categories: Determinants of UILs, Modes of interaction and Outcomes.

Research questions

Figure 3 displays the distribution of the 230 publications per research questions addressed. The figure shows the dominance of *determinants of UILs*: 153 (67%) of the 230 addressed questions related to drivers of, and conditions for, UILs. Some articles addressed the surrounding structural conditions, including science, technology and innovation policies

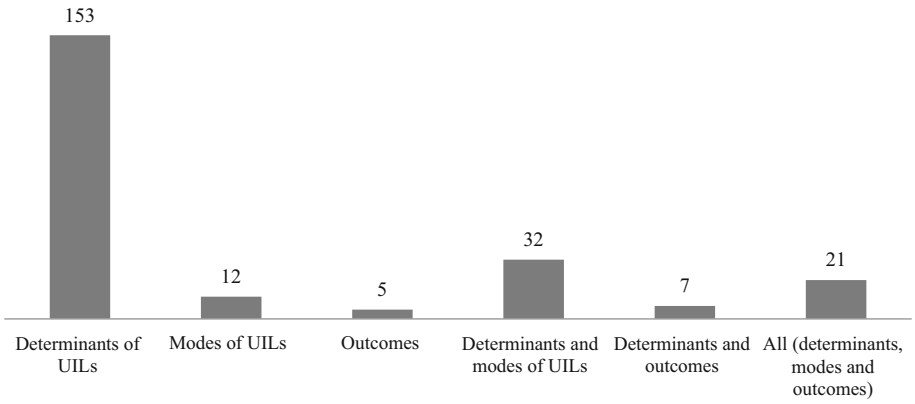

Fig. 3 Number of articles per research question addressed

(Adeoti 2002; Kahn and Blankley 2005; Letseka 2005; Kahn et al. 2007; Lorentzen 2009; Kahn 2006, 2013; Siyanbola et al. 2014; Ndabeni et al. 2016) and indicators (e.g. Tijssen 2007; Pouris and Pouris 2009; Pouris 2010; Mêgnigbêto 2013a, b; Confraria and Godinho 2015; Sooryamoorthy 2017; Owusu-Nimo and Boshoff 2017). Other articles addressed the conditions and capabilities of universities (Cloete et al. 2015), including what drivers them to engage in UILs (Kruss 2005, 2006a). There are also articles that addressed the conditions and capabilities of firms (Oerlemans and Pretorius 2006; Bothma 2007; Herman 2013; Sobanke et al. 2014; Egbetokun 2015a, b; Egbetokun et al. 2016), and articles addressing how academics' characteristics shape UILs (Giuliani et al. 2010; Giuliani and Rabellotti 2012; Meusburger and Antonites 2016).

12 (5%) articles examined the *modes of interaction* between universities and firms (e.g. Kruss 2008b, 2012b; Vera-Cruz 2014), 5 (2%) examined the *outcomes* (e.g. Kruss 2006b; Tumuti et al. 2013). There are also publications that researched more than one question: 32 (14%) combined *determinants and modes* (e.g. Oyelaran-Oyeyinka et al. 1996; Kruss et al. 2015b), 7 (3%) *determinants and outcomes* (Mgumia et al. 2015; Ishengoma and Vaaland 2016) and 21 (9%) examined *determinants, modes and outcomes* (Kruss and Petersen 2009; Kruss et al. 2012; Oyelaran-Oyeyinka and Adebowale 2013; Sá 2015; Zavale and Macamo 2016).

The over-representation of determinants suggests that scholars rather focus on the surrounding scientific, technological and institutional conditions of NISs, internal capabilities of universities and firms enabling them to foster UILs. The core research questions, particularly regarding the modes or channels of interaction, the kind of knowledge and resources universities and firms' exchange, and the outcomes yielded from these processes are still under-researched. In other words, the mechanisms of knowledge transfer between universities and firms of several SSA countries are still not well-known, and are often inferred from macro data from the NISs, or from the data on capabilities of universities and firms. Further and in-depth research is still needed to address and conceptualize the ways through which universities and firms collaborate.

Unit of analysis

Figure 4 displays the distribution of the 230 articles per observed unit of analysis. 45% have collected and analysed data on the surrounding conditions, policies and indicators of science and technology (Adeoti 2002; Pouris 2003; Kahn and Blankley 2005; Letseka 2005; Kahn et al. 2007; Lorentzen 2009; Siyanbola et al. 2014; Tijssen 2007; Pouris and Pouris 2009; Confraria and Godinho 2015; Sooryamoorthy 2017; Owusu-Nimo and Boshoff 2017). This percentage is partly consistent with the fact that 67% of research questions focus on determinants of UILs (see Fig. 3 above). In fact, scholars seem to focus more on surrounding determinants (e.g. science and technology policies, incentives and performance indicators) than on universities and firms' determinants, i.e., on universities and firms' conditions and capabilities.

15% of articles have empirically researched firms (e.g. Chan et al. 2012; Sobanke et al. 2014; Egbetokun 2015a, b; Egbetokun et al. 2016) and 13% have targeted universities (e.g. Ojewale et al. 2001; Kruss and Petersen 2009; Zavale and Macamo 2016). 4% researched intermediaries (e.g. Kruss 2008a; Szogs et al. 2011; Mgumia et al. 2015), 10% targeted scientists/researchers (e.g. Giuliani et al. 2010; Giuliani and Rabellotti 2012; Inglesi-Lotz and Pouris 2013; Meusburger and Antonites 2016; Fari and Ocholla 2016), 4% collected data in universities, firms and government (e.g. Mêgnigbêto 2013a; Vera-Cruz 2014), and the same percentage in universities and informal actors (Oluwale et al. 2013; Kawooya

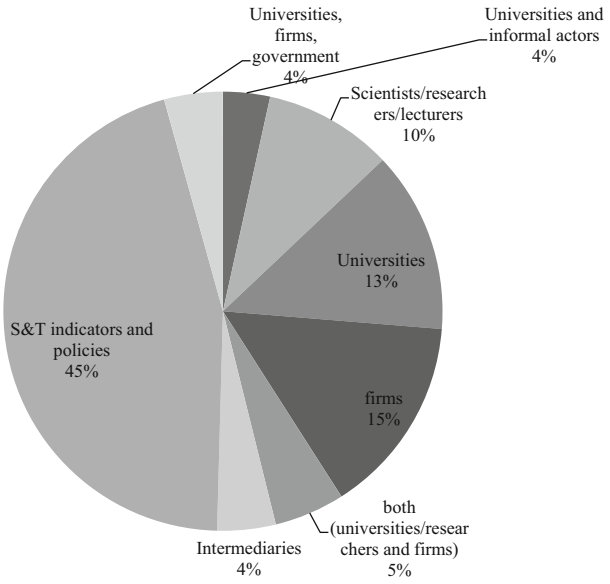

Fig. 4 share of articles per unit of analysis

2014; Kruss and Gastrow 2016; Gastrow et al. 2016, 2017). 5% of publications focused on universities/researchers and firms (e.g. Oyelaran-Oyeyinka et al. 1996; Adeoti and Adeoti 2005; Kruss et al. 2012).

Methods

More than half (57%) of research applied formal (29%) and mixed (28%) methods (Fig. 5). Formal methods, i.e., logical and mathematical modelling, were particularly used by research measuring performance indicators and variables of science, technology and innovation of the NISs, universities and firms (e.g. Pouris 2003; Chan et al. 2011, 2012; Mêgnigbêto, 2013a, b, 2015; Dragos and Dragos 2014; Confraria and Godinho 2015). Mixed methods consisted of combining formal modelling methods, surveys and interviews (Giuliani et al. 2010; Oyelaran-Oyeyinka and Adebowale 2013), formal modelling methods and surveys (Booyens 2011; Egbetokun 2015a, b) or combining surveys with case studies (Kruss et al. 2012) or surveys with interviews (Mgumia et al. 2015; Kruss et al. 2016).

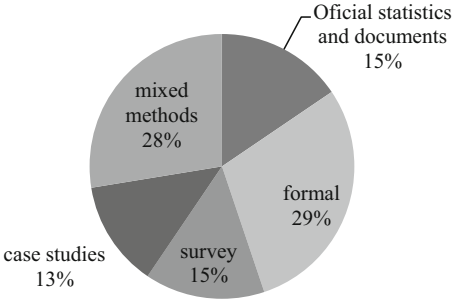

Fig. 5 Share of publications per methods used

43% used single research methods, namely surveys (15%), official statistics and documents (15%) and cases studies (13%). Surveys were used for universities (Kruss 2005; Kruss and Petersen 2009), for researchers/academics (Rorwana and Tengeh 2015; Meusburger and Antonites 2016), for firms (Ishengoma and Vaaland 2016), and, albeit rarely, for firms and universities in the same publication (Oyelaran-Oyeyinka et al. 1996). Studies relying on official statistics and documents are particularly those addressing the features of NISs, including S&T policies (Kahn 2006; Lorentzen 2009; Kahn et al. 2007). Cases studies have been used to research firms (Herman 2013), universities (Kruss 2006c, 2008a, 2012b), intermediaries (Szogs et al. 2011; Trojer et al. 2014), stakeholders from universities, firms and governments (Vera-Cruz 2014; Kruss et al. 2015b, Gastrow et al. 2016) and informal actors (Oluwale et al. 2013; Kawooya 2014; Gastrow et al. 2017; Kruss and Gastrow 2016).

Researched countries

South Africa is by far the largest researched SSA country, with a total of 100 (44%) publications (Fig. 6). This dominance is consistent with the presence in South Africa of a dynamic community of scholars of innovation and higher education studies, most of whom affiliated to public and private research institutions like Human Science research Council

Fig. 6 Number of publications by country or Region

(HSRC) (e.g. Glenda Kruss, Michael Gastrow), the Centre for Higher Education Trust (CHET)(e.g. Nico Cloete), University of Pretoria (Anastassios Pouris), University of Kwazulu-Natal (e.g. Radhamany Sooryamoothy) and University of Stellenbosch (e.g. Nelius Boshoff). These research institutions are located in major South African cities such as Cape Town, Pretoria and Durban. Besides, South Africa is the SSA' most productive country of science and technology, with the best ranked universities in the continent (Cloete et al. 2015) and audacious policies of incentivising science and technology, including university-industry partnerships (Letseka 2005). South Africa is followed by Nigeria, with 49 (21%) publications, undertaken particularly by scholars affiliated to the Federal Ministry of Science and Technology (e,g. Abiodun Egbetokun), Obafemi Awolowo University (e.g. Matthew Olugbemiga Ilori, Willie Owulabi Siyanbola) and the Nigerian Institute of Social and Economic Institute (e.g. John Adeoti, Banji Oyelaran-Oyeyinka).Tanzania falls in 3rd place with 12 publications (5%), produced particularly by scholars affiliated to the University of Dar es Salaam (e.g. Burton Mwamila, Bitrina Diyamet) and to the University of Lund, Sweden (e.g. Astrid Szogs).

The other countries have been less explored by research focusing on single countries. 29 publications (13%) focused on the whole continent, particularly scientometric studies (e.g. Confraria and Godinho 2015) and studies commissioned by continental organisations working on higher education or related issues (Ssebuwufu et al. 2012; Mihyo 2013; Sá 2015). Southern and Eastern African countries seem to having been more researched than countries from other regions. It is also worth-noting the presence of Uganda in most of the multiple-country research (e.g. Kruss et al. 2012; Trojer et al. 2014, Gastrow et al. 2017).

The influence of UILs' literature focusing on SSA

Citations

Based on Google scholar, citations were examined in order to measure the impact and influence of the literature. At least by 16th January 2017, the body of literature on UILs in SSA had produced 2554 citations (Table 2). While this number is lower compared to 15,000 citations generated by 2011 by global UILs' literature (Teixeira and Mota 2012), it reveals that UILs' literature focusing on SSA has a non-negligible impact, particularly given that it is an emerging field. Articles published in 36 (32%) journals or book-publishers have received 10 or more citations, with *Scientometrics* leading the top 15 (667 citations), followed by *South African Journal of Science* (196), *Technovation (188), Research Policy* (155), *Science and Public Policy* (136), *African Minds Book-Publisher* (120), *Science, Technology and Society* (109), *World Development* (76), *International Journal of Technology Management* (76), *Industry and Higher Education* (63), *Technology Analysis and Strategic Management* (47), *South African Review of Sociology* (46), *Journal of Technology Management and Innovation* (46), *Technological Forecasting and Social Change* (43). Highly cited journals are often internationally reputed. While this trait may mean that articles published in top international journals are more likely to have better quality, the citations may also reflect the common practice in scientific community of exclusively reading and considering articles published in prestigious journals.

A comparison of Table 2 with Table 1 reveals that the number of articles published by a journal does not always reflect its propensity to being cited. While *Scientometrics* has the highest number of articles (25, see Table 1) and also the highest number of citations, this is not the case for other journals. For example, the *African Journal of Science, Technology* has produced the largest number of papers (14) after *Scientometrics*, but it has only

Table 2 Number of citations per journal (total of 2554 citations). *Source*: Authors'computation based on Google Scholar Citations

Name of the journal	Citations	Name of the journal	Citations	Name of the journal	Citations
Scientometrics	667	*Asian Research Policy*	7	*Development Southern Africa*	0
South African Journal of Science	196	*Book-chapter Sarua*	6	*Publishing Research Quarterly*	0
Technovation	188	*International Journal of Innovation, Management and Technology*	6	*Book-Chapter ICG Global Publisher*	0
Research Policy	155	*European Journal of Training and Development*	6	*International Journal of Energy Sector Management*	0
Science and Public Policy	136	*Learned Publishing*	6	*African Higher Education Review*	0
Book-African Minds	120	*Journal of Business and Management Sciences*	5	Book-chapter IGI Global	0
Science, Technology and Society	109	*International Journal of Technology Intelligence and Planning*	4	*Journal of International Development*	0
World Development	76	*Current Science*	4	*Higher Education Research and Development*	0
International Journal of Technology Management	76	*South African Journal of Economic and Management Sciences*	4	*International Journal of Innovation Management*	0
Industry and Higher Education	63	*Inkanyiso: Journal of Humanities and Social Sciences*	4	*COLLNET Journal of Scientometrics and Information Management*	0
Technology Analysis and Strategic Management	47	*International Journal of Business Innovation and Research*	4	*The Journal of Technology Transfer*	0
South African Review of Sociology	46	*Education and Training*	4	*Journal of Asian and African Studies*	0
Journal of technology management & innovation	46	*African Journal of Economic and Management Studies*	3	*Triple Helix*	0
Technological Forecasting & Social Change	43	*Social Science & Medicine*	3	*Canadian Journal of Information and Library Service*	0
Journal of Developmental Enterpreneurship	36	*World Patent Information*	3	*Journal of Balkan Libraries Union*	0
International Journal of technology and Globalisation	34	*Journal of Scholarly Publishing*	3	*The Electronic Library*	0
First Monday	31	*Educational Research and Reviews*	3	*The Social Work Practitioner-Researcher*	0

Table 2 continued

Name of the journal	Citations	Name of the journal	Citations	Name of the journal	Citations
Research Evaluation	28	*African, Technology, Development Forum Journal*	3	*Acta Universitatis Danubius Œconomica*	0
Perspectives in Education	24	*Journal of Scientometric Research*	3	*African Education Review*	0
African Journal of Science, Technology, Innovation and Development	24	*African Journal of Library, Archives & Information Science*	3	*International Journal of Higher Education*	0
Innovation and Development	19	*Journal of Commercial Biotechnology*	3	*International Journal Innovation Science*	0
Technology in Society	19	*Book chapter—Cape Town University Press*	3	*Southern African Business Review*	0
Journal of Informetrics	19	*Online Information Review*	3	*New Review of Information Networking*	0
Tertiary Education and Management	18	*International Journal of Innovation Science*	3	*The Bottom Line*	0
Journal of Development Studies	14	*Revista Brasileira de Inovação*	2	*Research Journal of Applied Sciences*	0
Minerva	14	*International Journal of Technological Learning, Innovation and Development*	2	*Environmental Economics*	0
The African Journal of Information and Communication	14	*Journal of Higher Education in Africa*	2	*International Journal of Research, Innovation and Commercialisation*	0
Book publisher-Springer	14	*Education Policy Analysis Archives*	2	*International Journal of Technology Transfer and Commercialisation*	0
Innovation: Management Policy and Practice	14	*Journal of International and Intercultural Communication*	2	*Joumal of Management Research*	0
Journal of Knowledge Management	12	*Information, Communication & Society*	2		
Procedia-Engineering	12	*Journal of Adult and Continuing Education*	2		
Cambridge Journal of Economics	11	*Africa Review*	1		
South African Journal of Information Management	11	*Local Economy*	1		
Book-Evergreen Publishers	11	*Association of African Universities*	1		

Table 2 continued

Name of the journal	Citations	Name of the journal	Citations	Name of the journal	Citations
Current Sociology	10	*Journal of Open Innovation: Technology, Market, and Complexity*	1		
International Journal of Educational Development	10	*International Journal of Technology, Policy and Management*	1		
Journal of Higher Education Policy and Management	9	*Emerald Publishing (Book-chapter)*	1		
Palgrave	9	*Policy Futures in Education,*	1		
Management	9	*The Journal for Transdisciplinary Research in Southern Africa*	1		
Quality & Quantity	8	*International Journal of Sociology*	1		
Institutions and Economics	7	*African Journal of Plant Science and Biotechnology*	1		
Book-chapter-Sense Publishers	7	*Mousaion*	0		
Studies in Higher Education	7	*Procedia-Social and Behavioural Sciences*	0		

received 14 citations. This low level of citations is surely related to its younger age, but also to its relative low prestige in international standing, at least in comparison with journals like *Scientometrics, Research Policy, World Development, Science and Public Policy*. Reputed journals may have fewer publications, but they tend to have higher number of citations (e.g. *Research Policy* published 2 articles cited 155 times, and this feature is consistent with other reputed journals). It also worth-noting the positive standing of South African journals (e.g. *South African Journal of Science, South African Review of Sociology*) and Book-Publishers (e.g. *African Minds*) in the ranking of citations, a standing suggesting an international recognition of the quality of science produced in South Africa. Table 2 also shows that each of the remaining 77 (68%) journals or book publishers have been cited less than 10 times, and that 31 of these 77 journals have received none citation. Non- or less cited articles often share cumulatively or at least one of the following three features: they have been published in reputed journals but only recently, particularly from 2014 onwards (Kruss and Gastrow 2016; Kruss and Visser 2017); they have been published in less reputed, particularly non-indexed journals (Adepoju and Adedeji 2015) or they have focused on single countries and authored by one or fewer number of scholars (e.g. Vera-Cruz 2014).

These citations trends suggest that the publishing market and mind-set of the academic community involved in producing relevant UILs' literature on SSA is still dominated by the standards of developed countries. The possibility of visibility and impact of literature on SSA is partly still constrained by what Nwagwu (2010) considers to be a social cybernetics effect. The social cybernetics refers to hegemonic science politics, which centralises scholarly rankings and scientific databases to benefit already-advantaged developed countries, in detriment of developing world.

Based on Scopus' citations, Table 3 displays the top 69 most cited publications. The *first cluster* consists of articles examining continental, regional or national systems of innovation, including the state of science and technology in SSA. These studies either focus on the state or level of performance of science and technology in the whole continent (e.g. Tijssen 2007; Pouris and Pouris 2009; Toivanen and Ponomariov 2011, Confraria and Godinho 2015), in specific regions of the continent (Boshoff 2009, 2010; Pouris 2010; Mêgnigbêto 2013a, b, c), or in single countries (e.g. Sooryamoorthy 2009a, b). There is a subgroup of the third group, which focuses on policies and institutional capabilities of NISs, particularly of South Africa (e.g. Kahn 2006; Lorentzen 2009) and Nigeria (e.g. Adeoti 2002).The *second cluster* consists of articles produced in a context of cross-continental collaborative research involving African (mostly South Africa) and non-African countries (e.g. Giuliani et al. 2010; Cusmano et al. 2010, involving South Africa, Chile and Italy), (Amadi-Echendu 2007, involving South Africa and Australia), (Szogs et al. 2011, involving Tanzania and El Salvador). The *third cluster* is composed of studies which collected and analysed data on UILs in SSA, without collecting data in any other region of the world. Some studies researched several African countries (e.g. Kruss et al. 2012) and others, single countries (e.g. Oyelaran-Oyeyinka et al. 1996; Adeoti and Adeoti 2005, for Nigeria; Konde 2004 for Zambia; Kruss 2005, 2006a, b, c; Chan et al. 2011, for South Africa). The fourth cluster consists of studies produced by CHET scholars (Cloete et al. 2015, 2011). These studies examine the structural conditions under which African flagship universities operate, including their academic capabilities and their level of connectedness to external partners (Cloete et al. 2015, 2011).

The most cited publications are typically those which either collected data on sub-regions or the whole African continent. There are also citations on publications from various African and non-African countries. South Africa and Nigeria are the most cited on the continent. This trait is reflected by the dominance of South Africa and Nigeria as the homelands of institutional affiliation of the most cited scholars, followed by foreign-western institutions. Of the 139 authors and co-authors of the most cited publications, 63 (45%) are affiliated to South African institutions, 35 (25%) to Western (USA and Western Europe) institutions, 31 (22%) to Nigerian institutions and 5 (4%) to foreign non-Euro-American institutions. If South Africa and Nigeria are excluded, only 5 (4%) scholars who authored or co-authored most cited publications are affiliated to African institutions (Table 3). The possibility of producing a high-impact and influential work is dependent on (1) how developed, both economically and scientifically, a specific researched African country is, (2) how the specific African country attracts the interest of foreign (western scholars) both as knowledge consumers and producers, (3) how African-based scholars are connected to foreign (Western) scholars, (4) how comparative with other African but mostly non-African countries the research is. Low-income countries suffer, therefore, from vicious circle and double neglect: they are under-researched (see Fig. 6), but also ignored when research on them is produced.

Based on Scopus and on full texts, the nature of the publications citing the top 69 most cited articles were examined in order to draw a portrait of their influence. The top 69 have

Table 3 Top 69 most cited works (total of 1154 citations). *Source*: Authors' computation based on Scopus Citations

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
1. Tijssen (2007)	*Scientometrics*	71	Sub-Saharan Africa	Leiden University-Netherlands				
2. Pouris (2003)	*South African Journal of Science*	53	South Africa	University of Pretoria-South Africa				
3. Sooryamoorthy (2009b)	*Scientometrics*	52	South Africa	University of Kwazulu-Natal-South Africa				
4. Giuliani et al. (2010)	*Research Policy*	49	Chile, Italy and South Africa	University of Pisa-Italy	Utrecht University-Netherlands	University of Rome-Italy	University of Pavia-Italy	
5. Cusmano et al. (2010)	*World Development*	43	Chile, Italy and South Africa	Insubria University and Bocconi University-Italy	Utrecht University-Netherlands	University of Pavia-Italy		
6. Sooryamoorthy (2009a)	*Scientometrics*	35	South Africa	University of Kwazulu-Natal-South Africa				
7. Pouris and Pouris (2009)	*Scientometrics*	34	Sub-Saharan Africa	University of Pretoria- South Africa	National Research Foundation-South Africa			
8. Boshoff (2009)	*Scientometrics*	30	Central Africa	Stellenbosch University-South Africa				
9. Boshoff (2010)	*Scientometrics*	29	Southern Africa	Stellenbosch University-South Africa				
10. Onyancha and Maluleka (2011)	*Scientometrics*	28	Sub-Saharan Africa	University of South Africa	University of South Africa			

Table 3 continued

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
11. Lubango and Pouris (2007)	*Technovation*	25	South Africa	University of Pretoria	University of Pretoria			
12. Jeenah and Pouris (2008)	*South African Journal of Science*	24	South Africa	Nelson Mandela Metropolitan University-South Africa	University of Pretoria-South Africa			
13. Schubert and Sooryamoorthy (2010)	*Scientometrics,*	23	South Africa and Germany	Fraunhofer Institute Systems and Research and Karrlsrube-Germany	University of Kwazulu-Natal-South Africa			
14. Toivanen and Ponomariov (2011)	*Scientometrics*	22	Sub-Saharan Africa	VVT Technical Research Centre of Finland	University of Texas			
15. Oyelaran-Oyeyinka et al. (1996)	*Research Policy*	21	Nigeria	Nigerian Institute of Social and Economic Research-Nigeria	Nigerian Institute of Social and Economic Research-Nigeria	Nigerian Institute of Social and Economic Research-Nigeria		
16. Pouris and Ho (2014)	*Scientometrics*	21	Sub-Saharan Africa	University of Pretoria- South Africa	Asia University-Taiwan			
17. Inglesi-Lotz and Pouris (2013)	*Scientometrics*	20	South Africa	University of Pretoria-South Africa	University of Pretoria			

Table 3 continued

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
18. Egbetokun et al. (2008)	*International Journal of Technology Management*	20	Nigeria	National Center for Technology Management-Federal Ministry of Science and Technology-Nigeria	National Center for Technology Management-Federal Ministry of Science and Technology-Nigeria	National Center for Technology Management-Federal Ministry of Science and Technology-Nigeria	Obafemi Awolowo University	
19. Booyens (2011)	*Science and Public Policy*	19	South Africa	Human Sciences Research Council (HSRC)-South Africa				
20. Tijssen et al. (2006)	*Research Evaluation*	19	South Africa	Leiden University-Netherlands	Stellenbosch University-South Africa	Leiden University-Netherlands	Stellenbosch University-South Africa	
21. Pouris (2012a)	*South African Journal of Science*	18	South Africa	University of Pretoria- South Africa				
22. Adams et al. (2014)	*Scientometrics*	18	Sub-Saharan Africa	Leeds UK	Evidence Thompson Reuters-UK	Symplectic-UK	University of Amsterdam-Netherlands	
23. Mêgnigbêto (2013b)	*Scientometrics*	17	West Africa	University of Antwerp-Belgium				
24. Amadi-Echendu (2007)	*Technological Forecasting and Social Change*	16	South Africa and Australia	University of Pretoria-South Africa				

Table 3 continued

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
25. Adeoti and Adeoti (2005)	*Technovation*	15	Nigeria	Nigerian Institute for Social and Economic Research-Nigeria	University of Ibadan-Nigeria			
26. Kahn (2006)	*Science and Public Policy*	15	South Africa	HSRC-South Africa				
27. Pouris (2010)	*Scientometrics*	15	Southern Africa	University of Pretoria- South Africa				
28. Lorentzen (2009)	*Science and Public policy*	15	South Africa	HSRC-South Africa				
29. Oyebisi et al. (1996)	*Technovation*	15	Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria		
30. Ojewale et al. (2001)	*Technovation*,	15	Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	
31. Abereijo et al. (2009)	*Journal of technology management & innovation*,	14	Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	
32. Pouris (2012b)	*Scientometrics*	13	South Africa	University of Pretoria- South Africa				
33. Ondari-Okemwa (2007)	*First Monday*	13	Sub-Saharan Africa	Moi University-Kenya				

Table 3 continued

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
34. Kruss et al. (2015b)	*International Journal of Educational Development*	13	South Africa	HSRC-South Africa	University of Nottingham. UK University of the Western Cape-South Africa	HSRC-South Africa	HSRC-South Africa	HSRC-South Africa
35. Adeoti (2002)	*Science and Public Policy*	12	Nigeria	Nigerian Institute for Social and Economic Research				
36. Wong and Wang (2015)	*Journal of Informetrics*	12	BRICS	University of Malaya-Malasya	UNU-MERIT-Netherlands			
37. Matthews (2012)	*Scientometrics*	12	South Africa	University of KwaZulu-Natal				
38. Inglesi-Lotz and Pouris (2011)	*Scientometrics*	12	South Africa	University of Pretoria-South Africa	University of Pretoria-South Africa			
39. Kaplan (2008)	*Science Technology & Society*	11	South Africa	HSRC-South Africa				
40. Kruss (2006b)	*Perspectives in Education*	11	South Africa	HSRC-South Africa				
41. Szogs (2008)	*International Journal of technology and Globalisation*	11	Tanzania	Lund University-Sweden				

Table 3 continued

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
42. Kruss et al. (2012)	*Journal of Development Studies*	11	Nigeria, South Africa and Uganda	HSRC-South Africa	Nigerian Institute for Social and Economic Research	Markus Garvey Pan-African Research Institute-Uganda		
43. Williams and Woodson (2012)	*Minerva*	11	less economically developed countries, including Sub-Saharan Africa	Michigan State University-USA	SUNY Stone Brook University-New York			
44. Oyelaran-Oyeyinka (2006)	*Science, Technology and Society*	11	Sub-Saharan Africa	Nigerian Institute of Social and Economic Research-Nigeria				
45. Chan et al. (2010)	*Technology Analysis & Strategic Management*	10	South Africa	University Pretoria-South Africa	Tilburg University-Netherlands	University Pretoria-South Africa		
46. Oerlemans and Pretorius (2006)	*South African Journal of Science*	10	South Africa	Tilburg University-Netherlands	University Pretoria-South Africa			
47. Giuliani and Rabellotti (2012)	*Cambridge Journal of Economics*	10	Chile and South Africa	University of Pisa-Italy	University of Pavia-Italy			
48. Confraria and Godinho (2015)	*Scientometrics*	10	Sub-Saharan Africa	University of Lisbon-Portugal	University of Lisbon-Portugal			
49. Pouris and Richter (2000)	*South African Journal of Science*	10	South Africa	University of Pretoria	University of Witwatersrand			

Table 3 continued

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
50. Ilori et al. (2002)	*Technovation*	10	Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria	Obafemi Awolowo University-Nigeria
51. Cloete et al. (2015)	*African Minds*	9	Sub-Saharan Africa	CHET and University of Western Cape-South Africa	University of Oslo-Norway	CHET-South Africa		
52. Sooryamoorthy (2011)	*Scientometrics*	9	South Africa	University of Kwazulu-Natal-South Africa				
53. Kahn et al. (2007)	*South African Review of Sociology*	9	South Africa	HSRC-South Africa	HSRC-South Africa	HSRC-South Africa	HSRC-South Africa	
54. Albuquerque et al. (2015)	*Edward Elgar Publishing-Book publisher*	9	Developing countries, including from Asia, Latin America and Africa (South Africa, Nigeria and Uganda)	Universidade Federal de Minas Gerais-Brazil	Universidade de Campinas-Brazil	HSRC-South Africa	Seoul National University-South Korea	
55. Lubango and Pouris (2009)	*Technology in Society*	9	South Africa	University of Pretoria	University of Pretoria			
56. Sooryamoorthy (2010)	*Scientometrics*	8	South Africa	University of Kwazulu-Natal				
57. Kruger and Johnson (2010)	*Journal of Knowledge Management*	8	South Africa	University of Pretoria-South Africa	University of Pretoria-South Africa			

Table 3 continued

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
58. Kruss (2012a)	*South African Review of Sociology*	7	South Africa	HSRC-South Africa				
59. Kruss (2012a)	*South African Review of Sociology*	7	South Africa	HSRC-South Africa				
60. Konde (2004)	*International Journal of Technology Management*	6	Zambia	United Nations Conference on Trade and Development-Switzerland				
61. Sooryamoorthy (2014)	*Scientometrics*	6	South Africa					
62. Omobowale et al. (2014)	*Current Sociology*	6	Nigeria	University of Ibadan-Nigeria	University of Ibadan-Nigeria	Obafemi Awolowo University-Nigeria	Ahmadu Bello University-Nigeria	
63. Boersma et al. (2008)	*Tertiary Education and Management*	6	South Africa	Vrije Universiteit Amsterdam (Netherlands)	North-West University (South Africa),	University of Sussex (UK)		
64. Egbetokun (2015b)	*Technological Forecasting and Social Change*	6	Nigeria	National Center for Technology Management-Federal Ministry of Science and Technology-Nigeria				

Table 3 continued

Author(s) and year	Journal/book publishing	Citations (Scopus[a])	Country (ies) researched	Institutional affiliation				
				1st author	2nd	3rd	4th	5th author
65. Kruss (2008b)	*Technology Analysis & Strategic Management*	5	South Africa	HSRC-South Africa				
66. Kruss (2006a)	*Journal of Higher Education Policy and Management*	5	South Africa	HSRC-South Africa				
67. Cloete et al. (2011)	*African Minds and CHET*	5	Southern, Eastern and West Africa	CHET and University of Western Cape-South Africa	CHET-South Africa	University of Witwatersrand-South Africa	CHET-South Africa	University of Oslo-Norway
68. Nyerere and Friso (2013)	*European Journal of Training and Development*	5	Kenya and Italy	Kenyatta University - Kenya	University of Padua -Italy			
69. Mwamila and Diyamett (2009)	*Science and Public Polic*	5	Tanzania	University of Dar es Salaam				

[a]Accessed on 1st November 2017

been cited 1154 times, by about 2450 authors and co-authors. 38% of these authors and co-authors are affiliated to institutions of North America and Western Europe, 18% to South African institutions, 12% to Nigeria, 5% to other SSA countries, particularly Benin, Tanzania, Kenya, 12% to Asia (particularly China, Taiwan, Malaysia, South Korea), 5% to Latin American institutions, 5% to North Africa and Middle East, 2% to Eastern Europe and 2% to Australia and New Zealand (Fig. 7 and Table 4). This geographical distribution is a testament of the global influence of the UILs' literature on SSA, but also of the dominance of South Africa, Nigeria and Western societies both as consumers and producers of research in this domain. The low level of citations by other African countries, particularly the low-income ones, suggests the low reach of UILs' research to low-income African countries and the fact that the mechanisms of knowledge transfer between universities and firms (or other external productive stakeholders) in these countries are still under-researched. Figure 8 shows that UILs' literature focusing on SSA is mostly cited by studies examining UILs-determinants, both scientometric studies (37%) and studies examining other determinants such as innovation policies (10%). Innovation studies (14%), higher education studies (10%), and business studies (9%) are also significantly influenced. The literature is less cited by studies researching UILs' determinants and modes (3%), modes (4%), outcomes (1%) and all UILs' research questions (4%). Other areas (7%) (e.g. health, geography, natural sciences) are less influenced by this body of literature. This pattern of influence reflects the distribution of research questions addressed by the literature (i.e. overrepresentation of UILs determinants over other research questions (see Fig. 3), as well as the eclectic nature of the field.

Social network analysis

Results from SNA reveal that the co-authorship network has 94 nodes and 132 edges and the institutional network has 50 nodes and 52 edges. Both networks have a density of 0.03 (3%). This value means that only 3 percent of all the potential connections are present in the network (see Figs. 9, 10 to visualize the patterns of the network). Both networks are therefore small, as only 3% of interactions among most cited and prominent authors and institutions working on UILS are likely to occur.

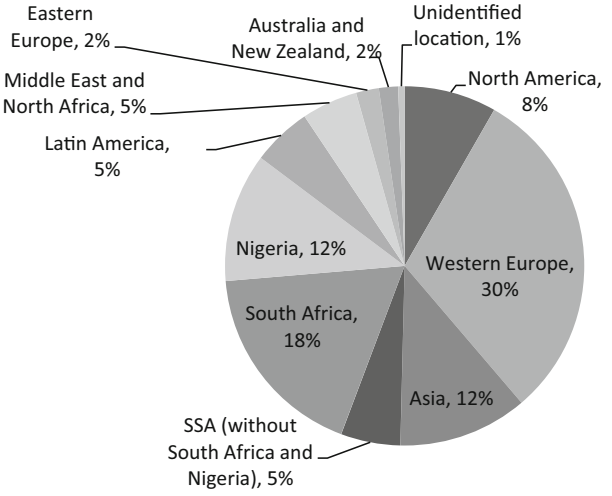

Fig. 7 % of citations per region

Table 4 Share (%) of citations per country

Countries	%
South Africa	18.7
Nigeria	12.1
USA	6.1
UK	6.1
Netherlands	4.3
Spain	4.1
Italy	3.7
China	3.7
Canada	2.4
Portugal	2.4
Brazil	2.3
India	2.3
Taiwan	1.7
Germany	1.6
South Korea	1.6
Sweden	1.6
France	1.4
Australia	1.4
Belgium	1.3
Kenya	1.2
Finland	1.1
Benin	1.1
Malasya	1.0
Subtotal	83.2
Iran, Norway, Switzerland, Ghana, Argentine, Mexico, Uganda, Russia, Mozambique, Ethiopia, Denmark, Colombia, New Zealand Chile, Turkey, Botswana, Peru, Tanzania, Morocco, Argelia, Jordan, Saudi Arabia, Japan, Rwanda, Senegal, Poland, Lithuania Cameroon, Austria, Philippines, Tunisia, Ireland, Pakistan, Croatia, Hungary, Slovenia, Malawi, Costa Rica, Gabon, Congo, Czech Republic, Hong Kong, Greece, Vietnam, Egypt, Serbia, Luxembourg, Bulgaria, Bangladesh, Slovakia, Latvia, Fiji, Cote d'Ivoire, Nepal, Swaziland, Iceland, Palestine, Cuba, Cyprus, Thailand, Undefined, Romania, Ecuador, Beyruth, Kuwait	Below 1
Subtotal	16.8

Table 5 displays the degree of centrality and degree of between-ness of authors. Matthew Olugbemiga Ilori (from Obafemi Awolowo University-Nigeria), has the highest degree of centrality (29), i.e., is the most prominent actor of the network, and Glenda Kruss (from the HSRC-South Africa) is the second most relevant actor (degree of centrality of 21). These are followed by 7 Nigerian-based scholars, namely Timothy Obeyisi, Abiola Adeniyi Adetokunbo, Willie Owulabi Siyanbola, Maruf Sanni, and I. A Irefin (all from Obafemi Awolowo University) and Olumuyiwa Olamade, Adiodun Egbetokun (from the National Centre for Technology Management of the Federal Ministry of Science and Technology). Then, in descending order of relevance, there are authors like Andrea Morrison (Utrecht University-Netherlands), Roberta Rabettoti (University of Pavia-Italy),

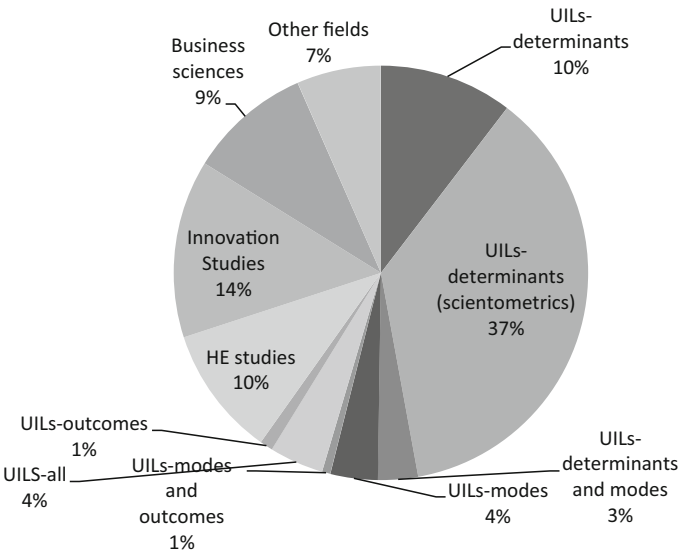

Fig. 8 % of citations per field

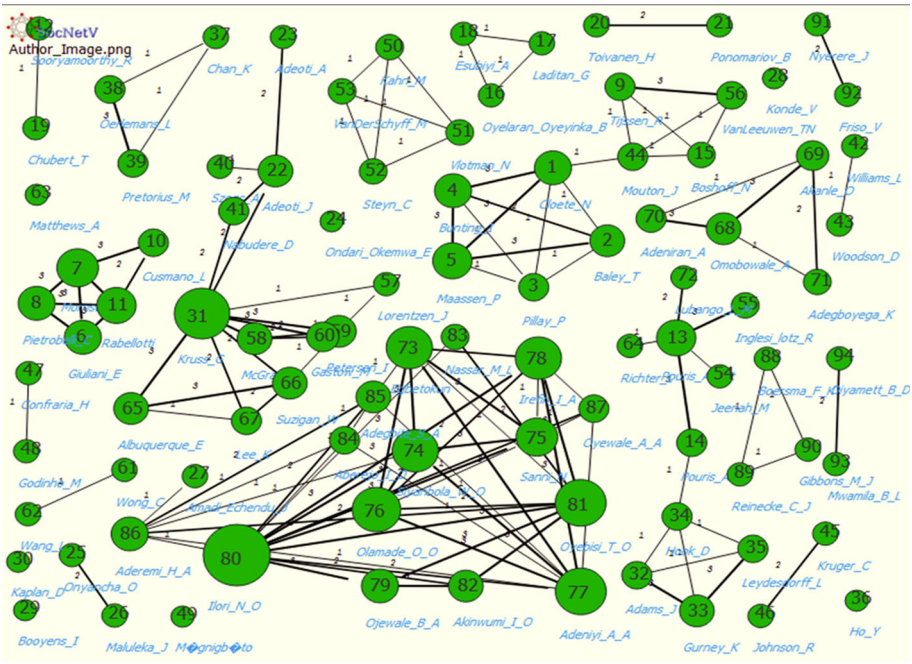

Fig. 9 Co-authorship Network of most cited authors

Nico Cloete (CHET-South Africa), Elisa Giuliani (University of Pisa-Italy), Carlo Pieotrobelli (University of Rome-Italy, UNU-MERRIT-Netherlands), B.A Ojewale, H. Aderemi, I.O. Akinwumi (Obafemi Awolowo University-Nigeria) John Adeoti (Nigerian

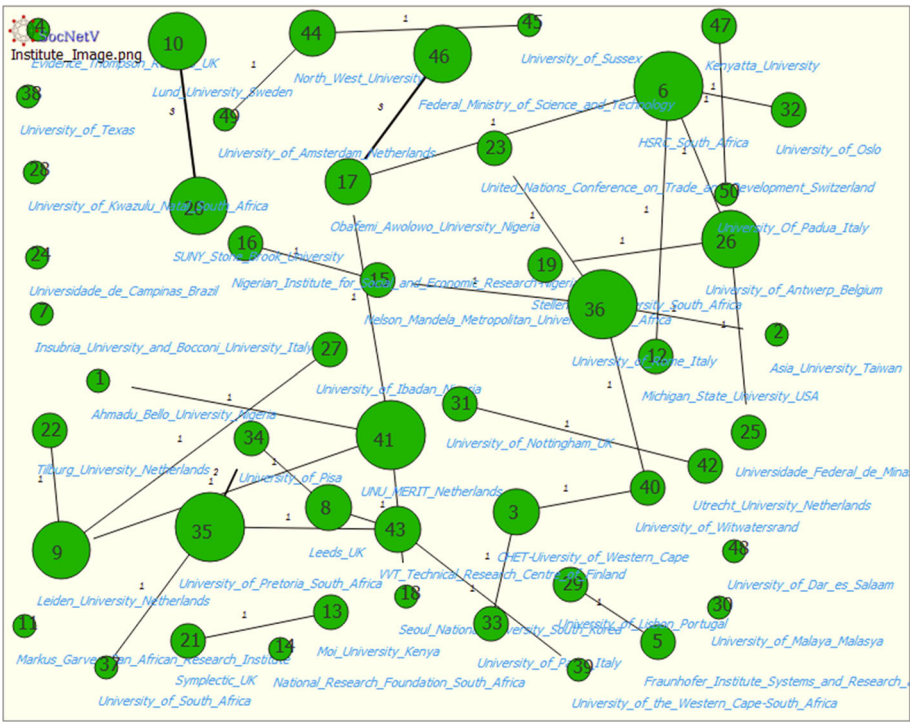

Fig. 10 Institutional Network

Institute for Social and Economic Research), Eduardo Albuquerque (Universidade Federal de Minas Gerais-Brazil), Peter Maassen (University of Oslo-Norway), Stephen Adegbite (Obafemi Awolowo University), Leon Olerlemans (Tilburg University-Netherlands), Simon McGrath (University of Nottingham-UK). In the top 40 are authors like Ian Bunting (CHET-South Africa), Tinus Pretorious (University of Pretoria), Pundy Pillay (University of Witwatersrand), Robert Tijssen (Leiden University-Netherlands), Anastassios Pouris (University of Pretoria), Michael Gastrow (HSRC-South Africa), and Wilson Suzigan (Universidade de Campinas-Brazil). In other words, the network is dominated by authors affiliated to South African and Nigerian institutions, followed by some affiliated to European (particularly Italian, Dutch) and Brazilian institutions. It is worth-mentioning the level of connectedness and influence of single authors from some countries, like John Adeoti from Nigeria, Peter Maassen from Norway and Simon McGrath from UK.

Table 5 shows that Glenda Kruss has the highest degree of between-ness, i.e., is the most influential broker among actors of the network. In the top 10, Glenda Kruss is followed by Matthew Olugbemiga Ilori (from Obafemi Awolowo University-Nigeria, Leon Olerlemans, Omwoyo Onyancha (University of South Africa), Nico Cloete, Johann Mouton (University of Western Cape and Stellenbosch University), H. Aderemi (Obafemi Awolowo University-Nigeria), Daniel Hook (Symplectic UK), John Adeoti, Banji Oyelaran-Oyeyinka (Nigerian Institute for Social and Economic Research). South African, Nigerian and some European (Dutch and British) authors are the main connectors among authors in the network.

Table 5 Measures of Centrality (Degree and Between-ness) of most cited authors

Rank	Author	Degree	Author	Between-ness
1	Ilori_M_O	29	Kruss_G	77
2	Kruss_G	21	Ilori_M_O	36
3	Oyebisi_T	19	Oerlemans_L	24
4	Adeniyi_A	18	Onyancha_O	19
5	Olamade_O	17	Cloete_N	16
6	Egbetokun_A_A	16	Aderemi_H_	16
7	Siyanbola_W_E	16	Mouton_J	15.5
8	Irefin_I_A	15	Hook_D	15
9	Sanni_M	12	Adeoti_J	13.5
10	Morrison_A	12	Oyelaran_O	12
11	Rabellotti_R	11	Oyebisi_T	11
12	Cloete_N	10	Pouris_Ana	9
13	Giuliani_E	9	Adeniyi_A	8
14	Pietrobelli_C	9	Egbetokun_A_A	3
15	Ojewale_B_	9	Adams_J	3
16	Aderemi_H_	9	Gurney_K	3
17	Akinwumi_I	8	Kahn_M	3
18	Adeoti_J	8	Siyanbola_W_O	2
19	Albuquerque_E	8	Irefin_I_A	2
20	Maassen_P	7	Sanni_M	2
21	Adegbite_S	7	Olamade_O_	2
22	Oerlemans_L	7	Adegbite_S	2
23	McGrath_S	7	Morrison_A	1
24	Bunting_I	6	Rabellotti_R	1
25	Chan_K	6	Tijssen_R	0.5
26	Pretorius_M	6	McGrath_S	0.5
27	Mouton_J	6	Oyewale_A	0.5
28	Bailey_T	5	Ojewale_B_	0
29	Oyewale_A_	5	Akinwumi_I	0
30	Pillay_P	5	Bailey_T	0
31	Tijssen_R	5	Pillay_P	0
32	Cusmano_L	5	Bunting_I	0
33	Pouris_Anas	5	Maassen_P	0
34	Onyancha_O	5	Giuliani_E	0
35	Adams_J	5	Pietrobelli_C	0
36	Gurney_K	5	Cusmano_L	0
37	Gastrow_M	5	Sooryamoorthy_R	0
38	Suzigan_W	5	Pouris_Ant	0
39	Boshoff_N	4	Boshoff_N	0
40	Oyelaran_O	4	Laditan_G	0
41	Van Leeuwen_T	4	Esubiyi_A	0
42	Petersen_I	4	Schubert_T	0
43	Lee_K	4	Toivanen_H	0

Table 5 continued

Rank	Author	Degree	Author	Between-ness
44	Aberejo_I_	4	Aberejo_I_	0
45	Toivanen_H	3	Ponomariov_B	0
46	Ponomariov_B	3	Adeoti_A	0
47	Adeoti_A	3	Ondari-Okemwa_E	0
48	Hook_D	3	Maluleka_J	0
49	Kahn_M	3	Amadi_Echendu_J	0
50	Omobowale_A	3	Konde_V	0
51	Akanle_O	3	Booyens_I	0
52	Adeniran_A	3	Kaplan_D	0
53	Nassar_M_L	3	Nassar_M_L	0
54	Adegboyega_K	3	Leydesdorf_L	0
55	Pouris_Ant	2	Ho_Y	0
56	Lubango_L	2	Lubango_L	0
57	Boersma_F	2	Boersma_F_	0
58	Reinecke_C	2	Reinecke_C	0
59	Gibbons_M	2	Gibbons_M_	0
60	Nyerere_J	2	Nyerere_J	0
61	Friso_V	2	Friso_V	0
62	Mwamila_B	2	Mwamila_B_	0
63	Diyamett_B	2	Diyamett_B	0
64	Laditan_G	2	Chan_K	0
65	Esubiyi_A	2	Pretorius_M	0
66	Maluleka_J	2	Szogs_A	0
67	Leydesdorf_L	2	Nabudere_D	0
68	Ho_Y	2	Williams_L	0
69	Szogs_A	2	Woodson_D	0
70	Nabudere_D	2	Kruger_C	0
71	Kruger_C	2	Johnson_R	0
72	Johnson_R	2	Confraria_H	0
73	Lorentzen_J	2	Godinho_M	0
74	Sooryamoorthy_R	1	Mêgnigbêto_E	0
75	Schubert_T	1	Vlotman_N	0
76	Williams_L	1	Steyn_C	0
77	Woodson_D	1	Van Der Schyff_M	0
78	Confraria_H	1	Jeenah_M	0
79	Godinho_M	1	Inglesi-lotz_R	0
80	Mêgnigbêto_E	1	Van Leeuwen_T	0
81	Vlotman_N	1	Lorentzen_J	0
82	Steyn_C	1	Petersen_I	0
83	Van Der Schyff_M	1	Gasrtow_M	0
84	Jeenah_M	1	Wong_C	0
85	Inglesi-lotz-R	1	Wang_L	0
86	Wong_C	1	Matthews_A	0

Table 5 continued

Rank	Author	Degree	Author	Between-ness
87	Wang_L	1	Richter_L	0
88	Richter_L	1	Albuquerque_E	0
89	Ondari-Okemwa_E	0	Suzigan_W	0
90	Amadi_Echendu_J	0	Lee_K	0
91	Konde_V	0	Omobowale_A	0
92	Booyens_I	0	Akanle_O	0
93	Kaplan_D	0	Adeniran_A	0
94	Matthews_A	0	Adegboyega_K	0

The power of South African, Nigerian and some European and Brazilian authors in the network is consistent with data on degree of centrality of institutions. The top 10 most powerful institutions are HSRC, University of Pisa, University of Pretoria, UNU-MERIT, Leeds, Nigerian Federal Ministry of Science and Technology (National Centre for Science and Technology), Obafemi Awolowo University, Leiden University, Stellenbosch University and University of Campinas, (Table 6). Table 6 also shows that the main connecting institutions are South African (e.g. HSRC, Pretoria, Witwatersrand, Western Cape), Nigerian (Nigerian Federal Ministry of Science and Technology, Obafemi Awolowo University, Institute for Social Economic Research) Italian (e.g. University of Pisa), Brazilian (e.g. University of Campinas) and Dutch (UNU-MERRIT).

The state of theory and main findings

The publications were analysed to systematise their main findings and state of theory. Three frameworks were used to examine the state of the theory on UILs in SSA. Firstly, the classification of different developing countries by Ribeiro et al. (2009). According to Ribeiro et al. (2009), when indicators of scientific production (WoS-indexed publications), technological production (patents) and wealth (GDP per capita) are correlated, countries may be grouped into three clusters or regimes of interaction, namely:

1. Countries with low scientific production tend to have low technological production and low GDP per capita and thus they belong to regime I (e.g. low income-countries);
2. Countries with middle scientific production tend to have middle technological production and middle GDP per capita and thus they belong to regime II (e.g. middle-income countries); and
3. Countries with high level of publications tend to have high level of patents and high level of GDP per capita, being group in regime III (e.g. high-income countries). Countries can move from one regime to another over time, depending on their speed in the catching-up process.

Secondly, differences in approaches of innovation: the narrow approach or STI mode, based on new-to-the world innovations or codified knowledge (e.g. patents, publications) prevailing in mature innovation systems (e.g. developed countries); and the broader

Table 6 Centrality measures (degree and between-ness) of most cited authors' institutional affiliations

Rank	Institutional affiliation	Degree	Institutions	Between-ness
1	HSRC_South_Africa	4	HSRC_South_Africa	42
2	University_of_Pisa_Italy	4	UNU_MERIT_Netherlands	42
3	University_of_Pretoria_South_Africa	4	Nigerian_Institute_for_Social_and_Economic_Research-Nigeria	36
4	UNU_MERIT_Netherlands	4	Leeds_UK	21
5	Leeds_UK	3	Universidade_de_Campinas_Brazil	21
6	Federal Ministry of Science and Technology- (National Centre for Technology Management)-Nigeria	3	Obafemi_Awolowo_University_Nigeria	20
7	Obafemi_Awolowo_University_Nigeria	3	Federal Ministry of Science and Technology- (National Centre for Technology Management)-Nigeria	18
8	Leiden_University_Netherlands	3	University_of_Pretoria_South_Africa	17
9	Stellenbosch_University_South_Africa	3	University of Witwatersrand_South Africa	10
10	Universidade_de_Campinas_Brazil	3	CHET-Uiversity_of_Western_Cape	6
11	University_of_Nottingham_UK	3	National_Research_Foundation_South_Africa"	6
12	VVT_Technical_Research_Centre_of_Finland	3	University_of_Pisa_Italy	5
13	CHET-Uiversity_of_Western_Cape	2	VVT_Technical_Research_Centre_of_Finland	5
14	Insubria_University_and_Bocconi_University_Italy	2	Insubria_University_and_Bocconi_University_Italy	1
15	National_Research_Foundation_South_Africa	2	University_of_Nottingham_UK	1
16	Nigerian_Institute_for_Social_and_Economic_Research-Nigeria	2	Ahmadu_Bello_University_Nigeria	0
17	University of Witwatersrand_South Africa	2	Asia_University_Taiwan	0
18	Ahmadu_Bello_University_Nigeria	1	Evidence_Thompson_Reuters_UK	0
19	Asia_University_Taiwan	1	Fraunhofer_Institute_Systems_and_Research_and_Karrlsrube_Germany	0
20	Fraunhofer_Institute_Systems_and_Research_and_Karrlsrube_Germany	1	University_of_the_Western_Cape-South_Africa	0
21	Markus_Garvey_Pan_African_Research_Institute	1	Leiden_University_Netherlands	0
22	Michigan_State_University_USA	1	Lund_University_Sweden	0
23	Nelson_Mandela_Metropolitan_University_South_Africa	1	Markus_Garvey_Pan_African_Research_Institute	0
24	Kenyatta University_Kenya	1	Michigan_State_University_USA	0

Table 6 continued

Rank	Institutional affiliation	Degree	Institutions	Between-ness
25	Seoul_National_University_South_Korea	1	Moi_University_Kenya	0
26	SUNY Stone Brook University_USA	1	Nelson_Mandela_Metropolitan_University_South_Africa"	0
27	Symplectic_UK	1	Obafemi_Awolowo_University_Nigeria	0
28	Tilburg_University_Netherlands	1	Seoul_National_University_South_Korea	0
29	University_of_Oslo	1	Stellenbosch_University_South_Africa	0
30	Universidade_Federal_Minas_Gerais_Brazil	1	SUNY Stone Brook University_USA	0
31	University_of_Antwerp_Belgium	1	Symplectic_UK	0
32	University_of_Kwazulu_Natal_South_Africa	1	Tilburg_University_Netherlands	0
33	University_of_Lisbon_Portugal	1	United_Nations_Conference_on_Trade_and_Development_Switzerland	0
34	University_of_Malaya_Malasya	1	University_of_Oslo	0
35	University_of_Rome_Italy	1	Universidade_Federal_Minas_Gerais_Brazil	0
36	University of Texas_USA	1	University_of_Pavia_Italy	0
37	Utrecht_University_Netherlands	1	University_of_Antwerp_Belgium	0
38	Evidence_Thompson_Reuters_UK	0	University_of_Ibadan_Nigeria	0
39	University_of_the_Western_Cape-South_Africa	0	University_of_Kwazulu_Natal_South_Africa	0
40	Lund_University_Sweden	0	University_of_Lisbon_Portugal	0
41	Moi_University_Kenya	0	University_of_Malaya_Malasya	0
42	United_Nations_Conference_on_Trade_and_Development_Switzerland	0	University_of_Rome_Italy	0
43	University_of_Pavia_Italy	0	University_of_South_Africa	0
44	University_of_Ibadan_Nigeria	0	University of Texas_USA	0
45	University_of_South_Africa	0	Utrecht_University_Netherlands	0
46	University of Sussex_UK	0	University of Sussex_UK	0
47	North-West University_South Africa	0	North-West University_South Africa	0
48	University of Dar es Salaam_Tanzania	0	University of Dar es Salaam_Tanzania	0
49	University of Padua-Italy	0	University of Padua-Italy	0

Table 6 continued

Rank	Institutional affiliation	Degree	Institutions	Between-ness
50	University of Amsterdam_Netherlands	0	University of Amsterdam_Netherlands	0

approaches DUI-mode, based on tacit knowledge and on personal and organizational competences, prevailing in developing countries (Zanello et al. 2015; Lundvall et al. 2009; Lorentzen and Mohamed 2009).

Thirdly, the descriptive frameworks of UILs. According to Arza (2010)'s taxonomy, the patterns of UILs may take four forms depending on universities and firms' motivations to collaborate: (1) *traditional*: when universities are triggered by intellectual motivations and firms by passive strategies; firms benefit from universities' traditional teaching and research (e.g. hiring graduates, conferences) and universities benefit from firms' financial assistance to support academic functions (e.g. scholarships, facilities) without imposing conditions to universities' intellectual projects; (2) *services*: when universities are triggered by economic motivations and firms by passive strategies; UILs often involve universities providing firms with scientific-technological services in exchange for money (e.g. consultancy, training of employees); (3) *commercial*: when universities are triggered by economic motivations and firms by proactive strategies; UILs consist of universities commercialising their research output (e.g. patenting and licensing, incubators) to firms; and (4) *bi-directional*: when universities are triggered by intellectual motivations and firms by proactive strategies; UILs are motivated by long-term objectives of knowledge creation by universities and innovation by firms (e.g. joint R&D projects, contract research, etc.), with knowledge flowing in both directions (from universities to firms and vice versa). Other classifications were suggested, namely: the degree of (in) formality (institutionalized vs. personalized UILs, D'Este and Patel 2007), the intensity of interaction (breadth or depth of UILs, Wang et al. 2015), the nature of universities and firms' sectors involved (teaching or research-intensive institutions; low vs. high-tech firms).

Theory shows heterogeneity of UILs in SSA: SSA countries belong to different regimes, have different innovation modes and display different patterns of UILs. Overall, literature suggests South Africa as an exception, being the richest SSA country. South Africa is in regime II since 1974 (Kruss et al. 2015a): it owns a relatively mature NIS (Kahn et al. 2007; Kahn 2013), produces more and better science and technology (Tijssen 2007; Pouris 2012a), owns more academically capable universities (Cloete et al. 2015) and technologically capable firms (Kruss et al. 2012, 2015b), has more incentives for fostering UILs (Letseka 2005). Given these conditions, South Africa displays rather strong, formal, direct and knowledge-intensive UILs (Cooper 2009, 2011; Kruss et al. 2012). Nevertheless, even in South Africa, heterogeneity exists: historically-advantaged universities, with strong research base, display rather formal, institutionalized and STI-based UILs, channelled through traditional (e.g. publications), commercial and bi-directional modes (e.g. licensing, patents); historically-disadvantaged universities display rather informal, DUI-based UILs, channelled mainly through traditional (e.g. hiring of graduates, conferences) and service (consultancy) modes (Kruss 2005, 2012b). With the emergency of inclusive innovation paradigm, incipient research unveils the potential of collaboration between universities and informal actors in South Africa (Kruss and Gastrow 2016).

Most of the other SSA countries remain in regime I since independence. They own undeveloped NISs characterized by low scientific outputs, low academic capability of universities and less technologically endowed firms. Given these conditions, most SSA countries displaying rather weak, informal and indirect UILs, mostly rooted in DUI innovation such as conferences, hiring of graduates and consultancies for cross-national studies, (see Mihyo 2013; Kruss and Petersen 2009; for national studies, Vera-Cruz 2014, for Cape Verde; Oyelaran-Oyeyinka et al. 1996, for Nigeria). However, there are differences across African countries. While both Nigeria and Uganda display relatively weak UILs, based on incremental innovation, Uganda profits from a favourable public policy

(Kruss et al. 2012). Likewise, Konde (2004) reports a successful case of commercialisation of university services in Zambia. Like in South Africa, literature on other countries also reports ad-hoc initiatives of linking universities to informal actors (Szogs et al. 2011). Except for South Africa, where some firms report long-term innovation benefits, in most SSA countries, benefits are concerned with short-term production for firms, and more intellectual than economic benefits for universities (Kruss et al. 2012; Kruss and Petersen 2009).

Conclusions

In this paper, we performed a systematic literature review of UILs with focus on SSA. The paper addressed the evolution, sources, main research questions, units of analysis, methods, countries researched, and the influence of this literature, as well as the social networks of authors who produced this literature. The paper also addressed the literature's main findings and state of theory.

The findings demonstrate that, while SSA continues to be a relatively under researched terrain, the emerging literature targeting the continent is noticeable and substantial than it is often portrayed by global systematic reviews (Teixeira and Mota 2012). Research on UILs in SSA is a recent phenomenon, and its emerging status is consistent with the global literature, which has mainly been produced in 2000s (Teixeira and Mota 2012). SSA literature on UILs has consistently been published from 2005 onwards, the year coinciding with the launching of the first large project on UILs in developing countries (Albuquerque et al. 2015).

The SNA revealed that the social and scientific community producing UILs' research focusing on SSA is small and characterized rather by a weak connectivity among the authors. There is also greater degree of centrality and between-ness of authors based in South Africa, Nigeria, Brazil, Netherlands, Italy, UK and Norway. In other words, authors based in the above mentioned countries occupy powerful and broker positions (nodes) in the networks. These authors are more likely to be influential and collaborate with authors based in other parts of the world.

The analysis of journals and book publishers reveals the multi-disciplinary nature of the field of UILs, a trait consistent with findings from systematic literature review on global literature (Teixeira and Mota 2012). It also reveals that its knowledge producers and publishing market reflects the hegemonic international scientific landscape, dominated by developed countries outside the African continent and by South Africa inside the continent. In SSA, South Africa and Nigeria are the research hub on UILs and home of leading authors. They are also the most researched SSA country. The dominance of South Africa, Nigeria and developed countries, both as knowledge producers and consumers, is also reflected in the patterns of citations. Other SSA countries seem to suffer from a double neglect: they are under-researched, but also ignored when research on them is produced.

The nature of research questions addressed by the literature on UILs in SSA demonstrates the need for producing further research on core questions of UILs.

Our findings suggest that existing literature seems to focus on the surrounding scientific, technological and institutional conditions of NIS, internal capabilities of universities and firms enabling them to foster UILs. The core research questions, particularly regarding the modes of interaction, the kind of knowledge and resources universities and firms' exchange, and the outcomes yielded from these processes are still under-researched. In

other words, the mechanisms of knowledge transfer between universities and firms in most African countries, particularly low-income countries, are still under-conceptualized. This is because these mechanisms are often inferred from macro data based on NIS or even on data about the capabilities of universities and firms. Further and in-depth research is still needed to explore the ways through which universities and firms collaborate. As Kruss et al. (2012) demonstrated, there may be niches of positive and successful cases in African low-income countries. To capture these cases, in-depth research is needed.

Since 2013, a new trend in the literature addressing the issue of knowledge transfer between university and stakeholder in the informal economic sector is emerging (see: Oluwale et al. 2013; Kawooya 2014; Kruss and Gastrow 2016; Grobbelaar et al. 2017), This literature suggests that there is a new research approach and interest on SSA which examines the linkages between universities and an array of other potential beneficiaries of the knowledge produced by African universities. Despite being in its inception stages of development, there is a growing interest towards research on NIS and UILs in SSA.

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