Additive manufacturing technologies for biomedical engineering applications: **Research trends and scientific impact**

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Abstract

Additive Manufacturing (AM) technologies, technologies that produce three-dimensional parts layer by layer from a material, have the potential to revolutionize the paradigm of manufacturing. Furthermore, in recent years AM technologies have sparked intense interest for developing medical implants, devices, and scaffolds. In this context, the main objective of this article is to present an overall view of the trends and the impact of the research carried out in AM technologies for biomedical engineering applications. Therefore, to achieve the main objective, a research trend and scientific impact analysis model was designed and implemented, to carry out a bibliometric indicator analysis, in general, and a web indicator analysis, in particular. The findings obtained will advance the means of visualizing the state of research in AM for biomedical engineering technologies.

Keywords

Additive manufacturing; Biomedical engineering; Bibliometric analysis; Web indicators; Webometrics.

1. Introduction

The term "Industry 4.0" is used to indicate the fourth industrial revolution, a new industrial model enabled by the introduction of the Internet of Things into the production and manufacturing environment (**Tjahjono** *et al.*, 2017). To achieve this new paradigm, Industry 4.0 is based on a set of key technologies that, when combined, make this new industrial model possible. Thereby, nine technologies are transforming industrial production: Big data and analytics, autonomous robots, simulation, horizontal and vertical system integration, the industrial internet of things, cyber security, the cloud, augmented reality, and additive manufacturing (AM).

In this context, one of the most visible elements of Industry 4.0 is the growth of AM technologies (**Cruickshank**, 2017), technologies that can produce desired parts faster, more flexibly and more precisely than ever before, i.e., technologies that can produce higher-quality goods at reduced costs.

These technologies produce three-dimensional parts layer by layer from a material and have the potential to revolutionize the paradigm of manufacturing (**Quarshie** *et al.*, 2012). In terms of industry specifics, AM has thrived considerably in particular areas over the last few years (*AM Platform*, 2014). The technology cuts across a large number of industries and applications, and that is part of what makes its potential so compelling. Aerospace, automotive, and medical products, among others, will drive AM into the future (**Bourell; Leu; Rosen**, 2009). Specifically, in recent years AM technologies have sparked intense interest for developing, among other things, medical implants, devices, and medical scaffolds (**Singh; Ramakrishna**, 2017).

Thus, in recent years the research community has worked to develop and improve the knowledge landscape of these research fields; however, the trends and the impact of such work have not been analyzed. Assessing trends and the value of research is becoming increasingly important (**Thelwall**; **Kousha**, 2015a; 2015b; **Thelwall**, 2016; **Filser**; **Da-Silva**; **De-Oliveira**, 2017) and the need to evaluate the research carried out by organizations involved in research and development and innovation (R&D&I) processes has increased dramatically in recent years.

In this way, the main aims of this study are to present an overall view of the trends and the impact of the research carried out in AM technologies for biomedical engineering applications.

The findings obtained will advance means of visualizing the state of research into AM technologies for biomedical applications. This will help, on the one hand, to better understand how structured this research field is and how it is growing, as well as identify the major actors. On the other hand, it will provide a better understanding of the impact or the benefits that research into these technologies has in different fields. This study will make it possible to know the evolution of the existing literature on technologies that will change, among other things, productive systems, skills, and well-being

(*OECD*, 2016), and that will have great implications for policy makers (**Campbell** *et al.*, 2011).

2. Research methodology

The main goal of the study is to present an overall view of the trends and the impact of research carried out on a technology. To do so, this article carries out a bibliometric indicator analysis, in general, and a web indicator analysis in particular.

A bibliometric analysis is a quantitative method that, based on analysis of related publications, allows the knowledge structure and the development of research fields to be examined (**Jing**; **Qinghua**; **Landström**, 2017). In this way, the simplest bibliometric indicator is the number of publications in a particular field. However, other indicators, such as cited references and citation counts, have gained importance for evaluating research performance and impact (**Holmberg**, 2015; **Marx**; **Bornmann**, 2016).

Web indicator analysis is a quantitative method that evaluates web indicators, where a web indicator is a number that is ideally associated with an aspect of research performance or impact, and that is derived from the Web and in no way based on counts of citations from academic journal articles. Therefore, different web



Figure 1. Workflow of research trends and scientific impact analysis model

indicators can show, among other things, the academic; educational; commercial and industrial; and public engagement impact of a set of publications (**Thelwall**, 2016).

Figure 1 shows the overall procedure for analyzing the trends and the impact of the research carried out on different technologies. The research methodology starts with the selection and determination of the targeted technologies; the second step consists of identifying relevant keywords; and, next is the selection of primary search engines and the adaptation of the query to the selected databases. These steps are fundamental and expert assessment is used to evaluate all of them. Next, a bibliometric indicator analysis, in general, and a web indicator analysis, in particular, are carried out. These include, on the one hand, the identification of main bibliometric indicators to obtain scientific publication trends and impact results, and on the other hand, the identification of main web indicators that further examine the knowledge of publication impact results. Finally, the state of research is visualized with the findings obtained.

2.1. Application of the proposed model to AM technologies for biomedical engineering applications

The research trends and scientific impact analysis model proposed in figure 1 were implemented for technologies for biomedical engineering applications.

Thus, we began with the selection and determination of AM technologies as targeted technologies, and more specifically, for biomedical engineering applications. This decision was made with the help of an expert in the field¹.

After that, in collaboration with the expert throughout the whole process, and based on studies in AM technologies (*Gridlogics Technologies Pvt Ltd*, 2014; **Rodríguez-Salvador**; **Río-Belver**; **Garechana-Anacabe**, 2017), a proper set of terms related to Additive Manufacturing and Bioprinting technologies was defined (see figure 2). To this end, two main terminology blocks were built: (1) Additive Manufacturing and bioprinting terms and (2) exclusion terms.



Figure 2. Main terminology related to additive manufacturing and bioprinting technologies.

Note: Words with an asterisk (*) are root words, i.e., these words plus all possible suffixes are contemplated in the query.

Based on (Gridlogics Technologies Pvt Ltd, 2014; Rodríguez-Salvador; Río-Belver; Garechana-Anacabe, 2017)

In addition, in order to find biomedical engineering applications of these technologies, the research query was completed by using the set of terms defined only in the 78 journals categorized in biomedical engineering, established in *Journal Citation Reports (JCR)*; the *JCR* year selected was 2017 (see Appendix).

In this study, the selected primary search engine was the *Web of Science (WoS)* database, since it offers comprehensive coverage of scientific journals with multidisciplinary information from over 18,000 high impact journals (**Filser**; **Da-Silva**; **De-Oliveira**, 2017; *Clarivate*, 2018).

The publications obtained from the WoS Core Collection were gathered and analyzed, making it possible to present an

overall view of the trends and the impact of the research carried out in AM technologies for biomedical engineering applications (see table 1 and figure 3).

Table 1. Analysis of the results obtained for det	ermining research trends a	and impact in AM technold	ogies for biomedical engir	neering applications
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Research trends										
Bibliometric indicators	Variables analyzed	Software to gather, clean, analyze and visualize articles data								
 Number of articles published Cited references of the articles studied 	 Publication year Country Affiliation Journal Author Research area Keywords 	 VantagePoint v.10 A powerful text-mining tool for discovering knowledge in search results from patent and literature databases (Vantage-Point, 2018). VOSViewer Software that allows the visualization of bibliometric networ- 								
Type of documents and time span: Scientific articles, from 2000 to 201	7	ks (VOSviewer, 2018).								
	Research i	impact								
Bibliometric indicator	Impact type	Software to gather and analyze web data								
- Citation counts	- Academic impact									
Web indicator	Impact type									
 Mendeley readers Wikipedia citations 	- Academic impact	Webometrics Analyst 2.0 Free software designed to conduct automatic web analyses of various types for social science research purposes (Thelwall , 2009a:								
- Google Patents citations	- Industrial and commercial impact	2009b).								
Type of documents and time span: and China), from 2006 to 2015	Scientific articles (from World, USA									



Figure 3. Research trends and scientific impact analysis model to determine research trends and impact in AM technologies for biomedical engineering applications

The two bibliometric indicators used to analyze research trend performance from the chosen variables (Publication year, Country, Affiliation, Journal, Author, Research area, and Keywords) were the usual bibliometric indicator number of articles published (when, where, who, and what is researching) and cited references of the articles studied (where does knowledge come from). The first was a quantitative output of research activity while the second brought a change of perspective and measured what the knowledge sources of AM technologies for biomedical engineering applications were (Diem; Wolter, 2013; Holmberg, 2015; Marx; Bornmann, 2016; Filser; Da-Silva; De-Oliveira, 2017).

It was not possible to obtain directly the country and the affiliation of the cited references from the *WoS* database. Therefore, all cited references under study were obtained from their DOI from the *WoS* database.

The software used to gather, clean, analyze, and visualize article data were *VantagePoint* and *VOSviewer*. As far as the mapping and clustering of bibliographic networks was concerned, the *VOS* mapping technique was used (**Van-Eck**; **Waltman**, 2007). We used the *VOSviewer* software to apply this technique (**Van-Eck**; **Waltman**, 2011). In this case, the mapping technique was performed on the basis of the co-occurrence matrix and the similarity matrix, the latter being obtained from the application in the co-occurrence matrix similarity measures, specifically known as the associative strength (**Van-Eck**; **Waltman**, 2009; 2010). The map that was defined based on similarity indicated the degree of relationship between the terms, i.e., a close position indicated a high degree of relationship between the items. In addition, the clustering technique, based on the *VOS* mapping technique (**Waltman**; **Van-Eck**; **Noyons**, 2010), made it possible to group items into research fields.

As far as the analysis of the impact of research was concerned, we used another bibliometric indicator called citation counts, i.e., how often each of the publications was cited in the *WoS* database. In addition, web indicators were also used to measure the impact of publications. Although there are many different types of web indicators, in this case, academic plus industrial and commercial impact indicators were used. The academic impact was measured from *Mendeley* readers (*Mendeley* readers of lists of scientific articles gathered) and *Wikipedia* citations (*Wikipedia* citations to a list of scientific articles gathered). And finally, the industrial and commercial impact was measured from *Google Patents* citations (citations from patents to a list of scientific articles gathered) (**Thelwall**, 2016). The software used to gather and analyze web data was *Webometrics Analyst* (**Thelwall**, 2009a; 2009b).

The type of documents analyzed was articles because, when calculating field normalized indicators, it is best to analyze only one document type—usually articles (**Thelwall**, 2018).

In the case of bibliometric analysis, articles published from 2000 to 2017 were analyzed. For impact indicator analysis, the years chosen for the analysis were from 2006 to 2015, i.e. a decade. The first few years were ignored due to the scarcity of results and it was decided that 2015 would be the last year analyzed as this left a performance interval of more than two years until the present, making it possible to analyze the impact of recently published articles in the field of interest. Also, it was analyzed if the research from predominant countries (countries with the highest number of publications) has higher impact than the world average.

3. Results

The query found 1,223 journal articles published from 2000 to 2017 concerning AM technologies for biomedical engineering applications (see appendix), and 33,868 references cited in those articles.

In order to analyze the most significant references, only those that were cited more than 5 times were taken into account. Thus, the sample was reduced to 778 documents. From those 778 documents it was possible to obtain the DOI of only 744 references, and finally, it was possible to find 737 of those documents in the *Web of Science Core Collection*. Therefore, the number of references analyzed was 737.

For impact analysis, the query used recovered the number of articles shown in Table 2 (see appendix).

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Articles	31	32	46	64	56	64	66	100	108	158

The analysis of the results obtained is described in the following sections.

3.1. Research trends

To identify where and how technologies emerge, scientific publication trends have been drawn after the results obtained from *WoS* analyses. More specifically, the section structures and analyzes the variables "Publication year", "Country", "Affiliation", "Author", "Journal", "Keywords", and "Research area" of the articles retrieved, and their cites, in AM technologies for biomedical engineering applications.

3.1.1. Publication year analysis

Although there were articles published after 2000, the greatest activity was in recent years. Figure 4 shows that article publication growth was exponential (the coefficient of determination is $R^2 = 0.8857$) and that the instant growth rate was 0.2943.



Figure 4. Annual article publications in AM for biomedical engineering applications from 2000 to 2017

It can be seen that, in recent years, AM technologies for biomedical engineering applications have become of growing interest and with very intensive article publication.

Figure 4 shows that article publication growth follows the bibliometric law of exponential growth (Derek J. de Solla Price's law) (**Ardanuy**, 2012). According to that law, the scientific production in this field is in the phase of exponential growth, i.e., it is an emerging research front.

3.1.2. Country analysis

The predominant country, by far, with the highest number of publications, and with the highest number of cited references, is the USA (see table 3). More than 34% of all articles published on AM technologies for biomedical engineering applications, and more than 50% of the references analyzed, were from that country. Therefore, the country with the greatest research activity in that field, and providing most knowledge, was the USA.

China also has extensive research activity; however, its contribution to this particular field has been secondary: despite being the second country with the highest number of publications (17.09% of the articles), it is relegated to ninth position in the rank of cited countries (3.93% of the cited references).

In addition, except on two occasions, there was a relationship between the countries that provided knowledge (countries referenced) and the countries that were researching the subject in question.

	Research	carried out in AM fo	r BE	Research used to develop research in AM for BE						
	(Wh	ere researching is)		(Where knowledge comes from)						
#	Country	# of articles	% of articles	#	Cited Country	# of times cited	% of references			
1	USA	425	34.75%	1	USA	375	50.88%			
2	China	209	17.09%	2	Germany	72	9.77%			
3	Germany	121	9.89%	3	Netherlands	54	7.33%			
4	South Korea	100	8.18%	4	South Korea	47	6.38%			
5	England	77	6.30%	5	England	41	5.56%			
6	Italy	69	5.64%	6	Japan	33	4.48%			
7	Japan	68	5.56%	7	France	32	4.34%			
8	Netherlands	61	4.99%	8	Singapore	32	4.34%			
9	Australia	52	4.25%	9	China	29	3.93%			
10	Canada	48	3.92%	10	Australia	27	3.66%			

Table 3. The 10 most frequent affiliation countries and the 10 most cited countries

3.1.3. Institution analysis

The top publishing and cited institutions are universities (see table 4).

The institution that has published the most articles about AM technologies for biomedical engineering applications is the *Massachusetts Institute of Technology* (36 articles) and the institution that has been the most cited is *Harvard University* (72 articles), closely followed by the *Massachusetts Institute of Technology* (70 articles), both from the USA.

On five occasions, the institutions from which the knowledge comes from matches the institution where the research is being developed.

3.1.4. Journal analysis

Table 5 provides an overview of the 10 journals with the most occurrences.

The journal *Biomaterials* was the most prolific journal in AM technologies for biomedical engineering applications and also the most cited.

As expected, all the journals that publish research carried out in AM for biomedical engineering are journals that specialize in biomedical engineering. Other less specific journals have also been cited, therefore the knowledge also comes from other research fields such as life and physical sciences. Even so, in this case too, there was some correspondence between journals that published articles about AM technologies for biomedical engineering applications and journals cited in these articles.

	Resea	arch carried (Where rese	out in AM fo arching is)	r BE		Research used to develop research in AM for BE (Where knowledge comes from)						
#	Institution	Type of institu- tion	Country	# of ar- ticles	% of articles	#	Cited institu- tion	Type of institu- tion	Country	# of times cited	% of cites	
1	MIT	University	USA	36	2.94%	1	Harvard Univ.	University	USA	72	9.77%	
2	Pohang Univ. Sci. & Technol.	University	South Korea	33	2.70%	2	MIT	University	USA	70	9.50%	
3	Harvard Univ.	University	USA	32	2.62%	3	Univ. Michigan	University	USA	32	4.34%	
4	Zhejiang Univ.	University	China	30	2.45%	4	Univ. Twente	University	Netherlands	22	2.99%	
5	Univ. Twente	University	Nether- lands	27	2.21%	5	Rice Univ.	University	USA	20	2.71%	
6	Queensland Univ. Technol.	University	Australia	19	1.55%	6	Pohang Univ. Sci. & Technol.	University	South Korea	19	2.58%	
7	Shanghai Jiao Tong Univ.	University	China	18	1.47%	7	Univ. Utrecht	University	Netherlands	19	2.58%	
8	Univ. Michigan	University	USA	18	1.47%	8	Clemson Univ.	University	USA	18	2.44%	
9	Univ. Med. Ctr. Utrecht	University	Nether- lands	17	1.39%	9	Drexel Univ.	University	USA	18	2.44%	
10	Univ. Wurzburg	University	Germany	17	1.39%	10	Natl. Univ. Sin- gapore	University	Singapore	18	2.44%	

Table 4. The 10 most frequent organizational affiliations and the 10 most cited organizational affiliations

Table 5. The 10 most frequent journals

	Research carried out in AM for BE (Who researching is)						Research used to develop research in AM for BE (Who knowled- ge comes from)								
#	Journal	# of ar- ticles	Field of re- search	Quar- tile	JCR 2017	% of articles	#	Cited jour- nal	# of times cited	Field of research	Quar- tile	JCR 2017	% of cites		
			Engineering, Biomedical	Q1						Engineering, Biomedical	Q1				
1 Biomaterial	Biomaterials	172	Materials scien- ce, Biomaterials	Q1	8.806	14.06%	1	Biomaterials	164	Materials science, Bio- materials	Q1	8.806	22.25%		
	Piofabrica		Engineering, Biomedical	Q1					A - 4 -		Engineering, Biomedical	Q1			
2	tion	161	Materials scien- ce, Biomaterials	Q1	6.838	13.16%	2	Biomater	40	Materials science, Bio- materials	Q1	6.383	5.43%		
	J. Biomed.		Engineering, Biomedical	Q1						Diefebries		Engineering, Biomedical	Q1		
3	Mater. Res. Part A	127	Materials scien- ce, Biomaterials	Q2	3.231	231 10.38%	3	Biofabrica- tion	34	Materials science, Bio- materials	Q1	6.838	4.61%		
	Acta Bio-		Engineering, Biomedical	Q1						Biotechnolo- gy & Applied microbiology	Q2	3.508			
4	mater	125	Materials scien-		6.383 10.2	10.22%	4	4 Tissue Eng	25	Cell Biology	Q2		3.39%		
			ce, Biomaterials	Q1						Cell & Tissue Engineering	Q3				

			Engineering,	Q1						Chemistry, Multidiscipli- nary	Q1		
			biomedical							Chemistry, Physical	Q1		
5	Adv. Healthc.	60	Materials scien-	01 5 609	5.609	4.91%	5	Adv. Mater	22	Materials science, Multidiscipli- nary	Q1	_	2.99%
	mater		ce, biomateriais							Nanoscience & Nanotech- nology	Q1		
			Neurosianas 0							Physics, Applied	Q1		
			Nanoscience & Nanotechnology	Q2						Physics, Condensed matter	Q1	_	
	J. Mater.	Eng Bic	Engineering, Biomedical	Q2	2.448					Biochemistry & Molecular biology	Q1		
6	SciMater. Med	56	Materials scien-	00		4.58%	6	Biomacromo- lecules	20	Chemistry, Organic	Q1	5.738	2.71%
			ce, Biomaterials	Q3						Polymer science	Q1		
_	J. Mech. Be-		Engineering, Biomedical	Q1	2 2 2 2 2	39 3.60%	-	Science	10	Multidis-	01	44.050	2 500/
	Mater	44	Materials scien- ce, Biomaterials	Q2	3.239				19	sciences	QI	41.058	2.58%
	J. Biomed.		Engineering, Biomedical	Q1	3.373			L Diama d	18	Engineering, Biomedical	Q1	3.652	
8	Mater. Res. Part B	42	Materials scien- ce, Biomaterials	Q2		3.43%	8	Mater. Res		Materials science, Bio- materials	Q1	(JCR 2004)	2.44%
	Ann Bin		Fueringering					J. Biomed.		Engineering, Biomedical	Q1		
9	med. Eng	41	Biomedical	Q1	3.405	3.35%	9	Mater. Res. Part A	17	Materials science, Bio- materials	Q2	3.231	2.31%
	Proc. Inst.	pc. Inst.			J. Mater.		Engineering, Biomedical	Q2					
10	10 Proc. Inst. Mech. Eng. Part H-J. Eng. Med	29	Engineering, Biomedical	Q4	1.124	124 2.37%		10 SciMater. Med	16	Materials science, Bio- materials	Q3	2.448	2.17%

3.1.5. Author analysis

Table 6 shows the 10 authors with the most occurrences and the 10 most cited authors. Among all the authors, the two most prominent are Dong-Woo Cho and Ali Khademhosseini. In addition to being the authors with more articles published about AM technologies for biomedical applications, they were also the most cited.

3.1.6. Research area analysis

According to the categories of the *Web of Science*, in all cases, as expected, articles studied were in the "Engineering, Biomedical" category, but in most cases, also in the "Materials Science, Biomaterials" category (see figure 5). In the case of cited documents, i.e. in the case of the knowledge used, the two predominant areas were the same (see figure 6). Therefore, the importance of Materials Sciences and Biomaterials for that field was noted.

The institution that has published the most articles about AM technologies for biomedical engineering applications is the *Massachusetts Institute of Technology* (36 articles) and the institution that has been the most cited is *Harvard University* (72 articles)

	Researd (ch carried o Who resear	ut in AM fo ching is)	Research used to develop research in AM for BE (Who knowledge comes from)						
#	Author	<i>h</i> -index*	# of articles	% of articles	Share of pu- blications*	#	Cited author	<i>h</i> -index*	# of times cited	% of cites
1	Cho, Dong-Woo	37	35	2.86%	254/35	1	Khademhosseini, Ali	91	24	3.26%
2	Khademhosseini, Ali	91	19	1.55%	597/19	2	Cho, Dong-Woo	37	23	3.12%
3	Moroni, Lorenzo	26	16	1.31%	133/16	3	Langer, Robert	184	21	2.85%
4	Mano, Joao F	58	13	1.06%	395/13	4	Picart, Catherine	40	19	2.58%
5	Shim, Jin-Hyung	19	13	1.06	54/13	5	Dhert, Wouter J. A	44	16	2.17%
6	Fischer, Horst	33	12	0.98%	176/12	6	Mikos, AG	109	16	2.17%
7	Gbureck, Uwe	39	12	0.98%	122/12	7	Hutmacher, Dietmar Werner	21	15	2.04%
8	Hollister, Scott J	40	12	0.98%	118/12	8	Sun, Wei	105	15	2.04%
9	Hutmacher, Dietmar Werner	21	12	0.98%	43/12	9	Voegel, JC	68	15	2.04%
10	Reis, Rui L	66	12	0.98%	692/12	10	Malda, Jos	32	14	1.90%

Table 6. The 10 authors with the most occurrences and the 10 most cited authors

*Data obtained on November 3th, 2018



Figure 5. The 10 most frequent research areas in AM technologies for BE application articles



Figure 6. The 10 most frequent research areas in references used for AM technologies for BE application articles

3.1.7. Keyword analysis

The distance-based graph allows us to define the relationship forces of items, i.e., the closer they are the stronger their relationship. With regard to mapping keywords relating to the articles under study, the main hotspots that have a strong relationship between them are, on the one hand, "3D print" "Scaffold" "Additive manufacturing" "bone" and "rapid prototype", along with "Tissue Engineering", "3D bioprinter" and "hydrogel", and on the other hand, "layer by layer" and "alginate" (see figure 7).



Figure 7. The top 50 keywords in AM technologies for BE application articles

As far as mapping keywords of the cited articles is concerned, the main points of knowledge are linked to "scaffold", "bone", "bone tissue engineering", "rapid prototype", "3D print" and "hydroxyapatite", and conversely "tissue engineering", "biomaterial", "hydrogel" and "bioprinter" (see figure 8).

The clustering process carried out on the map of study articles defines 5 clusters, the terms of which allow us to define the following research fields: "Tissue engineering and bioprinting", "Scaffold and bone tissue engineering", "3D print and rapid prototyping", "layer by layer - surface modification - alginate" and "microstructure and stem cell". Regarding the clusters defined in the keyword map of the cited articles, there are also 5 clusters that define the following research



Figure 8. The top 50 keywords in references used for AM technologies for BE application articles

areas: "Scaffold and bone tissue engineering", "Tissue engineering and bioprinting", "3D print and bone", "Biomimetic and microstructure" and "Regenerative medicine".

3.2. Research impact

In this section, in order to appreciate the impact of these technologies, the impact that scientific publications had was determined from the results obtained from different impact indicator analyses. Moreover, the research impact measured and analyzed was varied: academic impact (from citation counts, *Mendeley* readers, and *Wikipedia* citations), and industrial and commercial impact (from *Google Patents* citations).

In addition, with the USA and China the countries with more publications in the field of study, the behavior of the impact of the research carried out by these countries was analyzed.

Tables 5 and table 6 contain the arithmetic mean, the geometric mean, the arithmetic mean of the log-transformed of the indicators analyzed, and the proportion of articles with at least one measure. In addition, where possible, 95% confidence intervals are given. They also contain the Mean Normalized Log-transformed Citation Scores (MNLCS)² and the Normalized Proportion Cited (EMNPC)³ with confidence intervals, where possible.

3.2.1. Academic impact

Citation counts

First, it can be seen that the most cited articles, in general, are those that have been published earlier, i.e., those that have had the longest time to be cited (see table 7).

From the results obtained, it is observed that, on the one hand, practically all articles are cited at least once; and on the other hand, in general, the USA is cited above the world average, however, this does not occur with China.

For articles published from 2006 to 2015, the MNLCS values are higher than 1 for the USA, which indicates that the citation counts for the USA tend to be above the world average. However, for articles published in 2014 the confidence interval does not contain 1 so only in that case is the difference statistically significant, for the rest of the years the difference is not statistically significant. In the case of China, it is observed that, in general, Chinese articles are cited below the world average.

Finally, for articles published in the decade analyzed, when the non-zero proportion is not 1 for the World, the USA and China are above the world average for the proportion cited (except in the case of 2013 for the USA, and 2013 and 2015 for China), i.e. EMNPC values are higher than 1.

Mendeley reader counts

Mendeley readership counts are useful indicators of academic impact and they can provide earlier evidence of impact than citations might (**Thelwall**, 2016; **Aduku**; **Thelwall**; **Kousha**, 2017).

In this case, the most read articles, in general, are not those that have been published earlier, i.e., there is no relation between the publication date and number of readers (see table 8).

Practically all articles have been gathered by *Mendeley* users. Likewise, it is observed that practically all articles analyzed from the USA and China have been gathered in *Mendeley* at least once.

Finally, the articles from USA are more read than the world average. The MNLCS value is higher than 1 for all analyzed years. Nevertheless, the same does not occur in the case of China, i.e. the research analyzed from China is less read than the world average, in general.

Wikipedia citation counts

Wikipedia citations are a useful new source of evidence for scholarly impact; however, citations from the online encyclopaedia to academic studies may reflect the value of research for a more general public or education (**Thelwall**; **Kousha**, 2015a; **Kousha**; **Thelwall**, 2017a; **Thelwall**, 2018; **Thelwall**; **Sud**, 2018). Nonetheless, in this case, it is observed that practically no articles of the study were cited on *Wikipedia* (see table 9). The proportion of articles with at least 1 *Wikipedia* citation was a maximum of 3.6% in 2010. Moreover, no Chinese article were mentioned on *Wikipedia*.

3.2.2. Industrial and commercial impact

Google Patents citation counts

Citations from patents to scientific articles could be used to assess the commercial value or technological benefits of the cited studies (**Thelwall**; **Kousha**, 2015a; **Thelwall**, 2018).

In this case, it can be observed that the most cited articles in patents, in general, are those that have been published earlier, i.e., those that have had the longest time to be cited (see table 10).

In this case, both countries, the USA and China, in general, are cited above the world average and their non-zero proportion is also above world average.

Table 7. Academic impact of AM technologies for biomedical engineering applications

Academic impact										
		— Citation counts	for individual sets of articles —							
Indicators	Year	World	USA	China						
	2006	84.032258	99.875000	103.000000						
	2007	68.187500	84.666667	66.000000						
	2008	50.695652	52.333333	34.600000						
	2009	64.578125	113.105263	51.571429						
Arithmetic	2010	61.107143	85.272727	55.571429						
data	2011	43.296875	51.608696	43.750000						
uuu	2012	35.409091	46.217391	35.250000						
	2013	34.820000	52.562500	24.437500						
	2014	37.425926	50.285714	31.600000						
	2015	23.411392	22.105263	21.148148						
	2006	61.403058 (44.368132, 84.834296)	84.802648 (61.030532, 117.685010)	99.969791 (62.821825, 158.740005)						
	2007	42.739649 (27.909845, 65.176656)	58.212670 (27.134051, 123.622657)	54.181519 (-0.984488, 196295.414710)						
	2008	28.461897 (19.646144, 41.041910)	42.873627 (25.735862, 70.996747)	23.936505 (4.537577, 111.292673)						
Coonstrie	2009	36.162970 (27.451244, 47.542211)	48.330852 (23.943112, 96.563326)	34.758256 (18.500242, 64.571129)						
Geometric	2010	36.551322 (28.126404, 47.413178)	44.843045 (27.646500, 72.362708)	39.525709 (16.090030, 95.098899)						
of raw data	2011	26.276796 (19.647951, 35.033773)	34.471750 (21.387664, 55.202606)	25.409614 (8.995830, 68.775868)						
	2012	21.793240 (16.800286, 28.186710)	24.017256 (14.035283, 40.626294)	22.547858 (11.089531, 44.866266)						
	2013	20.175256 (16.189655, 25.084959)	24.344006 (14.872179, 39.468207)	14.203120 (7.239744, 27.051219)						
	2014	21.611618 (17.404608, 26.780287)	32.456863 (22.840587, 45.951934)	17.450977 (10.001326, 29.945229)						
	2015	13.139339 (10.865472, 15.848963)	13.469733 (9.939594, 18.139025)	12.722162 (7.928466, 20.089597)						
	2006	4.133614 (3.814810, 4.452419)	4.452050 (4.127627, 4.776473)	4.614821 (4.156095, 5.073548)						
	2007	3.778255 (3.364182, 4.192328)	4.081136 (3.336981, 4.825290)	4.010628 (-4.166125, 12.187381)						
	2008	3.383098 (3.027529, 3.738667)	3.781313 (3.286006, 4.276621)	3.216333 (1.711557, 4.721109)						
Moon (95%())	2009	3.615313 (3.348192, 3.882434)	3.898550 (3.216598, 4.580502)	3.576781 (2.970427, 4.183135)						
of In(1+raw	2010	3.625709 (3.371645, 3.879772)	3.825224 (3.355031, 4.295416)	3.701937 (2.838495, 4.565378)						
data)	2011	3.306036 (3.027616, 3.584457)	3.568737 (3.108510, 4.028963)	3.273728 (2.302168, 4.245288)						
	2012	3.126464 (2.879215, 3.373713)	3.219566 (2.710400, 3.728732)	3.159035 (2.492340, 3.825730)						
	2013	3.052833 (2.844308, 3.261359)	3.232542 (2.764568, 3.700517)	2.721501 (2.108969, 3.334032)						
	2014	3.118464 (2.912601, 3.324327)	3.510257 (3.171389, 3.849124)	2.915117 (2.398016, 3.432219)						
	2015	2.648961 (2.473633, 2.824289)	2.672059 (2.392389, 2.951729)	2.619012 (2.189245, 3.048780)						
	2006	1.000000 (0.889745, 1.000000)	1.000000 (0.806392, 1.000000)	1.000000 (0.510109, 1.000000)						
	2007	0.968750 (0.842557, 0.994462)	1.000000 (0.700855, 1.000000)	1.000000 (0.342380, 1.000000)						
	2008	0.978261 (0.886647, 0.996152)	1.000000 (0.700855, 1.000000)	1.000000 (0.565518, 1.000000)						
Proportion	2009	1.000000 (0.943376, 1.000000)	1.000000 (0.831821, 1.000000)	1.000000 (0.784689, 1.000000)						
(95%CI)	2010	1.000000 (0.935806, 1.000000)	1.000000 (0.851345, 1.000000)	1.000000 (0.645670, 1.000000)						
non-zero	2011	0.984375 (0.916659, 0.997236)		1.000000 (0.675592, 1.000000)						
	2012	1.000000 (0.944997, 1.000000)	1.000000 (0.856883, 1.000000)	1.000000 (0.757506, 1.000000)						
	2013	0.980000 (0.929988, 0.994498)	0.968750 (0.842557, 0.994462)							
	2014	0.990741 (0.949407, 0.998364)	1.000000 (0.901099, 1.000000)	0.062062 (0.817165 0.002422)						
	2015	1,00000 (0,909257, 1,112144)	0.982430 (0.907093, 0.990890)	0.902905 (0.817105, 0.995452)						
	2000	1.000000 (0.898337, 1.113144)	1.090164 (0.991315 1.305376)	1.061502 (0.705642, 1.442172)						
	2007	1.000000 (0.853539, 1.104959)	1 117707 (0 955024 1 305360)	0.950706 (0.620988, 1.301663)						
MNLCS - mean	2000	1,000000 (0,802575, 1,159520)	1.078344 (0.997113 1.281412)	0.990342 (0.822578, 1.166068)						
(95%Cl) of	2009	1,000,000 (0,906364, 1,103309)	1.055028 (0.915100 1.205161)	1 021024 (0.818497 1 233429)						
world norma-	2010	1,000000 (0,888473, 1,105509)	1 079461 (0 924069 1 250273)	0 990227 (0 734631 1 259970)						
lized ln(1+raw	2011	1 000000 (0.894934 1 117401)	1 029779 (0 858410 1 214109)	1 010418 (0 806342 1 227211)						
data)	2012	1 000000 (0 908632 1 100556)	1.058866 (0.898164, 1.229297)	0.891467 (0.697145, 1.094147)						
	2013	1 000000 (0 911568 1 097011)	1,125637 (1,001509, 1,259421)	0 934793 (0 769841 1 107764)						
	2015	1 000000 (0 910488 1 098312)	1.008720 (0.889653, 1.136663)	0 988694 (0 823503 1 162586)						
	2006	1.000000 (NaN ⁴ . NaN)	1.000000 (NaN. NaN)	1.000000 (NaN. NaN)						
	2007	1.000000 (0.940134, 1.063678)	1.032258 (NaN. NaN)	1.032258 (NaN. NaN)						
	2008	1.000000 (0.958063. 1.043772)	1.022222 (NaN, NaN)	1.022222 (NaN, NaN)						
EMNPC (NPC) -	2009	1.000000 (NaN, NaN)	1.000000 (NaN, NaN)	1.000000 (NaN. NaN)						
world normali-	2010	1.000000 (NaN, NaN)	1.000000 (NaN, NaN)	1.000000 (NaN. NaN)						
zed proportion	2011	1.000000 (0.969723, 1.031222)	1.015873 (NaN, NaN)	1.015873 (NaN, NaN)						
(95%CI) cited	2012	1.000000 (NaN, NaN)	1.000000 (NaN, NaN)	1.000000 (NaN, NaN)						
(non-zero)	2013	1.000000 (0.966373, 1.034797)	0.988520 (0.940399, 1.039104)	0.956633 (0.873188, 1.048051)						
	2014	1.000000 (0.981974, 1.018356)	1.009346 (NaN, NaN)	1.009346 (NaN, NaN)						
	2015	1.000000 (0.962948, 1.038478)	1.014563 (0.978509, 1.051944)	0.994432 (0.938128, 1.054116)						

Table 8. Mendeley reader counts of AM	technologies for biomedical	engineering applications
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— Mendeley reader counts —									
Indicators	Year	World	USA	China					
	2006	80.322581	105.375000	84.750000					
	2007	63.187500	112.222222	80.500000					
	2008	56.782609	80.666667	30.400000					
	2009	79.468750	169.105263	42.785714					
Arithmetic	2010	85.464286	127.454545	48.428571					
mean of raw	2011	67.062500	82.913043	72.375000					
uata	2012	61.439394	96.260870	56.750000					
	2013	71.140000	114.968750	29.687500					
	2014	86.990741	131.142857	64.500000					
	2015	63.829114	63.105263	51.962963					
	2006	42.858398 (25.962429, 70.342202)	65.098589 (31.233380, 134.543449)	70.485395 (22.480137, 216.637640)					
	2007	40.531585 (26.858925, 60.914540)	66.312377 (27.517542, 157.883125)	54.695601 (-0.999584, 7464696.637597)					
	2008	26.393798 (17.042271, 40.592335)	60.056535 (31.823396, 112.574491)	23.500815 (7.141632, 72.730911)					
	2009	41.128847 (32.140176, 52.555532)	71.156707 (38.024113, 132.419825)	31.957020 (19.720930, 51.418747)					
Geometric mean	2010	47.286862 (35.912207, 62.166666)	64.483888 (39.317602, 105.358994)	41.708099 (23.280220, 74.122123)					
(95%CI) of raw	2011	39.875029 (29.617857, 53.568415)	53.910422 (35.071271, 82.588804)	36.177941 (14.146939, 90.252718)					
uata	2012	34.760151 (26.584395, 45.359123)	41.650246 (22.265398, 77.186646)	28.227489 (13.784274, 56.780729)					
	2013	36.569170 (28.651956, 46.600318)	52.448148 (33.476166, 81.860273)	20.445194 (11.902626, 34.643623)					
	2014	47.498319 (37.409307, 60.237423)	78.744293 (51.824747, 119.382069)	33.471535 (18.921628, 58.648074)					
	2015	39.345145 (33.151499, 46.662059)	43.719463 (34.858349, 54.770285)	35.861180 (23.250475, 55.029691)					
	2006	3.780966 (3.294444, 4.267488)	4.191147 (3.473003, 4.909292)	4.269493 (3.156155, 5.382831)					
	2007	3.726454 (3.327153, 4.125755)	4.209344 (3.350519, 5.068169)	4.019901 (-7.785893, 15.825695)					
	2008	3.310317 (2.892717, 3.727916)	4.111800 (3.491142, 4.732459)	3.198706 (2.096991, 4.300422)					
	2009	3.740733 (3.500746, 3.980719)	4.278840 (3.664180, 4.893501)	3.495204 (3.031144, 3.959264)					
Mean (95%CI) of	2010	3.877160 (3.608542, 4.145777)	4.181804 (3.696788, 4.666820)	3.754389 (3.189662, 4.319115)					
ln(1+raw data)	2011	3.710519 (3.421583, 3.999455)	4.005703 (3.585497, 4.425910)	3.615716 (2.717798, 4.513633)					
	2012	3.576834 (3.317250, 3.836418)	3.753033 (3.146967, 4.359099)	3.375110 (2.693564, 4.056655)					
	2013	3.626184 (3.389528, 3.862839)	3.978712 (3.540268, 4.417156)	3.065501 (2.557431, 3.573570)					
	2014	3.881529 (3.648300, 4.114758)	4.378825 (3.966980, 4.790671)	3.540134 (2.991806, 4.088462)					
	2015	3.697471 (3.530806, 3.864136)	3.800409 (3.579576, 4.021241)	3.607159 (3.188436, 4.025882)					
	2006	0.967742 (0.838059, 0.994283)	0.937500 (0.716713, 0.988881)	1.000000 (0.510109, 1.000000)					
	2007	0.968750 (0.842557, 0.994462)	1.000000 (0.700855, 1.000000)	1.000000 (0.342380, 1.000000)					
	2008	0.934783 (0.824973, 0.977572)	1.000000 (0.700855, 1.000000)	1.000000 (0.565518, 1.000000)					
	2009	1.000000 (0.943376, 1.000000)	1.000000 (0.831821, 1.000000)	1.000000 (0.784689, 1.000000)					
Proportion	2010	1.000000 (0.935806, 1.000000)	1.000000 (0.851345, 1.000000)	1.000000 (0.645670, 1.000000)					
(95%CI)	2011	0.968750 (0.893027, 0.991388)	1.000000 (0.856883, 1.000000)	1.000000 (0.675592, 1.000000)					
	2012	0.984848 (0.919041, 0.997320)	0.956522 (0.790088, 0.992283)	1.000000 (0.757506, 1.000000)					
	2013	0.970000 (0.915481, 0.989745)	1.000000 (0.892821, 1.000000)	1.000000 (0.806392, 1.000000)					
	2014	0.972222 (0.921497, 0.990509)	0.971429 (0.854669, 0.994939)	1.000000 (0.838875, 1.000000)					
	2015	0.981013 (0.945669, 0.993522)	1.000000 (0.936861, 1.000000)	0.962963 (0.817165, 0.993432)					
	2006	1.000000 (0.835602, 1.196743)	1.108486 (0.895276, 1.358281)	1.129207 (0.907152, 1.389285)					
	2007	1.000000 (0.861350, 1.160968)	1.129584 (0.904172, 1.381237)	1.078747 (0.566643, 1.615911)					
	2008	1.000000 (0.837112, 1.194584)	1.242117 (1.032706, 1.491702)	0.966284 (0.708469, 1.255351)					
MNLCS - mean	2009	1.000000 (0.913956, 1.094145)	1.143851 (0.975314, 1.321842)	0.934364 (0.808333, 1.068117)					
world norma-	2010	1.000000 (0.907374, 1.102081)	1.078574 (0.942031, 1.225315)	0.968335 (0.836317, 1.109509)					
lized In(1+raw	2011	1.000000 (0.896467, 1.115490)	1.079553 (0.947580, 1.224698)	0.974450 (0.761796, 1.198994)					
data)	2012	1.000000 (0.903185, 1.107193)	1.049261 (0.873699, 1.235935)	0.943603 (0.761772, 1.135425)					
	2013	1.000000 (0.912532, 1.095852)	1.097217 (0.964348, 1.239286)	0.845379 (0.705984, 0.992006)					
	2014	1.000000 (0.919201, 1.087901)	1.128119 (1.008923, 1.255326)	0.912046 (0.770583, 1.059987)					
	2015	1.000000 (0.938192, 1.065879)	1.027840 (0.955170, 1.104695)	0.975575 (0.860030, 1.095092)					
	2006	1.000000 (0.938248, 1.065816)	0.968750 (0.877548, 1.069431)	1.033333 (NaN, NaN)					
	2007	1.000000 (0.940134, 1.063678)	1.032258 (NaN, NaN)	1.032258 (NaN, NaN)					
	2008	1.000000 (0.906673, 1.102934)	1.069767 (NaN, NaN)	1.069767 (NaN, NaN)					
EMINPC (NPC) -	2009	1.000000 (NaN, NaN)	1.000000 (NaN, NaN)	1.000000 (NaN, NaN)					
zed proportion	2010	1.000000 (NaN, NaN)	1.000000 (NaN, NaN)	1.000000 (NaN, NaN)					
(95%Cl) cited	2011	1.000000 (0.947739, 1.055142)	1.032258 (NaN, NaN)	1.032258 (NaN, NaN)					
(non-zero)	2012	1.000000 (0.970630, 1.030258)	0.971237 (0.910601, 1.035911)	1.015385 (NaN, NaN)					
	2013	1.000000 (0.956586, 1.045384)	1.030928 (NaN, NaN)	1.030928 (NaN, NaN)					
	2014	1.000000 (0.959774, 1.041912)	0.999184 (0.951089, 1.049710)	1.028571 (NaN, NaN)					
	2015	1.000000 (0.972427, 1.028355)	1.019355 (NaN, NaN)	0.981601 (0.928647, 1.037574)					

Table 9. Wikipedia citations counts of AM technologies for biomedical engineering applications

— Wikipedia citations counts —						
Indicators	Year	World	USA	China		
	2006	0.032258	0.000000	0.000000		
	2007	0.000000	0.000000	0.000000		
	2008	0.000000	0.000000	0.000000		
	2009	0.015625	0.052632	0.000000		
Arithmetic mean	2010	0.035714	0.045455	0.000000		
(unique URLs⁵)	2011	0.015625	0.043478	0.000000		
	2012	0.045455	0.130435	0.000000		
	2013	0.020000	0.031250	0.000000		
	2014	0.000000	0.000000	0.000000		
	2015	0.012658	0.035088	0.000000		
	2006	0.022611 (-0.022986, 0.070337)	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)		
	2007	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)		
	2008	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)		
	2009	0.010889 (-0.010772, 0.033025)	0.037155 (-0.039335, 0.119735)	0.000000 (0.000000, 0.000000)		
Geometric mean	2010	0.025064 (-0.010228, 0.061615)	0.032008 (-0.033455, 0.101905)	0.000000 (0.000000, 0.000000)		
(95%CI) of unique	2011	0.010889 (-0.010772, 0.033025)	0.030596 (-0.031732, 0.096935)	0.000000 (0.000000, 0.000000)		
UNES	2012	0.021227 (-0.020785, 0.065041)	0.062127 (-0.062457, 0.203267)	0.000000 (0.000000, 0.000000)		
	2013	0.013959 (-0.005627, 0.033932)	0.021897 (-0.022275, 0.068065)	0.000000 (0.000000, 0.000000)		
	2014	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)		
	2015	0.008813 (-0.003465, 0.021242)	0.024619 (-0.010056, 0.060508)	0.000000 (0.000000, 0.000000)		
	2006	0.022360 (-0.023254, 0.067973)	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)		
	2007	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)		
	2008	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)		
	2009	0.010830 (-0.010830, 0.032491)	0.036481 (-0.040130, 0.113092)	0.000000 (0.000000, 0.000000)		
Mean (95%CI) of	2010	0.024755 (-0.010281, 0.059792)	0.031507 (-0.034027, 0.097041)	0.000000 (0.000000, 0.000000)		
log (T+unique	2011	0.010830 (-0.010830, 0.032491)	0.030137 (-0.032246, 0.092520)	0.000000 (0.000000, 0.000000)		
URLS)	2012	0.021004 (-0.021004, 0.063013)	0.060274 (-0.064493, 0.185040)	0.000000 (0.000000, 0.000000)		
	2013	0.013863 (-0.005643, 0.033369)	0.021661 (-0.022527, 0.065849)	0.000000 (0.000000, 0.000000)		
	2014	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)	0.000000 (0.000000, 0.000000)		
	2015	0.008774 (-0.003471, 0.021019)	0.024321 (-0.010106, 0.058748)	0.000000 (0.000000, 0.000000)		
	2006	0.032258 (0.005717, 0.161941)	0.000000 (0.000000, 0.193608)	0.000000 (0.000000, 0.489891)		
	2007	0.000000 (0.000000, 0.107179)	0.000000 (0.000000, 0.657620)	0.000000 (0.000000, 0.299145)		
	2008	0.000000 (0.000000, 0.077074)	0.000000 (0.000000, 0.299145)	0.000000 (0.000000, 0.434482)		
	2009	0.015625 (0.002764, 0.083341)	0.052632 (0.009352, 0.246387)	0.000000 (0.000000, 0.215311)		
Proportion non-ze-	2010	0.035714 (0.009849, 0.121188)	0.045455 (0.008069, 0.217980)	0.000000 (0.000000, 0.354330)		
ro (95%Cl)	2011	0.015625 (0.002764, 0.083341)	0.043478 (0.007717, 0.209912)	0.000000 (0.000000, 0.324408)		
	2012	0.015152 (0.002680, 0.080959)	0.043478 (0.007717, 0.209912)	0.000000 (0.000000, 0.242494)		
	2013	0.020000 (0.005502, 0.070012)	0.031250 (0.005538, 0.157443)	0.000000 (0.000000, 0.193608)		
	2014	0.000000 (0.000000, 0.034347)	0.000000 (0.000000, 0.098901)	0.000000 (0.000000, 0.161125)		
	2015	0.012658 (0.003478, 0.044973)	0.035088 (0.009676, 0.119208)	0.000000 (0.000000, 0.124555)		
MNLCS - mean (95%Cl) of world	2006	1.000000 (NaN, NaN)	0.000000 (NaN, NaN)	0.000000 (NaN, NaN)		
	2007	NaN (NaN, NaN)	NaN (NaN, NaN)	NaN (NaN, NaN)		
	2008	NaN (NaN, NaN)	NaN (NaN, NaN)	NaN (NaN, NaN)		
	2009	1.000000 (NaN, NaN)	3.368421 (NaN, NaN)	0.000000 (NaN, NaN)		
	2010	1.000000 (NaN, NaN)	1.272727 (NaN, NaN)	0.000000 (NaN, NaN)		
normalized log	2011	1.000000 (NaN, NaN)	2.782609 (NaN, NaN)	0.000000 (NaN, NaN)		
(1_unique URLs)	2012	1.000000 (NaN, NaN)	2.869565 (NaN, NaN)	0.000000 (NaN, NaN)		
	2013	1.000000 (NaN, NaN)	1.562500 (NaN, NaN)	0.000000 (NaN, NaN)		
	2014	NaN (NaN, NaN)	NaN (NaN, NaN)	NaN (NaN, NaN)		
	2015	1.000000 (NaN, NaN)	2.771930 (NaN, NaN)	0.000000 (NaN, NaN)		
	2006	1.000000 (0.109949, 9.095124)	0.000000 (0.000000, 0.124555)	0.000000 (0.000000, 0.124555)		
EMNPC - world nor-	2007	0.000000 (NaN, NaN)	0.000000 (NaN, NaN)	0.000000 (NaN, NaN)		
	2008	0.000000 (NaN, NaN)	0.000000 (NaN, NaN)	0.000000 (NaN, NaN)		
	2009	1.000000 (0.106833, 9.360444)	3.368421 (0.371563, 30.536600)	0.000000 (0.000000, 0.000000)		
malized proportion	2010	1.000000 (0.180240, 5.548168)	1.272727 (0.178693, 9.064912)	0.000000 (0.000000, 0.000000)		
non-zero (95%Cl)	2011	1.000000 (0.106833, 9.360444)	2.782609 (0.304509, 25.427506)	0.000000 (0.000000, 0.000000)		
[ie risk ratio]	2012	1.000000 (0.106746, 9.368058)	2.869565 (0.313896, 26.232896)	0.000000 (0.000000, 0.000000)		
	2013	1.000000 (0.177108, 5.646260)	1.562500 (0.214718, 11.370277)	0.000000 (0.000000, 0.000000)		
	2014	0.000000 (NaN, NaN)	0.000000 (NaN, NaN)	0.000000 (NaN, NaN)		
	2015	1.000000 (0.175675, 5.692336)	2.771930 (0.493049, 15.583837)	0.000000 (0.000000, 0.000000)		

Table 10. Industrial and commercial impact of AM technologies for biomedical engineering applications

	Industrial and commercial impact						
Indicators Year Oxed USA China 2007 0.90000 0.666667 0.90000 0.90000 2008 0.04939 0.64697 0.90000 0.71429 2009 0.648570 0.79447 0.571429 0.71429 2000 0.648570 0.20000 0.53104 0.62000 2011 0.275700 0.23000 0.32000 0.32000 2012 0.27570 0.240070 0.30000 0.23200 2014 0.79529 0.242877 0.23000 0.232000 2014 0.79686 0.224870 0.23000 0.232229 0007 0.41414 (0.013563, 0.09714) 0.315950 (0.027174) 1.000000 (1.00000, 1.00000) 0009 0.33910 (0.22894, 0.07716) 0.315950 (0.027174) 0.00000 (1.00000, 1.00000) 0010 0.439910 (0.228140, 0.07714) 0.315950 (0.027775) 0.440214 (0.03594, 0.277975) 0110 0.349910 (0.228140, 0.077140 0.315970 (0.02716, 0.229970) 0.44214 (0.13763, 0.377775) 0111 0.019990 (1.12767, 0.028290, 0.219970, 0.22999	— Google Patents citation counts —						
Mean 9000 0.587500 1.00000 2007 0.580001 0.66677 0.50000 2009 0.428571 0.400001 0.71226 2010 0.228770 0.259070 0.571429 2011 0.375000 0.391304 0.625000 2011 0.375000 0.391304 0.625000 2012 0.237767 0.20070 0.500000 2013 0.440000 0.406250 0.125000 2013 0.400000 0.406250 0.239917 2015 0.170886 0.018710 0.239917 0.239917 2007 0.441214 0.245507 0.239910 0.239910 0.239910 2007 0.441214 0.245507 0.239910 0.249917 0.239910 0.449011 0.399291 0.449214 0.239239 0.449214 0.239927 0.449214 0.239239 0.449214 0.239239 0.449214 0.239239 0.449214 0.239239 0.449214 0.239239 0.449214 0.239239 0.449214 <td< th=""><th>Indicators</th><th>Year</th><th>World</th><th>USA</th><th>China</th></td<>	Indicators	Year	World	USA	China		
20000.500000.666670.5000020000.4697500.7789470.57142920100.4697500.700010.7142620110.3750000.5913040.62500120120.257560.2606700.50000020140.2592500.2486700.25000020150.1168660.220700.2592920150.1168660.220700.5929520050.2384000.4485700.25000020150.1178610.597590.26070446020100.3490010.2294900.3195860.17958620000.2384800.1178700.3278700.40271420100.3490010.2294900.3197590.2697720100.3490010.2294900.3197590.2697720110.3490010.229490.3195860.47958920100.3490010.229490.379590.2699720110.3490010.229490.379580.54959120120.1994800.199670.229490.3795820130.109390.12760.229270.49237120140.199590.124700.229490.3795920150.127590.299790.239770.4121420120.199390.127590.299790.4121420130.127590.299700.299490.4997120140.199390.127590.299700.3914720150.199390.127590.299710.39177<		2006	0.580645	0.687500	1.000000		
1990 3.03438 0.44444 0.400000 2000 0.406750 0.57947 0.571429 2011 0.406750 0.59947 0.571429 2011 0.237500 0.591344 0.62000 2012 0.237500 0.406250 0.12000 2015 0.170866 0.32857 0.25000 2005 0.470850 0.537401 (0.11599), 1.072231 0.414214 (0.90227), 1.1470500 2006 0.439518 (0.316637, 0.699702 0.619970 (0.027130, 0.00288) 0.419950 (0.17690, 1.11441) 2007 0.444214 (0.42557, 0.609701, 0.027130, 0.002880 0.45994 (0.20995), 0.424997 0.414214 (0.90227, 1.1470500 2008 0.439900 (0.236480, 0.017180, 0.002880 0.45979 (0.20981), 0.377351 0.45974 (0.13978), 0.14141 (0.912757, 0.77735) 2014 0.19964 (0.119663, 0.017810) 0.43579 (0.20981), 0.377250 0.44141 (0.12375, 0.77735) 2015 0.112556 (0.102864, 0.02830, 0.028840 0.45979 (0.20981), 0.37275 2014 0.19964 (0.11860, 0.02896) 0.45079 (0.2981), 0.37275 2015 0.12755 (0.19747, 0.02781) 0.45074 (0.45877, 4.51541 2016		2007	0.500000	0.666667	0.500000		
1990 0.468750 0.57947 0.571429 1001 0.42571 0.40901 0.71286 1012 0.325756 0.26079 0.50000 2013 0.20070 0.25000 0.25000 2014 0.259259 0.34287 0.25000 2015 0.116866 0.24070 0.25000 2006 0.445216 0.614901(0.349650, 0.021721 1.000001, 0.00000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.000000, 1.00000, 1.000000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.00000, 1.		2008	0.304348	0.44444	0.400000		
Arithmetic mean (unique domain) 0.402971 0.409091 0.2714286 2010 0.237500 0.23004 0.620090 2011 0.237500 0.240870 0.25000 2015 0.17086 0.24287 0.25000 2016 0.242870 0.242870 0.25000 2017 0.441214 (0.25527, 0.050400 0.537401 (0.215989, 1.07293) 0.414214 (0.92731, 1.1705660) 2006 0.343910 (0.263839, 0.0509401 0.437590 (0.26971, 0.050800 0.444714 (0.937273, 1.1705660) 2001 0.343900 (0.225440, 0.071701 0.3279490 0.444214 (0.127273, 0.127987, 0.250800 2010 0.343900 (0.225440, 0.027810, 0.237930 0.445974 (0.17980, 5.074980) 0.445971 (0.07981, 0.37727) 2011 0.199540 (0.12580, 0.028240, 0.07313 0.172664, 0.327820 0.950870 (0.02811, 0.37727) 2012 0.199540 (0.12580, 0.02820, 0.028200 0.46591 (0.01993, 0.42971 0.37491 (0.23773, 1.17056) 2013 0.199540 (0.12580, 0.02820, 0.028200 0.46591 (0.13993, 0.23775) 0.196540 (0.19893, 0.23775) 2014 0.199540 (0.12581, 0.02820, 0.028200 0.46591 (0.151990, 0.4571, 0.15690, 0.13712)		2009	0.468750	0.578947	0.571429		
(unique domain) 2010 0.37500 0.68070 0.50000 2013 0.24000 0.406250 0.125000 0.25000 2014 0.259259 0.342857 0.250000 0.25000 2015 0.110866 0.22070 0.259259 2005 0.414214 (0.24567, 0.069700 0.0517920 0.41414 (0.38573, 1.15641) 2006 0.435910 (0.23598, 0.059910 0.6407910 (0.15798, 0.52928) 0.41414 (0.24567, 0.059710 2006 0.343910 (0.23598, 0.059910 0.047591, 0.3228910, 0.249959, 0.249970, 7.04466 0.459591 (0.39976, 0.22797, 0.45981, 0.459980 2010 0.343901 (0.23598, 0.059910 0.342571 (0.45918, 0.379851, 0.23797, 0.24997, 0.25971, 0.452171, 0.14189, 1.037032 2011 0.139991 (0.112768, 0.23840 0.135270 (0.06912, 0.57128) 0.09890 (0.08661, 0.23793 2015 0.12750 (0.080260, 0.127363) 0.345271 (0.59317, 0.13927) 0.416214 (0.12787, 0.23772) 2015 0.12750 (0.080260, 0.127363) 0.426296 (0.130364, 0.42228) 0.198964 (0.198964, 0.33732) 2016 0.12757, 0.12771 0.246296 (0.130364, 0.42289) 0.346574 (0.49877, 4.751524) 2011 0.259930 (0.175	Arithmetic mean	2010	0.428571	0.409091	0.714286		
912 0.25776 0.26670 0.50000 2013 0.240000 0.40250 1.25000 2014 0.25929 0.34287 0.25900 2015 0.178866 0.22070 0.259259 2000 0.441214 (0.24557, 0.656940 0.557401 (0.215598, 1.07223) 0.141214 (0.92072, 1.1476506, 1.115441) 2000 0.343910 (0.268399, 0.59941) 0.493759 (0.260979, 0.027180, 0.035840, 0.319506 (-1776956, 1.115441) 2001 0.345901 (0.268399, 0.59941) 0.493759 (0.260979, 0.027180, 0.319566) 0.455941 (0.19956, 1.24405) 2011 0.256460 (0.15936, 0.239260 0.235237 (0.169332, 0.591284) 0.495947 (0.02993, 0.82497) 2012 0.195660 (0.13893, 0.239260 0.235237 (0.169332, 0.591284) 0.495947 (0.49937, 4.773753) 2013 0.195660 (0.13936, 0.239260 0.235237 (0.169382, 0.432860) 0.366314 (0.69317, 4.75124) 2014 0.195670 (0.03908, 0.23737) 0.112570 (0.09283, 0.23996) 0.366314 (0.69317, 4.75124) 2015 0.12579 (0.019264, 0.338130) 0.346574 (0.13957, 0.37136) 0.346574 (0.13957, 0.37136) 2016 0.12579 (0.019264, 0.338137) 0.112564 (0.1393634, 0.33737) 0.	(unique domains)	2011	0.375000	0.391304	0.625000		
913 0.40000 0.40620 0.12500 2014 0.239259 0.324857 0.23000 2005 0.479686 0.22007 0.429259 2007 0.449518 (0.316537, 0.598702) 0.61499 (0.349650, 0.221742) 1.400000 (1.000200, 1.000000, 1.000000) 2007 0.414214 (0.245507, 0.05949 (0.2713598, 1.072232) 0.414214 (0.24272, 114.76056) 2008 0.328910 (0.228989, 0.59941 (0.2173598, 0.529970) 0.445594 (0.20956, 0.24297) 2010 0.358910 (0.228989, 0.59941 (0.217359, 0.59940) 0.446574 (0.12955, 1.244095) 2011 0.35990 (0.225848, 0.477110 0.327494 (0.13758, 0.529200) 0.446214 (0.02956, 0.237202) 2012 0.199464 (0.12895, 0.25920) 0.248227 (0.19932, 0.59128) 0.549211 (0.141815) 2014 0.199954 (0.12758) 0.446204 (0.13956, 0.25920) 0.446214 (0.025842, 0.551312) 2014 0.19954 (0.12758) 0.248274 (0.21991, 0.27358) 0.446204 (0.199236, 0.52276) 0.54954 (0.035842, 0.257312) 2014 0.19954 (0.12758, 0.12070) 0.41254 (0.19958, 0.52751) 0.22837 (0.19938, 0.27758) 0.499518 (0.19938, 0.27758) 2014 0.19954 (0.12758, 0.12978) 0.349634		2012	0.257576	0.260870	0.500000		
20140.259290.242870.2500020150.1708660.2280700.25925920060.455518 (0.316637, 0.69270)0.611490 (0.249650, 0.27123)1.000001 (0.00000, 1.00000)20080.12414 (0.245567, 0.605669)0.557401 (0.215596, 1.02223)0.141214 (0.392723, 114.706050)20090.348910 (0.268399, 0.59940)0.405790 (0.227130, 0.802283)0.319508 (0.17180, 0.239538)20100.345900 (0.25846, 0.17110)0.237249 (0.17354, 0.59980)0.460571 (0.19956, 1.24405)20110.296840 (0.19638, 0.41720)0.232249 (0.17354, 0.59980)0.402471 (0.129573, 1.20958)20120.195486 (0.10868, 0.428266)0.292040, 0.375490.44214 (0.122763, 0.27753)20130.195970 (0.02713), 0.129684, 0.5322100.499871 (0.029147), 0.373275)20140.195970 (0.02714), 0.2398400.47539 (0.29984, 0.535232)0.495840 (0.05861, 0.27753)20150.402471 (0.12593, 0.1735500.277550 (0.20766), 0.595820)0.34574 (0.15587)20100.297051 (0.2033, 0.39040)0.238500 (0.12887, 0.435240)0.360574 (0.10587)20100.299930 (0.17375, 0.41480)0.230500 (0.12887, 0.435240)0.34574 (1.0583, 0.574650)20100.299930 (0.17375, 0.44420)0.230500 (0.12887, 0.435240)0.360564 (0.039940, 0.22759)20110.177575 (0.12263, 0.235750)0.235500 (0.12875, 0.435240)0.345271 (0.136263, 0.43940)20100.299930 (0.17375, 0.44580)0.230500 (0.12875, 0.435240)0.300000 (0.17571)20110.17757 (0.12974, 0.23757)0.485571 (0.128440, 0.43771)0.366571 (0.039740)		2013	0.240000	0.406250	0.125000		
10.170860.2280700.5292920000.495318 (0.31637, 0.09702)0.557401 (0.21558, 0.072742)0.400000 (1.000000, 1.000000)20030.415214 (0.245567, 0.059970)0.557401 (0.21558, 1.072232)0.410214 (0.20933, 0.224997)20040.238910 (0.22594, 0.35933)0.369790 (0.227130, 0.02033)0.349594 (0.20993, 0.244997)20100.249800 (0.12176), 0.3593330.35759 (0.26097, 0.769460)0.46971 (0.1995, 1.244095)20110.296840 (0.11693, 0.11126)0.327247 (0.113748, 0.59996)0.441214 (0.12376, 0.779735)20120.196946 (0.11695, 0.23900)0.325227 (0.16933, 0.50128)0.040057 (0.1998, 1.32737)20130.109936 (1.1276, 0.023300)0.325227 (0.16933, 0.226920)0.34121 (0.493147, 0.493147)20140.196944 (0.12859, 0.29904)0.326930 (0.13936, 0.22984)0.196864 (0.05944, 0.383132)20150.127570 (0.02033, 0.39940)0.236928 (0.139236, 0.22983)0.366374 (0.693147, 0.693147)20100.326913 (0.27555, 0.41207)0.401256 (0.231902, 0.57089)0.396084 (0.19550, 0.61579)20110.259930 (0.15757, 0.34403)0.495150 (0.1879, 0.34524)0.306663 (0.35744)20120.25950 (0.12576, 0.359912)0.27228 (0.11998, 0.21718)0.306643 (0.03937, 4.57324)20110.25950 (0.12576, 0.35920)0.35950 (0.12576, 0.31424)0.495150 (0.18950, 0.61579)20120.15753 (0.14963, 0.23579)0.306644 (0.19596, 0.35245)0.366574 (0.35926)20110.15950 (0.13774, 0.35790)0.35950 (0.12576, 0.33424)0.495150 (0.18950, 0.45652)20120.12595		2014	0.259259	0.342857	0.250000		
Geometry0.4059118 (0.316.027, 0.059720)0.471494090.23972400.414214 (0.237273, 1.147.05950)Geometry0.20140.2345910 (0.226393)0.359701 (0.227190, 0.02839)0.435994 (0.20963, 0.824997)(95%C) 0.10.345910 (0.225848, 0.4777100.227494 (0.13748, 0.549986)0.449071 (0.19950, 1.244095)(95%C) 0.10.154568 (0.104764, 0.28825)0.198201 (0.047594, 0.27495)0.542711 (0.19150, 0.1244095)20100.154568 (0.104764, 0.28825)0.198201 (0.047594, 0.27045)0.414214 (0.12756, 0.779735)20110.195640 (0.19163), 0.111268, 0.2534000.252827 (0.169832, 0.501285)0.09001 (0.03727)20150.115750 (0.062020, 0.17313)0.171267 (0.028352, 0.266925)0.198201 (0.03861, 0.237051)20160.195640 (0.19163), 0.41158)0.462098 (0.199236, 0.128930)0.346574 (0.03874, 7.51524)20170.346574 (0.19591, 0.473555)0.462098 (0.199236, 0.128930)0.346574 (0.4083147, 0.693147)20180.210958 (0.114918, 0.30699)0.300805 (0.02679, 0.589320)0.277529 (0.194745, 0.749231)20190.234913 (0.23757), 0.4144630.41256 (0.213942)0.346574 (0.19591, 0.4124120100.234913 (0.23757), 0.4144630.241254 (0.19594, 0.21494)0.24124 (0.12754)20110.25990 (0.17575, 0.414463)0.241254 (0.15684), 0.244924)0.24124 (0.12754)20120.169345 (0.13974, 0.238333)0.212256 (0.12847), 0.2382910.432371 (0.13624)20140.179975 (0.12974, 0.23843)0.23756 (0.12384)0.413217 (0.12684), 0.49137120140.179976 (0.12974, 0.23833)0.2		2015	0.170886	0.228070	0.259259		
Geometric mean (95%C1) of unique domains 0.0141241 (0.245567, 0.050990) 0.053790 (0.27594) 0.041970 (0.209966, 1.115441) 0000 0.24860 (0.127710, 0.352380) 0.053790 (0.027584) 0.049097, 0.769480) 0.049071 (0.19950, 1.244095) 0010 0.345900 (0.225840, 0.477710) 0.327849 (0.137548, 0.549960) 0.040671 (0.19950, 1.244095) 0210 0.345900 (0.225848, 0.477710) 0.325237 (0.102584, 0.527961) 0.442211 (0.141819, 1.03304) 0211 0.156864 (0.18874, 0.28822) 0.192501 (0.047594, 0.370459) 0.049231 (0.027981, 0.0279735) 02121 0.156964 (0.12856, 0.269020) 0.252327 (0.163832, 0.052832) 0.699314 (0.029811, 0.37735) 0211 0.125750 (0.08020, 0.173135) 0.171267 (0.082812, 0.267823) 0.369564 (0.055844, 0.3531321) 02000 0.249763 (0.275981, 0.529844) 0.475539 (0.299845, 0.453232) 0.6493147 (0.4593147, 0.4593147) 02000 0.329714 (0.12951, 4.713550 0.349504 (0.159545, 0.479263) 0.349504 (0.159545, 0.479263) 02001 0.329751 (0.131970, 0.309877, 0.349240 0.349574 (0.119583, 0.42937147, 0.529274 02102 0.129750 (0.105974, 0.238439) 0.239756 (0.159764, 0.239173) 0.349564 (0.109897, 0.319178)		2006	0.495518 (0.316637, 0.698702)	0.610490 (0.349650, 0.921742)	1.000000 (1.000000, 1.000000)		
Geometric mean (95%C)1 of u0389510 (0.2369839, 0.509941) 0.493759 (0.250977, 0.769480) 0.485994 (0.209563, 0.824997) 0.493750 (0.250977, 0.49369) 0.445294 (0.191563, 0.824997) Geometric mean (95%C)1 of u018 0.21550 (0.025848, 0.477710) 0.237249 (0.137548, 0.54998) 0.440671 (0.19950, 1.244095) 2010 0.349500 (0.225848, 0.477710) 0.237249 (0.137548, 0.54998) 0.441241 (0.137563, 0.737735) 2012 0.195640 (0.19163, 0.411240) 0.31579 (0.26824, 0.528322) 0.490371 (0.03861, 0.237032) 2015 0.195640 (0.22750) 0.245264 (0.139532, 0.269263) 0.416214 (0.137275) 2016 0.195640 (0.22750) 0.246527 (0.05823, 0.239362) 0.4963147 (0.693147, 0.693147) 2017 0.346574 (0.21591, 0.473550) 0.462098 (0.198236, 0.22890) 0.346574 (0.116830, 5.75532) 2008 0.219593 (0.114918, 0.306990) 0.306056 (0.02879, 0.593322) 0.246574 (0.116830, 5.75641207) 2010 0.239930 (0.123575, 0.412407) 0.346574 (0.116830, 5.75641207) 0.346574 (0.116830, 5.75641207) 2011 0.239930 (0.13575, 0.412407) 0.234534 (0.13930, 0.43539) 0.3475474 (0.116830, 5.7646317 2011 0.239930 (0.13575, 0.412407) 0.345544 (0.16830, 2.355431 0.436574 (0.116830, 5.7564531 2011 <th></th> <th>2007</th> <th>0.414214 (0.245567, 0.605694)</th> <th>0.587401 (0.215598, 1.072923)</th> <th>0.414214 (-0.982723, 114.760560)</th>		2007	0.414214 (0.245567, 0.605694)	0.587401 (0.215598, 1.072923)	0.414214 (-0.982723, 114.760560)		
Geometric man (95%C) of unique domains) 0.033910 (0.268399059941) 0.492979 (0.269970784480) 0.463071 (0.299560244997) 2010 0.345900 (0.22488477710) 0.327249 (0.173748.0.549986) 0.441214 (0.123763.0.727973) 2012 0.195468 (0.108674.0.288223) 0.198201 (0.047594.0.3574032) 0.441214 (0.123763.0.727973) 2013 0.160993 (0.112768.0.253400) 0.252237 (0.169832.0.501235) 0.090506 (0.03061.0.237052) 2014 0.169644 (0.12856.0.269260) 0.268266 (0.130368.0.422986) 0.196927 (0.029811, 0.237032) 2015 0.125750 (0.02608.0.137313) 0.171267 (0.058212, 0.2569310) 0.346574 (0.038717, 0.693147, 0.693147) 2006 0.346574 (0.21563) 0.476298 (0.129785, 0.215926, 0.239600) 0.346574 (0.01568.0, 0.680502) 2010 0.346574 (0.15633, 0.39049) 0.23550 (0.128216, 0.2389512) 0.345574 (0.1568.0, 0.68052) 2011 0.259930 (0.17375, 0.344880) 0.237556 (0.124248, 0.357352) 0.438574 (0.11688.0, 0.59648) 2011 0.259950 (0.138340) 0.237560 (0.444444, 0.833541) 1.030000 (0.63774, 0.038742) 2014 0.17976 (0.15974, 0.238430) 0.23756 (0.12543, 0.352758) 0.17327 (0.039276, 0.337119) 2015		2008	0.234860 (0.121781, 0.359338)	0.360790 (0.027130, 0.802838)	0.319508 (-0.176956, 1.115441)		
Geometry mean growth of ung (1) 2010 0.2358401 0.137540, 0.549986) 0.6499801 2011 0.2368401 0.19983, 0.11240 0.311579 (0.25684, 0.522711) 0.542211 (0.114191, 0.03004) 2012 0.19963(0.112760, 0.231400 0.311579 (0.126840, 0.230640) 0.81207 (0.029811, 0.373275) 2013 0.19980 (0.112760, 0.23400) 0.226820 (0.13936, 0.422961) 0.189207 (0.029811, 0.373275) 2015 0.192670 (0.139580, 0.27960) 0.404273 (0.27981, 0.539964) 0.499845, 0.653221 0.699147 (0.698174, 0.237375) 2006 0.404273 (0.27758), 0.437964) 0.499845, 0.653221 0.699147 (0.698174, 7.47553) 2007 0.346574 (0.219591, 0.21946) 0.499453, 0.653221 0.699147 (0.698174, 7.47553) 2010 0.219958 (0.114918, 0.306990 0.30805 (0.226769, 0.589362) 0.326084 (0.039474, 0.238313) 2011 0.279903 (0.23633, 0.390493) 0.238550 (0.128175, 0.344840 0.499149, 0.372751524 2011 0.279903 (0.23634) 0.231591 (0.158660, 0.449342) 0.3405416 (0.198479, 0.27275) 2011 0.179270 (0.129847, 0.228350) 0.172327 (0.29875, 0.317148) 0.3405416 (0.19837, 0.2783314) 2011 0.179705 (0.129974, 0.248435)	Companyiamaan	2009	0.383910 (0.268399, 0.509941)	0.493759 (0.260997, 0.769486)	0.485994 (0.209963, 0.824997)		
Description 2011 0.296840 (0.19169), 0.4112640 0.511579 (0.129646, 0.522761) 0.522211 (0.141819, 1.083004) 2012 0.195646 (0.10887, 0.28825) 0.192047 (0.047594, 0.370459) 0.414214 (0.12756), 0.727753) 2014 0.196640 (0.128596, 0.269262) 0.268260 (0.130366, 0.422960) 0.182070 (0.02813, 0.266902) 0.196646 (0.08842, 0.353132) 2015 0.125750 (0.008200, 0.17313) 0.171267 (0.008230, 0.266920) 0.366574 (-0.363147, 0.693147) 2006 0.02473 (0.275981, 0.47350) 0.462058 (0.026759, 0.5839362) 0.277259 (-0.194745, 0.794263) 2007 0.336574 (0.13951), 0.473550 0.462058 (0.12875, 0.438240) 0.495105 (0.18937, 4.73714) 2018 0.297058 (0.20333, 0.390498) 0.28350 (0.12887, 0.438240) 0.495105 (0.18990, 0.05137) 2011 0.297058 (0.10831, 0.229580) 0.28350 (0.12875, 0.438240) 0.495105 (0.1890, 0.606137) 2012 0.166351 (0.10861, 0.22560) 0.28150 (0.12875, 0.43824) 0.495105 (0.1890, 0.50687, 0.32422) 2014 0.17975 (0.12974, 0.238433) 0.281507 (0.12284), 0.325750 (0.1798, 0.43653) 0.19795 (0.156861 (0.39949, 0.21275) 2014 0.129747 (0.156897, 0.325176) 0.558006 (0.047950, 0.358624) 0.5500	Geometric mean	2010	0.345900 (0.225848, 0.477710)	0.327849 (0.137548, 0.549986)	0.640671 (0.19950, 1.244095)		
2012 0.195468 (0.108874, 0.288825) 0.198921 (0.047594, 0.370459) 0.41214 (0.123763, 0.279073) 2014 0.18993 (0.112768, 0.235400) 0.285237 (0.19882, 0.0126861, 0.23702) 2015 0.12579 (0.080280, 0.173133) 0.171267 (0.03882, 0.026962) 0.196664 (0.03664, 0.033312) 2006 0.402473 (0.275081, 0.529640) 0.475539 (0.299845, 0.05322) 0.693147 (0.693147, 0.693147) 2007 0.346574 (0.219591, 0.473550 0.4202676, 0.5839620 0.277529 (0.194745, 0.749263) 2009 0.23093 (0.119318, 0.309693) 0.280560 (0.12875, 0.348246) 0.495105 (0.181906, 0.808302) 2011 0.259930 (0.175375, 0.344485) 0.227123 (0.121938, 0.420252) 0.495105 (0.181906, 0.808302) 2012 0.176357, 0.344485 0.227123 (0.121938, 0.420252) 0.495643 (0.196649, 0.19747) 2011 0.125991 (0.15375, 0.344485) 0.237550 (0.12263, 0.338141) 0.4956140, 0.196490, 0.12715) 2012 0.176375, 0.344485 0.227123 (0.121938, 0.420252) 0.496643 (0.039490, 0.12715) 2014 0.170976 (0.120974, 0.23753) 0.1790840, 0.325580, 0.12263, 0.338143) 0.400000 (0.34974, 0.439179, 0.13280490, 0.23715) 2015 0.118449 (0.077220, 0.15960, 0.44944, 0.438779, 0.33	domains	2011	0.296840 (0.191693, 0.411264)	0.311579 (0.129684, 0.522761)	0.542211 (0.141819, 1.083004)		
2013 0.180993 (0.112768, 0.253400) 0.325237 (0.169832, 0.501285) 0.090508 (0.028616, 0.237032) 2015 0.125750 (0.080280, 0.173133) 0.171267 (0.082832, 0.268925) 0.198646 (0.058642, 0.353132) 2006 0.402473 (0.275681, 0.529864) 0.476539 (0.199266, 0.192356, 0.232860) 0.346574 (4.058377, 4.571524) 2008 0.210953 (0.114918, 0.306998) 0.308065 (0.026769, 0.589362) 0.237259 (1.0494745, 0.749263) 2009 0.32913 (0.237755, 0.1414815, 0.306998) 0.380865 (0.025769, 0.589362) 0.237259 (1.019573) 2010 0.297063 (0.23033, 0.390493) 0.28350 (0.128875, 0.438266) 0.495105 (0.181908, 0.808302) 2011 0.259930 (0.175375, 0.344485) 0.271232 (0.121938, 0.420525) 0.403214 (0.196536, 0.631275) 2013 0.166355 (0.106851, 0.023450) 0.281591 (0.15866, 0.406322) 0.086643 (0.039439, 0.212715) 2014 0.179975 (0.159978) 0.158086 (0.079580, 0.286593) 0.179270 (0.056987, 0.302422) 2015 0.118449 (0.077220, 0.159678) 0.580847 (0.344252) 0.400000 (0.510119, 1.000000 2016 0.538045 (0.407663), 0.735842 0.400079444, 0.8385341 1.000000 (0.51718)79 2016 0.538045 (0.407663), 0.73584		2012	0.195468 (0.108874, 0.288825)	0.198201 (0.047594, 0.370459)	0.414214 (0.123763, 0.779735)		
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2015 0.125750 (0.080280, 0.173133) 0.171267 (0.082828, 0.266925) 0.196864 (0.056642, 0.353132) 2006 0.4062473 (0.22758), 0.1229840 0.4765370 (0.299845, 0.0589322) 0.699147 (0.0693147) 2007 0.346574 (0.219591, 0.473556) 0.462098 (0.195236, 0.728960) 0.346574 (4.058377, 4.751524) 2008 0.210938 (0.114918, 0.306999) 0.308065 (0.026769, 0.589362) 0.3277259 (-0.194745, 0.749263) 2010 0.2297063 (0.203633, 0.390493) 0.283500 (0.238102, 0.050689) 0.396643 (0.199852, 0.613514) 2011 0.259930 (0.175375, 0.343445) 0.271232 (0.119386, 0.432515) 0.435127 (0.116633, 0.576465) 2013 0.166355 (0.106651, 0.225800) 0.281591 (0.126860, 0.466522) 0.036663 (-0.093470, 0.11798) 2015 0.118449 (0.077220, 0.115978) 0.158066 (0.079580, 0.235593) 0.177805 (0.025867, 0.302422) 2016 0.580645 (0.407650, 0.735845) 0.667500 (0.444044, 0.883544) 0.00000 (0.51019, 1.00020) 2010 0.428571 (0.307690, 0.558624) 0.400091 (0.322556) 0.470247 (0.38450, 0.47649) 2011 0.370500 (0.266660, 0.497496) 0.391304 (0.21757, 0.552145) 0.652000 (0.035740, 0.16014) 2011 0.375750 (0.167488,		2014	0.196864 (0.128596, 0.269262)	0.268266 (0.130368, 0.422986)	0.189207 (0.029811, 0.373275)		
Mean (95%Cl) 2006 0.402473 (0.275081, 0.529864) 0.476539 (0.299845, 0.655222) 0.693147 (0.693147), 0.693147) Mean (95%Cl) 0.306 (0.21995), 0.47536, 0.4260208 (0.192857, 0.478536) 0.220988 (0.19475, 0.479536) 0.240743 (4.058377, 4.4751524) 2009 0.324913 (0.237575, 0.412070) 0.401296 (0.231902, 0.570689) 0.396048 (0.190590, 0.601579) 2011 0.239930 (0.173575, 0.341407) 0.401296 (0.231902, 0.570689) 0.438217 (0.132623, 0.733811) 2012 0.178538 (0.103345, 0.23576) 0.128159 (0.16865), 0.406232) 0.406643 (-0.039429, 0.212715) 2013 0.166355 (0.106851, 0.427660) 0.231591 (0.156660, 0.406232) 0.036643 (-0.039429, 0.212715) 2014 0.179705 (0.120974, 0.238435) 0.637500 (0.440444, 0.585354) 1.000000 (0.510109, 1.000001 2005 0.5800645 (0.40763, 0.735845) 0.6675700 (0.444044, 0.585354) 1.000000 (0.510109, 1.000001 2007 0.500000 (0.33309, 0.663611) 0.66667 (0.354202, 0.879416) 0.500000 (0.94511, 0.950459) 2010 0.428571 (0.3769406) 0.444444, 0.1888779, 0.733349) 0.400000 (0.171621, 1.0750276) 2009 0.468750 (0.251766, 0.589279) 0.578494 (0.325756, 0.5281451) 0.571429 (0.358964, 0.91771717		2015	0.125750 (0.080280, 0.173133)	0.171267 (0.082832, 0.266925)	0.196864 (0.058642, 0.353132)		
Mean (95%Cl) of log(1+unique domains) 2007 0.346574 (0.219591, 0.473556) 0.462098 (0.195236, 0.728960) 0.346574 (-4.058377, 4.751524) 2009 0.324913 (0.14918, 0.30998) 0.308056 (0.026769, 0.589362) 0.279558 (0.79286) 0.396084 (0.190590, 0.601579) 2010 0.2797063 (0.015357, 0.412070) 0.401296 (0.231902, 0.570689) 0.308010 (0.495170 (0.181906, 0.408302) 2011 0.2797063 (0.015357, 0.344480) 0.272122 (0.121938, 0.420525) 0.433217 (0.132623, 0.733811) 2012 0.178538 (0.103345, 0.223843) 0.237550 (0.122544, 0.352778) 0.168660, 0.406322) 0.086643 (0.039429, 0.212715) 2014 0.179705 (0.120974, 0.23843) 0.237505 (0.122544, 0.35278) 0.17370 (0.35737, 0.373811) 0.0806451 (0.033429, 0.212715) 2015 0.118449 (0.077220, 0.159678) 0.158066 (0.079580, 0.236593) 0.179705 (0.056987, 0.302422) 2006 0.580047 (0.34309, 0.65101) 0.66676 (0.354220, 0.23759, 0.768591) 0.501109, 1.000000 2010 0.466750 (0.33429, 0.213563) 0.647500 (0.34497, 0.36279, 0.763849) 0.400000 (0.094511, 0.00000 2010 0.18494 (0.077220, 0.159678) 0.158066 (0.079580, 0.236593) 0.179705 (0.056874, 0.332723) 2000 <td< th=""><th></th><th>2006</th><th>0.402473 (0.275081, 0.529864)</th><th>0.476539 (0.299845, 0.653232)</th><th>0.693147 (0.693147, 0.693147)</th></td<>		2006	0.402473 (0.275081, 0.529864)	0.476539 (0.299845, 0.653232)	0.693147 (0.693147, 0.693147)		
Mean (95%Cl) 2008 0.210958 (0.114918, 0.306998) 0.308055 (0.026769, 0.939626) 0.277259 (-0.194745, 0.749263) Mean (95%Cl) 0.309005 (0.023775, 0.341270) 0.401295 (0.231705, 0.418120) 0.4095105 (0.181908, 0.601579) Of log(1+unique) 2010 0.297063 (0.23633, 0.390493) 0.283550 (0.128875, 0.438246) 0.495105 (0.181908, 0.608302) 2011 0.259930 (0.175375, 0.344455) 0.271232 (0.121938, 0.420252) 0.433217 (0.132623, 0.733811) 2012 0.176355 (0.103845, 0.223860) 0.281591 (0.156860, 0.406322) 0.466647 (0.039429, 0.212715) 2013 0.117604 (0.077220, 0.159678) 0.158066 (0.075800, 0.236593) 0.1739705 (0.059477, 0.032422) 2014 0.179705 (0.407720, 0.159678) 0.158066 (0.075800, 0.236593) 0.1739705 (0.059477, 0.032422) 2005 0.580645 (0.407663, 0.73845) 0.687500 (0.234502, 0.2379416) 0.500000 (0.904510, 0.905469) 2007 0.500000 (0.336309, 0.636901) 0.574947 (0.362759, 0.768581) 0.571429 (0.325906, 0.786192) 2008 0.448750 (0.351760, 0.589279) 0.578947 (0.362750, 0.722145) 0.656500 (0.35776, 0.597400) 0.500000 (0.39742, 0.463156) 2010 0.468750 (0.32776, 0.58132) 0.574947 (0.3257		2007	0.346574 (0.219591, 0.473556)	0.462098 (0.195236, 0.728960)	0.346574 (-4.058377, 4.751524)		
Mean (95%Cl) of log(1+unique domains) 2009 0.324913 (0.237755, 0.412070) 0.401296 (0.231902, 0.578669) 0.396084 (0.190590, 0.601579) 2011 0.259930 (0.175375, 0.344485) 0.271232 (0.121938, 0.420525) 0.433217 (0.132623, 0.733811) 2012 0.178538 (0.103835, 0.2235731 0.180821 (0.046496, 0.315146) 0.346574 (0.116683, 0.576465) 2014 0.179705 (0.120974, 0.238435) 0.237650 (0.122543, 0.352758) 0.173287 (0.029375, 0.317198) 2015 0.118449 (0.077220, 0.159678) 0.158086 (0.079580, 0.3465533) 0.179705 (0.05987, 0.302422) 2007 0.500000 (0.336309, 0.663691) 0.666667 (0.354202, 0.879416) 0.500000 (0.0194531, 0.905469) 2008 0.3448 (0.190798, 0.448056) 0.444444 (0.188779, 0.7333149) 0.400000 (0.117621, 0.769276) 2009 0.466757 (0.1351760, 0.598279) 0.578947 (0.362759, 0.768511) 0.571429 (0.32596, 0.786192) Proportion 2010 0.428571 (0.307690, 0.558624) 0.409091 (0.232558, 0.612652) 0.714286 (0.358934, 0.917781) non-zero (95%Cl) 2011 0.37500 (0.444464, 0.837374) 0.250000 (0.337742, 0.663156) 2010 0.428571 (0.37768, 0.537731) 0.3200271 0.5268467 (0.351760, 0.5883 </th <th></th> <th>2008</th> <th>0.210958 (0.114918, 0.306998)</th> <th>0.308065 (0.026769, 0.589362)</th> <th>0.277259 (-0.194745, 0.749263)</th>		2008	0.210958 (0.114918, 0.306998)	0.308065 (0.026769, 0.589362)	0.277259 (-0.194745, 0.749263)		
of log(1+unique domains) 2010 0.297063 (0.20633, 0.390493) 0.283560 (0.128875, 0.438249) 0.495105 (0.181908, 0.080302) domains) 0.297063 (0.75375, 0.444845) 0.271232 (0.2129838, 0.420525) 0.438217 (0.132623, 0.733811) 2012 0.178535 (0.103345, 0.253731) 0.180821 (0.046496, 0.315146) 0.346574 (0.116683, 0.576465) 2013 0.166335 (0.109974, 0.238435) 0.237560 (0.122543, 0.332785) 0.179205 (0.056987, 0.302422) 2015 0.118449 (0.077220, 0.159678) 0.158086 (0.079580, 0.236539) 0.179705 (0.056987, 0.302422) 2006 0.530645 (0.407663, 0.735845) 0.687500 (0.444044, 0.683554) 1.000000 (0.510109, 1.000000) 2007 0.50000 (0.336309, 0.63691) 0.66667 (0.354202, 0.879416) 0.500000 (0.094531, 0.905469) 2008 0.349148 (0.190786, 0.48065) 0.444444 (0.188779, 0.733849) 0.400000 (0.17621, 0.762576) 2009 0.466750 (0.351760, 0.589279) 0.578947 (0.362759, 0.768581) 0.571428 (0.358944, 0.917781) 0.012 0.21000 (0.166913, 0.332331) 0.426870 (0.255196, 0.577400) 0.520000 (0.03742, 0.663156) 2010 0.240000 (0.166913, 0.332331) 0.426870 (0.255196, 0.577400) 0.520000 (0.037472, 0.663156)	Mean (95%Cl)	2009	0.324913 (0.237755, 0.412070)	0.401296 (0.231902, 0.570689)	0.396084 (0.190590, 0.601579)		
domains) 2011 0.25993 (0.1753/5, 0.344485) 0.271232 (0.121938, 0.420525) 0.435371 (0.132623, 0.733811) 2012 0.17653/5, 0.253731 0.180821 (0.040469, 0.315146) 0.346574 (0.116688, 0.574665) 2013 0.166355 (0.106851, 0.225860) 0.281591 (0.152680, 0.406322) 0.086643 (-0.039429, 0.212715) 2014 0.179075 (0.120974, 0.238435) 0.237650 (0.122543, 0.325758) 0.173287 (0.029375, 0.317198) 2015 0.118449 (0.077220, 0.155062) 0.158068 (0.079580, 0.2355834) 1.000000 (0.506987, 0.302422) 2006 0.580645 (0.407663, 0.735845) 0.666667 (0.354202, 0.8779416) 0.500000 (0.036339, 0.663691) 2007 0.500000 (0.356309, 0.663691) 0.666667 (0.354202, 0.8779416) 0.500000 (0.076613) 2010 0.428571 (0.307690, 0.558624) 0.40991 (0.232558, 0.612652) 0.714286 (0.358934, 0.917781) non-zero (95%CI) 0.2100 (0.166913, 0.332323) 0.466270 (0.125486, 0.464700) 0.500000 (0.253782, 0.746218) 2011 0.275976 (0.167488, 0.374331) 0.260870 (0.125486, 0.464700) 0.500000 (0.253782, 0.746218) 2012 0.259759 (0.185914) 0.440257 (0.263817, 0.508481) 0.259000 (0.111662, 0.466871) 2014	of log(1+unique	2010	0.297063 (0.203633, 0.390493)	0.283560 (0.128875, 0.438246)	0.495105 (0.181908, 0.808302)		
2012 0.178538 (b.103345, 0.25837) 0.180827 (0.046495, 0.37146) 0.346574 (0.116683, 0.376465) 2014 0.17975 (0.120974, 0.238435) 0.237650 (0.122543, 0.352758) 0.0180427 (0.221715) 2015 0.118449 (0.077220, 0.159678) 0.158086 (0.079580, 0.236593) 0.179705 (0.056987, 0.302422) 2015 0.118449 (0.077220, 0.159678) 0.158086 (0.079580, 0.236593) 0.179705 (0.056987, 0.302422) 2007 0.500000 (0.336309, 0.63691) 0.666667 (0.354202, 0.879416) 0.500000 (0.04531, 0.905469) 2008 0.34348 (0.190788, 0.448056) 0.444444 (0.188779, 0.733349) 0.400000 (0.117621, 0.769276) 2009 0.468750 (0.351760, 0.589279) 0.578497 (0.362759, 0.768581) 0.571429 (0.325906, 0.786192) 2010 0.428571 (0.307690, 0.558624) 0.409091 (0.22555, 0.612652) 0.714286 (0.358934, 0.917781) non-zero (95%CI) 2011 0.375000 (0.26660, 0.497496) 0.391304 (0.21576, 0.592145) 0.652000 (0.305742, 0.863156) 2012 0.25757 (0.167488, 0.37431) 0.260870 (0.125486, 0.4607400) 0.50000 (0.253782, 0.746218) 2013 0.20000 (0.696717, 1.58039) 1.148028 (0.711693, 1.914521) 1.72222 (1.308160, 2.519955) 2014	domains)	2011	0.259930 (0.175375, 0.344485)	0.271232 (0.121938, 0.420525)	0.433217 (0.132623, 0.733811)		
2013 0.166353 (0.106851, 0.22580) 0.281591 (0.156860, 0.406222) 0.0086634 (0.039429, 0.212/15) 2014 0.179205 (0.120974, 0.238453) 0.237560 (0.122374, 0.352758) 0.173287 (0.029375, 0.31798) 2005 0.580645 (0.407663, 0.735845) 0.668750 (0.444044, 0.838354) 1.000000 (0.51019, 1.00000) 2007 0.500000 (0.336309, 0.663619) 0.666667 (0.354202, 0.879416) 0.500000 (0.017621, 0.769276) 2008 0.303438 (0.190798, 0.448056) 0.444444 (0.18979, 0.733349) 0.400000 (0.0117621, 0.769276) 2009 0.468750 (0.351760, 0.589279) 0.578947 (0.362759, 0.768581) 0.571429 (0.325906, 0.786192) 2010 0.428571 (0.307690, 0.58624) 0.409091 (0.232558, 0.612522) 0.714286 (0.358934, 0.917781) non-zero (95%CI) 2011 0.37000 (0.266660, 0.497496) 0.391304 (0.221576, 0.552145) 0.625000 (0.305742, 0.863156) 2011 0.32000 (0.166913, 0.332232) 0.406250 (0.255196, 0.77400) 0.125000 (0.34477, 0.360228) 2013 0.240000 (0.66914, 0.321713) 0.228070 (0.138419, 0.352060) 0.259259 (0.131704, 0.446786) 2006 1.000000 (0.632776, 1.580339) 1.184028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795)		2012	0.178538 (0.103345, 0.253731)	0.180821 (0.046496, 0.315146)	0.346574 (0.116683, 0.576465)		
2014 0.1797/05 (0.120974, 0.23832) 0.13950 (0.122543, 0.235738) 0.179780; (0.059877, 0.03524738) 2006 0.580645 (0.079580, 0.2365738) 0.179705 (0.059687, 0.0302422) 2007 0.500000 (0.336309, 0.663691) 0.666667 (0.354202, 0.879416) 0.500000 (0.094531, 0.905469) 2008 0.304348 (0.190798, 0.448056) 0.444444 (0.188779, 0.733349) 0.400000 (0.117621, 0.769276) 2009 0.466750 (0.331760, 0.589279) 0.57847 (0.362759, 0.768581) 0.571429 (0.322906, 0.786192) 2010 0.428571 (0.307690, 0.558624) 0.409091 (0.232558, 0.612652) 0.714286 (0.330742, 0.863156) 2011 0.257576 (0.167488, 0.374313) 0.260870 (0.125486, 0.4617400) 0.650000 (0.253782, 0.746218) 2012 0.257576 (0.167488, 0.374313) 0.228070 (0.138419, 0.352060) 0.252926 (0.131704, 0.446786) 2014 0.25929 (0.185891, 0.349165) 0.342857 (0.208317, 0.508481) 0.250000 (0.2778, 3.387999) 2007 1.000000 (0.634776, 1.580339) 1.184028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795) 2007 1.000000 (0.649709, 2.213251) 1.460317 (0.268993, 3.397228) 1.314286 (0.619937, 2.016201) 1000000 (0.654917, 1.712279) 1.333333 (0.616767, 2		2013	0.166355 (0.106851, 0.225860)	0.281591 (0.156860, 0.406322)	0.086643 (-0.039429, 0.212715)		
Proportion non-zero (95%CI) 0.118449 (0.07722), 0.159678 0.158080 (0.079580, 0.235853) 0.179705 (0.05987, 0.302422) Proportion non-zero (95%CI) 0.500000 (0.336309, 0.63691) 0.666667 (0.354202, 0.879416) 0.500000 (0.91019), 1.000000 2009 0.468750 (0.444044, 0.858354) 0.400000 (0.510109), 1.07621, 0.769276) 0.040000 (0.117621, 0.769276) 2009 0.468750 (0.351760, 0.589279) 0.578947 (0.362759, 0.658581) 0.571429 (0.325906, 0.786192) 2010 0.428571 (0.307690, 0.558624) 0.409091 (0.232558, 0.612652) 0.714286 (0.358934, 0.917781) 2011 0.375000 (0.266660, 0.497496) 0.391304 (0.221576, 0.592145) 0.652000 (0.039772, 0.863156) 2012 0.257576 (0.167488, 0.373331) 0.260070 (0.125486, 0.646700) 0.125000 (0.034977, 0.360228) 2014 0.259259 (0.13704, 0.446786) 0.342857 (0.208317, 0.50841) 0.250000 (0.117867, 3.83799) 2006 1.000000 (0.54907, 1.712279) 1.33333 (0.616767, 2.463397) 1.000000 (1.077876, 3.83799) 2008 1.000000 (0.639077, 1.58033) 1.184028 (0.711633, 1.914321 1.72222 (1.308160, 2.519785) 2009 1.000000 (0.63907, 1.472754) 1.233333 (0.616767, 2.463397) 1.000007 (0.569471, 3.83799)		2014	0.1/9/05 (0.1209/4, 0.238435)	0.237650 (0.122543, 0.352758)	0.173287 (0.029375, 0.317198)		
Proportion 0.530494 (1.407/653,0.735349) 0.636927 (0.535420, 0.635421) 0.50000 (0.034510, 0.905469) 2007 0.50000 (0.33020, 0.636391) 0.66667 (0.035420, 0.354246) 0.50000 (0.094951), 0.905469) 2009 0.468750 (0.351760, 0.589279) 0.578947 (0.352759, 0.768581) 0.571429 (0.325966, 0.786192) 2010 0.428571 (0.307690, 0.558624) 0.409091 (0.232558, 0.612652) 0.714286 (0.358934, 0.917781) 2011 0.375000 (0.26660, 0.497496) 0.391304 (0.221576, 0.52145) 0.625000 (0.035474, 0.863156) 2012 0.257576 (0.167488, 0.374331) 0.260870 (0.125486, 0.464700) 0.500000 (0.253782, 0.746218) 2013 0.240000 (0.166913, 0.332323) 0.406250 (0.255196, 0.577400) 0.125000 (0.034977, 0.360228) 2014 0.259259 (0.138891, 0.349165) 0.342857 (0.208317, 0.508481) 0.2500200 (0.111862, 0.468701) 2015 0.100000 (0.584017, 1.712279) 1.33333 (0.616767, 2.463397) 1.000000 (-1.077876, 3.387999) 2008 1.000000 (0.496709, 2.013251) 1.460317 (0.2869393, 3.397228) 1.314286 (0.317955, 3.387303) 2010 1.000000 (0.528417, 1.712279) 1.33333 (0.616767, 2.463397) 1.666667 (0.7272978, 2.918277) 2008 <		2015	0.118449 (0.077220, 0.159678)	0.158086 (0.079580, 0.236593)			
Proportion non-zero (95%CI) 0.300348 (0.19098, 0.448055) 0.400309 (0.35237, 0.903489) 0.400000 (0.17521, 0.759276) 2009 0.468750 (0.351760, 0.589279) 0.578947 (0.362759, 0.768581) 0.571429 (0.325906, 0.786192) 2010 0.428571 (0.307690, 0.558624) 0.400901 (0.232558, 0.612652) 0.714286 (0.358934, 0.917781) 2011 0.375000 (0.266660, 0.497496) 0.391304 (0.221576, 0.552145) 0.625000 (0.305742, 0.863156) 2012 0.257576 (0.167488, 0.374331) 0.260070 (0.125486, 0.464700) 0.150000 (0.03977, 0.360228) 2014 0.252575 (0.167488, 0.374331) 0.228070 (0.138419, 0.352060) 0.259259 (0.11852, 0.468701) 2015 0.70000 (0.52776, 1.580339) 1.84028 (0.711693, 1.943210) 1.722222 (1.308160, 2.519795) 2006 1.000000 (0.63777, 1.580393) 1.84028 (0.716893, 3.397228) 1.314286 (-0.317905, 3.633703) 2007 1.000000 (0.64709, 2.013251) 1.460317 (0.266993, 3.397228) 1.314286 (-0.317905, 3.633703) 2008 1.000000 (0.649709, 2.013251) 1.460317 (0.266993, 3.397228) 1.314286 (-0.317905, 3.633703) 2009 1.000000 (0.649709, 2.013251) 1.460371 (0.266993, 3.1957830) 1.219048 (0.610937, 2.016201) 10000		2000	0.500000 (0.326200, 0.663601)	0.666667 (0.254202, 0.870416)			
Proportion non-zero (95%CI) 2009 0.468750 (0.351760, 0.589279) 0.578947 (0.362759, 0.758581) 0.571429 (0.32596, 0.786192) 9 0.428571 (0.307690, 0.558624) 0.409091 (0.232558, 0.612652) 0.714286 (0.358934, 0.917781) 9 0.2101 0.375000 (0.266660, 0.497496) 0.391304 (0.221576, 0.592145) 0.625000 (0.305742, 0.863156) 2012 0.257576 (0.167488, 0.374331) 0.260870 (0.125486, 0.464700) 0.50000 (0.033977, 0.360228) 2014 0.259259 (0.185891, 0.349165) 0.426857 (0.208317, 0.508481) 0.250000 (0.011862, 0.466201) 2015 0.170886 (0.120183, 0.237213) 0.228070 (0.138419, 0.352060) 0.259259 (0.131704, 0.446786) 2016 1.000000 (0.632776, 1.580339) 1.184028 (0.711693, 1.914321) 1.72222 (1.308160, 2.519795) 2007 1.000000 (0.69709, 2.013251) 1.460317 (0.266939, 320321) 1.000000 (0.1077876, 3.387999) 2008 1.000000 (0.69709, 2.013251) 1.460317 (0.266933, 1.65501) 1.219048 (0.610937, 2.016201) 0.95%CI) of world normalized log 1.000000 (0.638018, 1.677742) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2010 1.000000 (0.639018, 1.697742) 1.4525780 (0.488465, 2.972352) 0.		2007	0.304348 (0.190798 0.448056)	0.000007 (0.334202, 0.879410)	0.300000 (0.094551, 0.905469)		
Proportion non-zero (95%CI) 2010 0.428571 (0.30769), 0.538249 0.40901 (0.232558, 0.612652) 0.71428 (0.325893, 0.91781) 2011 0.375000 (0.266660, 0.497496) 0.391304 (0.221576, 0.592145) 0.625000 (0.305742, 0.863156) 2012 0.257576 (0.167488, 0.374331) 0.260870 (0.125486, 0.464700) 0.500000 (0.253782, 0.746218) 2013 0.240000 (0.166913, 0.332323) 0.406250 (0.255196, 0.577400) 0.125000 (0.034977, 0.360228) 2014 0.259259 (0.183891, 0.349165) 0.342857 (0.208317, 0.508481) 0.250000 (0.11862, 0.468701) 2015 0.170886 (0.120183, 0.237213) 0.228070 (0.138419, 0.352060) 0.2559259 (0.131704, 0.446786) 2006 1.000000 (0.632776, 1.580339) 1.184028 (0.711633, 1.914321) 1.722222 (1.308160, 2.519795) 2007 1.000000 (0.632071, 1.712279) 1.333333 (0.616767, 2.463397) 1.000000 (.1077876, 3.38799) 2008 1.000000 (0.67909, 2.013251) 1.460317 (0.28693, 3.397228) 1.314286 (-0.317905, 3.633703) 2009 1.000000 (0.620921, 1.610510) 1.043478 (0.468331, 865901) 1.666667 (0.656941, 3.06869) 2010 1.000000 (0.620921, 1.610510) 1.043478 (0.4589324) 1.6202083 (.0194141, 1.388639)		2000	0.304348 (0.190798, 0.448030)	0.578947 (0.362759 0.768581)	0.571429 (0.325906 0.786192)		
MNLCS - mean (95%Cl) 2010 1.00000 (0.256660, 0.497496) 0.391304 (0.221576, 0.592145) 0.625000 (0.305742, 0.863156) 2011 0.375000 (0.256660, 0.497496) 0.391304 (0.221576, 0.592145) 0.625000 (0.305742, 0.863156) 2012 0.257576 (0.167488, 0.374331) 0.260870 (0.125486, 0.464700) 0.500000 (0.3039742, 0.863156) 2014 0.259259 (0.185891, 0.349165) 0.342857 (0.208317, 0.508481) 0.250000 (0.31860, 2.468701) 2015 0.170886 (0.120183, 0.237213) 0.228070 (0.138419, 0.352060) 0.259259 (0.131704, 0.446786) 2006 1.000000 (0.632776, 1.580339) 1.148028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795) 2007 1.000000 (0.632476, 1.580339) 1.148028 (0.73875, 1.957830) 1.219048 (0.610937, 2.016201) 05%Cl) of world normalized log (1_unique do- mains) 1.000000 (0.621921, 1.610510) 1.043478 (0.468033, 1.865792) 1.666667 (0.772978, 2.918297) 2011 1.000000 (0.529021, 1.610510) 1.043478 (0.464033, 1.365901) 1.666667 (0.72978, 2.918297) 2011 1.000000 (0.529021, 1.610510) 1.043478 (0.464033, 1.365951) 1.466667 (0.666941, 3.060869) 2012 1.000000 (0.529041, 1.607871) 1.333333 (0.6477612, 2.189739) 1.94	Proportion	2005	0.428571 (0.307690 0.558624)	0.409091 (0.232558 0.612652)	0 714286 (0 358934 0 917781)		
MNLCS - mean (95%CI) of world normalized pro- portion non-zero (95%CI) (i.e. risk ratio] 2012 0.257576 (0.167488, 0.374331) 0.260870 (0.122486, 0.464700) 0.500000 (0.253782, 0.746218) 2013 0.240000 (0.16913, 0.332323) 0.406250 (0.255196, 0.577400) 0.125000 (0.034977, 0.360228) 2014 0.259259 (0.185891, 0.349165) 0.342857 (0.208317, 0.508481) 0.259000 (0.111862, 0.468701) 2015 0.170886 (0.120183, 0.237213) 0.228070 (0.138419, 0.352060) 0.259259 (0.131704, 0.446786) 2006 1.000000 (0.632776, 1.580339) 1.184028 (0.711633, 1.911321) 1.722222 (1.308160, 2.519795) 2007 1.000000 (0.649709, 0.13251) 1.460317 (0.286993, 3.397228) 1.314286 (-0.317905, 3.633703) 2009 1.000000 (0.67900, 1.472754) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2011 1.000000 (0.620921, 1.61010) 1.043478 (0.468033, 1.865901) 1.666667 (0.666941, 3.060869) 2012 1.000000 (0.594018, 1.697742) 1.692708 (0.398465, 2.273522) 0.520833 (0.194141, 1.388639) 2014 1.000000 (0.594978, 1.680734) 1.334633 (0.677782, 2.189739) 1.941176 (0.730814, 3.988658) 2015 1.000000 (0.64172, 1.505635) 1.184028 (0.776782, 1.804782) <th>non-zero (95%Cl)</th> <th>2010</th> <th>0.375000 (0.266660, 0.497496)</th> <th>0.391304 (0.221576, 0.592145)</th> <th>0.625000 (0.305742, 0.863156)</th>	non-zero (95%Cl)	2010	0.375000 (0.266660, 0.497496)	0.391304 (0.221576, 0.592145)	0.625000 (0.305742, 0.863156)		
MNLCS - mean (95%CL) of world normalized pro- portion non-zero (95%CL) [i.e. risk ratio] 0.20100 (0.166913, 0.332323) 0.406250 (0.255196, 0.577400) 0.125000 (0.142073, 0.360228) 2014 0.259259 (0.185891, 0.349165) 0.342857 (0.208317, 0.508481) 0.250000 (0.111862, 0.468701) 2015 0.170886 (0.120183, 0.237213) 0.228070 (0.138419, 0.352060) 0.259259 (0.131704, 0.446786) 2006 1.000000 (0.632776, 1.580339) 1.184028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795) 2007 1.000000 (0.694070, 2.013251) 1.460317 (0.286993, 3.397228) 1.314286 (-0.317905, 3.633703) 2008 1.000000 (0.679000, 1.472754) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2010 1.000000 (0.62921, 1.610510) 1.043478 (0.468033, 1.865901) 1.666667 (0.666941, 3.060869) 2011 1.000000 (0.528419, 1.892436) 1.012788 (0.276594, 2.185739) 1.941176 (0.730814, 3.988658) 2013 1.000000 (0.590734), 1.607742) 1.692708 (0.898465, 2.972352) 0.520833 (-0.194141, 1.388639) 2014 1.000000 (0.6590741, 1.1617430) 1.334433 (0.647040, 2.390200) 1.517147 (0.505898, 2.946691) 2006 1.000000 (0.659051, 1.437803) 1.334533 (0.647040, 2.390200)		2017	0.257576 (0.167488 0.374331)	0.260870 (0.125486, 0.464700)	0.500000 (0.253782, 0.746218)		
EMNLCS - mean (95%Cl) of world normalized log (1_unique do- mains) 2014 0.259259 (0.185891, 0.349165) 0.342857 (0.208317, 0.508481) 0.250000 (0.111862, 0.468701) 0.2000 0.170886 (0.120183, 0.237213) 0.228070 (0.138419, 0.352060) 0.259259 (0.131704, 0.446786) 2006 1.000000 (0.632776, 1.580339) 1.184028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795) 2007 1.000000 (0.634017, 1.712279) 1.333333 (0.616767, 2.463397) 1.000000 (-1.077876, 3.387999) 2008 1.000000 (0.67909, 2.013251) 1.460317 (0.286993, 3.397228) 1.314286 (-0.317905, 3.633703) 2009 1.000000 (0.67909, 2.17274) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2011 1.000000 (0.620921, 1.610510) 1.043478 (0.468033, 1.865901) 1.666667 (0.772978, 2.918297) 2012 1.000000 (0.528419, 1.892436) 1.012788 (0.276594, 2.185739) 1.941176 (0.730814, 3.988658) 2013 1.000000 (0.6999774, 1.680734) 1.332449 (0.664615, 2.289534) 0.964286 (0.202781, 1.951286) 2014 1.000000 (0.694978, 1.680734) 1.334633 (0.647040, 2.390200) 1.517147 (0.505898, 2.946691) 2006 1.000000 (0.694978, 1.680734) 1.334633 (0.647040, 2.390200) 1		2012	0.240000 (0.166913, 0.332323)	0.406250 (0.255196, 0.577400)	0.125000 (0.034977, 0.360228)		
MNLCS - mean (95%Cl) of world normalized log (1_unique do- mains) 2015 0.170886 (0.120183, 0.237213) 0.228070 (0.138419, 0.352060) 0.259259 (0.131704, 0.446786) (95%Cl) of world normalized log (1_unique do- mains) 1.000000 (0.632776, 1.580339) 1.184028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795) 2006 1.000000 (0.632776, 1.580339) 1.184028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795) 2007 1.000000 (0.496709, 2.013251) 1.460317 (0.286993, 3.397228) 1.314286 (-0.317905, 3.633703) 2009 1.000000 (0.679000, 1.472754) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2010 1.000000 (0.620921, 1.610510) 1.043478 (0.468033, 1.865901) 1.666667 (0.772978, 2.918297) 2011 1.000000 (0.528419, 1.892436) 1.012788 (0.276594, 2.185739) 1.941176 (0.730814, 3.988658) 2013 1.000000 (0.594978, 1.680734) 1.334633 (0.647040, 2.390200) 1.517147 (0.505898, 2.946691) 2008 1.000000 (0.64172, 1.50535) 1.184028 (0.776782, 1.804782) 1.72222 (NaN, NaN) 2009 1.000000 (0.65506, 1.437803) 1.235088 (0.791688, 1.926821) 1.219048 (0.74264, 1.996708) 2014 1.000000 (0.65506, 1.764722) 1.460317 (0.669484		2014	0.259259 (0.185891, 0.349165)	0.342857 (0.208317, 0.508481)	0.250000 (0.111862, 0.468701)		
MNLCS - mean (95%CI) of world normalized log (1).00000 (0.632776, 1.580339) 1.184028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795) 2007 1.000000 (0.632776, 1.580339) 1.184028 (0.711693, 1.914321) 1.722222 (1.308160, 2.519795) 2008 1.000000 (0.584017, 1.712279) 1.333333 (0.616767, 2.463397) 1.000000 (-1.077876, 3.387999) 2008 1.000000 (0.496709, 2.013251) 1.460317 (0.286993, 3.397228) 1.314286 (-0.317905, 3.633703) 2009 1.000000 (0.679000, 1.472754) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2010 1.000000 (0.620921, 1.610510) 1.043478 (0.468033, 1.865901) 1.666667 (0.666941, 3.060869) 2011 1.000000 (0.59018, 1.697742) 1.692708 (0.898465, 2.972352) 0.520833 (-0.194141, 1.388639) 2013 1.000000 (0.594978, 1.680734) 1.32449 (0.664615, 2.289534) 0.964286 (0.202781, .1.951286) 2014 1.000000 (0.64172, 1.505635) 1.184028 (0.776782, 1.804782) 1.72222 (NaN, NaN) 2007 1.000000 (0.64172, 1.505635) 1.804782 (0.776782, 1.804782) 1.722222 (NaN, NaN) 2015 1.000000 (0.64172, 1.505635) 1.814028 (0.776782, 1.804782) 1.722222 (NaN, NaN) 2016 1.00000		2015	0.170886 (0.120183, 0.237213)	0.228070 (0.138419, 0.352060)	0.259259 (0.131704, 0.446786)		
MNLCS - mean (95%Cl) of world normalized log (1_unique do- mains) 2007 1.000000 (0.584017, 1.712279) 1.333333 (0.616767, 2.463397) 1.000000 (-1.077876, 3.387999) 2008 1.000000 (0.496709, 2.013251) 1.460317 (0.286993, 3.397228) 1.314286 (-0.317905, 3.633703) 2009 1.000000 (0.679000, 1.472754) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2010 1.000000 (0.620921, 1.610510) 1.043478 (0.468033, 1.865901) 1.666667 (0.772978, 2.918297) 2011 1.000000 (0.528419, 1.892436) 1.012788 (0.276594, 2.185739) 1.941176 (0.730814, 3.988658) 2012 1.000000 (0.59907, 1.610510) 1.043478 (0.468033, 1.865901) 1.666667 (0.466941, 3.060869) 2013 1.000000 (0.59918, 1.697742) 1.692708 (0.898465, 2.972352) 0.520833 (-0.194141, 1.388639) 2014 1.000000 (0.694978, 1.680734) 1.334633 (0.647040, 2.390200) 1.517147 (0.505898, 2.946691) 2006 1.000000 (0.64172, 1.505635) 1.184028 (0.776782, 1.804782) 1.722222 (NaN, NaN) 2007 1.000000 (0.64172, 1.505635) 1.184028 (0.791688, 1.926821) 1.219048 (0.744264, 1.996708) 007 1.000000 (0.657052, 1.521950) 0.954545 (0.543139, 1.677576) 1.666667 (1.0233	MNLCS - mean (95%Cl) of world	2006	1.000000 (0.632776, 1.580339)	1.184028 (0.711693, 1.914321)	1.722222 (1.308160, 2.519795)		
MNLCS - mean (95%Cl) of world normalized log (1_unique do- mains) 2008 1.000000 (0.496709, 2.013251) 1.460317 (0.286993, 3.397228) 1.314286 (-0.317905, 3.633703) 2009 1.000000 (0.679000, 1.472754) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2010 1.000000 (0.631677, 1.583088) 0.954545 (0.435792, 1.678302) 1.666667 (0.772978, 2.918297) 2011 1.000000 (0.620921, 1.610510) 1.043478 (0.468033, 1.865901) 1.666667 (0.666941, 3.060869) 2012 1.000000 (0.528419, 1.892436) 1.012788 (0.276594, 2.185739) 1.941176 (0.730814, 3.988658) 2013 1.000000 (0.594978, 1.680734) 1.322449 (0.664615, 2.289534) 0.964286 (0.202781.,1.951286) 2015 1.000000 (0.64172, 1.505635) 1.184028 (0.776782, 1.804782) 1.722222 (NaN, NaN) 2007 1.000000 (0.64172, 1.505635) 1.184028 (0.776782, 1.804782) 1.722222 (NaN, NaN) 2008 1.000000 (0.657052, 1.521950) 0.954545 (0.543139, 1.677576) 1.666667 (1.023382, 2.714312) 2010 1.000000 (0.657052, 1.521950) 0.954545 (0.543139, 1.677576) 1.666667 (1.023382, 2.714312) 2010 1.000000 (0.657052, 1.521950) 0.954545 (0.543139, 1.677576) 1.666667 (1.023382, 2.714		2007	1.000000 (0.584017, 1.712279)	1.333333 (0.616767, 2.463397)	1.000000 (-1.077876, 3.387999)		
MNLCS - mean (95%Cl) of world normalized log (1_unique do- mains) 2009 1.000000 (0.679000, 1.472754) 1.235088 (0.703875, 1.957830) 1.219048 (0.610937, 2.016201) 2010 1.000000 (0.631677, 1.583088) 0.954545 (0.435792, 1.678302) 1.666667 (0.772978, 2.918297) 2011 1.000000 (0.620921, 1.610510) 1.043478 (0.468033, 1.865901) 1.666667 (0.666941, 3.060869) 2012 1.000000 (0.528419, 1.892436) 1.012788 (0.276594, 2.185739) 1.941176 (0.730814, 3.988658) 2013 1.000000 (0.598918, 1.697742) 1.692708 (0.898465, 2.972352) 0.520833 (-0.194141, 1.388639) 2014 1.000000 (0.594978, 1.680734) 1.334633 (0.647040, 2.390200) 1.517147 (0.505898, 2.946691) 2005 1.000000 (0.664172, 1.505635) 1.184028 (0.776782, 1.804782) 1.722222 (NaN, NaN) 2006 1.000000 (0.6547518, 1.826422) 1.460317 (0.669484, 3.185330) 1.314286 (0.495971, 3.482756) 2009 1.000000 (0.657052, 1.521950) 0.954545 (0.543139, 1.677576) 1.666667 (1.023382, 2.714312) 2010 1.000000 (0.644078, 1.552606) 1.043478 (0.585395, 1.860019) 1.666667 (0.950797, 2.921527) 2011 1.000000 (0.644078, 1.552606) 1.043478 (0.585395, 1.860019) 1.666667 (0.		2008	1.000000 (0.496709, 2.013251)	1.460317 (0.286993, 3.397228)	1.314286 (-0.317905, 3.633703)		
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AND A CONTRACTOR OF A CONTRACTOR OF A CONTRACT		2014	1.00000 (0.640527, 1.561214)	1.322449 (0.766984, 2.280193)	0.964286 (0.442831, 2.099777)		

4. Discussion

The findings from this work suggest that AM technologies for biomedical engineering applications are emerging technologies, i.e. they are at an early stage of development, which agrees with the results obtained by other studies for additive manufacturing technologies (**Rodríguez-Salvador**; **Río-Belver**; **Garechana-Anacabe**, 2017; **Zarrabeitia-Bilbao** *et al.*, 2019).

Within this scenario, the USA and China are undoubtedly the central characters in scientific production in this field. In this case, the USA shows the supremacy also demonstrated in other studies related to both research areas, additive manufacturing, and medicine; however, in the case of China it seems that this position is due to the area of the technology and not to the medicine. While in other studies related to the technology, both countries are among the first positions, in the case of China, in other studies related to medicine it does not appear in the first positions of the countries with more publications (López-Muñoz *et al.*, 2003; López-Illescas; De-Moya-Anegón; Moed, 2009; Filser; Da-Silva; De-Oliveira, 2017; Rodríguez-Salvador; Río-Belver; Garechana-Anacabe, 2017; Caviggioli; Ughetto, 2019; Muhuri; Shukla; Abraham, 2019).

The top publishing and cited institutions, as expected, are universities. However, the presence of certain laboratories or medical centers is omitted. Due to this, it would be interesting, for future works, to include an analysis of the departments (**Filser**; **Da-Silva**; **De-Oliveira**, 2017) which were involved in the published articles and analyze if there are more medical or more technical departments.

The findings from academic impact and industrial and commercial impact indicators suggest that AM technologies for biomedical engineering application research, in general, produces good results, and, consequently, fine quality research is performed. The findings from this work suggest that AM technologies for biomedical engineering applications are emerging technologies, i.e. they are at an early stage of development

In the case of citation counts for individual sets of ar-

ticles, this emphasizes that the proportion of articles with at least 1 citation $(\Sigma_{year 2006}^{year 2015} Proportion non - zero/10)$ is practically 100% (98.7%).

For *Mendeley* readers count it is observed that the proportion of articles with at least 1 *Mendeley* reader is 97.5%, while the proportion with at least one *Mendeley* reader varied from 40.7% in humanities to 81% in psychology (72.4% for biomedical research and 71.6% for engineering and technology) for articles from 2010 to 2012 in *PubMed* and *Web of Science* (Haustein *et al.*, 2014). There is a high level of interest among researchers in biomedical engineering applications.

In the case of *Google Patents* citation counts, the proportion of articles with at least 1 *Google Patents* citation is 35.9%, while the coverage in applied science and engineering varies for 1.9% in mechanical engineering to 10.1% in biomedical engineering for articles from 1996 to 2012 in *Scopus* (Kousha; Thelwall, 2017b). Therefore, we can say that a high rate of transfer between science and technology is taking place.

As for *Wikipedia* citation counts, the proportion of articles with at least 1 *Wikipedia* citation is only 1.5%, whereas the proportion with at least one *Wikipedia* citation varied from 1.4% in Computer Science to 10.7% in History for articles from 2005 to 2012 in *Scopus* (Kousha; Thelwall, 2017a). More time is required for new research and its applications to be broadly transferred to the academic field.

4.1. Limitations and other considerations

Finally, the present study, like all bibliometric/webometric analyses, has its inherent methodological limitations. Reliability of bibliometric data can be affected by the bibliometric database coverage (*Web of Science*). The impact indicators used show academic, and industrial and commercial impact, and have been used as a proxy for quality. However, estimates of quality based on these variables can be misleading because work may be cited for a variety of reasons, not all of which may reflect quality (**Gunashekar** *et al.*, 2015). The USA shows the supremacy also demonstrated in other studies related to both research areas, additive manufacturing, and medicine; however, in the case of China it seems that this position is due to the area of the technology and not to the medicine

Hence, despite the fact that bibliometric/webometric analysis has been used increasingly as a tool within the scientific community (**Ellegaard**, 2018) and bibliometric/webometric methods offer a practical and impartial way to estimate publication profiles of scientific researchers, it would also be interesting to complete the results obtained with other methods, such as expert opinions and panels (**Koskinen** *et al.*, 2008).

5. Conclusions and future lines of research

This research contributes to the diffusion of technologies to society, providing key elements to scientific and technological policy makers. Usually main productivity impact studies come from firms and follow a variety of methodological approaches. This paper addressing trends and the scientific impact of additive manufacturing technologies for biomedical engineering applications provides evidence on the generation and impact of scientific production from bibliometric data and suggests only one methodological approach for every study, which may be extended to other fields.

Additive manufacturing technologies have been identified as revolutionary because of their power to change, among other things, productive systems, skills and well-being; and they will have major implications for society, in general; and for policy makers, in particular.

In general, in AM technologies for BE applications is worth noting the clear agreement between where knowledge comes from and who is researching it (countries and institutions), except for the case of China, who, despite Additive manufacturing technologies have been identified as revolutionary because of their power to change, among other things, productive systems, skills and well-being; and they will have major implications for society, in general; and for policy makers, in particular

extensive research activity, would appear to have contributed relatively little to that field to date.

The greatest research areas from where the knowledge comes and research areas developed, are in both cases "Engineering, Biomedical" and "Materials Science, Biomaterials". It can also be deduced that the different areas of knowledge are following the same paths, for both where the knowledge comes from and where it goes. In addition, the fields of research have evolved very little, in general, inferring that they cover the same topics.

With respect to scientific journals, the most prolific journals and the most cited journals are in upper quartile rankings, which demonstrates the quality of the articles being published in the area.

Another important point to highlight is that the USA, apart from being the central character in scientific production, produces scientific studies into AM technologies for biomedical engineering applications that have higher academic, industrial, and commercial impact than the world average. This is not the case for China, the second most productive country in the area for academic impact but with merely good results in terms of industrial and commercial impact.

Finally, future work related with this study could take many forms, given the diversity of the current situation for additive manufacturing and informetrics. It would be interesting to analyze specific AM technologies and their behavior in different biomedical engineering applications. Further research should also use other primary

The most prolific journals and the most cited journals are in upper quartile rankings, which demonstrates the quality of the articles being published in the area

search engines (like *Scopus*) and other scientific impact indicators. New scientific impact indicators could be *Google Books* citations and citations from the Grey Literature (academic impact); Syllabus mentions (educational impact); Clinical Trials or Guidelines (medical impact); and Blog citations (public engagement impact). Finally, it would also be interesting to expand this study to include other processes and technologies.

6. Notes

1. A top technician was identified through Addimat (the Spanish Association of Additive Manufacturing Technologies and 3D, http://www.addimat.es). At the time of furnishing assistance, the expert selected was a qualified engineer from Optimus3D (http://optimus3d.es), a company that provides comprehensive engineering and part manufacturing solutions, using different additive manufacturing technologies, both in plastic materials or resins, as well as metal.

2. MNLCS is the average number of log-transformed citations for the group, divided by the average number of log-transformed citations for the corresponding world set (**Thelwall**, 2016).

3. EMNPC is the proportion of articles cited for the group, divided by the corresponding world proportion of cited articles for the same field and year (**Thelwall**, 2016).

4. NaN (Not a Number) in the sample confidence limits mean that these are impossible to calculate and are effectively infinite.

5. Even though normally unique domains value is best information value (to avoid counting multiple similar pages in a single website), in the case of *Wikipedia* URLs value is better (**Kousha**; **Thelwall**, 2017a).

7. Appendix

Search query for Additive Manufacturing for Biomedical Engineering Applications adapted to the Web of Science Core Collection database

Equation (1) [World]	(TS=(I(3D OR*3 D*0 R3-2) OR*3 dimension** OR 3-dimension* OR*three* dimension** OR three-d OR*three d' OR desktop* OR additive* OR freeform) NERAY1 (priot* OR bio-priot*OR*bio priot** OR bio- manufactur**) OR ((rapid) NEAR/1 (prototype* OR bio-prototyp* OR bio-prototyp* OR*bio prototyp**)) OR Tayer by Jayer* OR Jayer -by-Jayer) NOT (stereoscoje* OR *oiadition product** OR* to prototyp**)) OR*iayer by Jayer* OR Jayer -by-Jayer) NOT (stereoscoje* OR *oiadition product** OR* streaming interactive* (OR*non halogen* OR non-halogen OR*media access control* OR*multi-wafer 3D CAM cell**OR nanoweb OR*nano web* OR nano- meb OR nanofiber* OR*nano fiber** OR (fnood* OR feed* OR liquid*) NEAR/1 (additive*)) OR (wibration) NEAR/1 (solator*)) OR antibacteria* OR 3-sigma OR*three sigma*OR ((heolog*) NEAR/1 (additive*)) OR ((wibration) NEAR/1 (solator*)) OR collet OR paper OR transistor OR*solar cell*OR*light** OR SO=**Ata Biomaterialia* OR SO=**Ata Biomedicale and Biotechnology* OR SO=**Biofabrication* OR SO=**Ata Biomaterialia* OR SO=**Ata Biomedicale and Biotechnology* OR SO=**Biomaterials* OR SO=**Ata Biomaterialia* OR SO=**Ite Hedicial mage Analysis* OR SO=**Europance Cells & Materials* OR SO=**Clinical Oral Implants Research* OR SO=**Ite Transactions on Biomedical Engineering* OR SO=**Journal of NeuroEngineering and Rehabilitation* OR SO=**Ite Transactions on Biomedical Engineering* OR SO=**Ite Transactions on NeuroIs Systems and Rehabilitation Engineering* OR SO=**Biomechanics and Modeling in Mechanobiology* OR SO=**Physics in Medicial Engineering* OR SO=**Journal of Biomechanics and Modeling in Mechanobiology* OR SO=**Physics in Medicial Engineering* OR SO=**Journal of Biomechanics or SO=**Gourter Nethods and Programs in Biomedicial Engineering* OR SO=**Journal of Biomechanics or SO=**Gourter Nethods and Programs in Biomedicial Engineering* OR SO=**Journal of Biomechanics or SO=**Gourter Nethods of SO=**Physics in Medicine Erist* OR SO=**Journal of Biomechanics OR SO=**Journal of Auterials Science-Materials in Medici
Equation (2) [USA]	Equation (1) AND (AD=USA)
Equation (3) [China]	Equation (1) AND (AD=China)
Source	Web of Science
Databases	Core Collection
Timespan (1)	From 2000 to 2017
Timespan (2)	From 2006 to 2015
Document type	Articles
Date of the search	October 01, 2018
Results [equation (1) + timespan (1)]	1223 articles
Results [equation (1) + timespan (2)]	31 articles (in 2006), 32 articles (in 2007), 46 articles (in 2008), 64 articles (in 2009), 56 articles (in 2010), 64 articles (in 2011), 66 articles (in 2012), 100 articles (in 2013), 108 articles (in 2014), 158 articles (in 2015)
Results [equation (2) + timespan (2)]	16 articles (in 2006), 9 articles (in 2007), 9 articles (in 2008), 19 articles (in 2009), 22 articles (in 2010), 23 articles (in 2011), 23 articles (in 2012), 32 articles (in 2013), 35 articles (in 2014), 57 articles (in 2015)
Results [equation (3) + timespan (2)]	4 articles (in 2006), 2 articles (in 2007), 5 articles (in 2008), 14 articles (in 2009), 7 articles (in 2010), 8 articles (in 2011), 12 articles (in 2012), 16 articles (in 2013), 20 articles (in 2014), 27 articles (in 2015)

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