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Citation and impact factor distributions of scientific journals published in individual countries

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ABSTRACT

The distributions of citations L, two- (IF2) and five-year impact factors (IF5), and citation half-lives λ of journals published in different selected countries are analyzed using Langmuir-type relation: $y_n = y_0\ \{1 - \alpha Kn/(1 + Kn)\}$, where y_n denotes L_n, IF2$_n$ or IF5$_n$ of n-ranked journal, y_0 is the value of y_n when journal rank $n = 0$, α is an empirical effectiveness parameter, and K is the Langmuir constant. It was found that: (1) the general features of the distribution of L_n, IF2$_n$ or IF5$_n$ of the journals published in different individual countries are similar to the results obtained before by the author from the analysis of the citation distribution data of papers of individual authors (K. Sangwal, *Journal of Informetrics* 7 (2013) 36–49), (2) in contrast to the theoretically expected value of the effectiveness parameter $\alpha = 1$, the calculated values of $\alpha > 1$ for journals published in different countries, (3) the trends of the distribution of cited half-lives λ_n of journals differ from those of L_n, IF2$_n$ and IF5$_n$ data for different countries, and show one, two or three linear regions, the longest linear regions with low slopes are observed in the case of countries publishing relatively high number of journals, and (4) the product of the Langmuir constant K and the number N of journals for the processes of citations and two- and five-year impact factors of journals published in different countries is constant for a process. The results suggest that: (1) the values of $\alpha > 1$ are associated with a process that retards the generation of items (i.e. citations or impact factors), the difference $(\alpha - 1)$ being related to the dissemination of contents of the journals published by a country, and (2) the constancy of KN is related to the publication potential of a country.

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1. Introduction

The number of published papers, the number of citations received by the published papers and impact factors of journals in which the papers are published are known indicators of the research performance of individuals, groups and institutions. In recent times however, selection/promotion committees, funding agencies and governments usually use journal impact factors (IF) based on two-year citation window to evaluate and compare the scientific performance of individuals, research groups and institutions. The impact factor of a journal in a particular year is calculated as the ratio of number of citations received in that year by papers published in the journal in the previous two years to the number of papers published in that journal in those two years. Since it is a measure of the mean citations per paper over a two-year period, there are a number of problems associated with this measure, which are mainly concerned with the short time window for citation record, the robustness/reliability of data sources, and the coverage of data by the source.

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Table 1
Number *N* of journals of groups A and B countries indexed in JCR of 2008–2011.

Country	Group	*N* in different years			
		2008	2009	2010	2011
Australia	B	73	97	132	105
Brazil	A	28	65	89	96
Croatia	A	11	24	35	36
Czech Republic	A	22	31	32	33
India	B	45	68	94	100
Italy	A	75	100	121	125
New Zealand	B	23	26	27	31
Poland	A	59	103	122	126
Romania	A	10	33	44	47
Singapore	B	44	47	51	50
Slovakia	A	11	16	19	19
South Africa	B	21	29	36	37
Spain	A	37	60	73	78
Turkey	A	8	32	49	54

For the calculation of impact factors (IFs) of journals a relatively short time window of two years is used to collect citations of papers published in them although there are many disciplines in which citations to their papers do not reach a peak during this short time (Mingers, 2008; Sangwal, 2012a; Whitehouse, 2001). The IF of a journal is essentially determined by highly cited papers because the distribution of citations of papers is always skewed. Since IF is the mean citations per paper over a time period, curves of its value calculated for two-year time window reveal considerable fluctuations with time in contrast to relatively smooth curves of their five-year impact factors (Amin & Mabe, 2000). Wallace, Lariviere, and Gingras (2009) analyzed changes in mean citations received by papers over a 107 year period (1900–2006) in the fields of natural sciences and engineering, medicine and social sciences, and observed that the mean number of citations received by papers for two- and ten-year citation window follow the same trends. van Leeuwen (2012) found that two-year impact factor (IF2) is a good predictor of the citation impact of the journals with the possible exception of relatively low number of publications. However, the use of longer citation window has been suggested by several authors (Sombatsompop, Markpin, & Premkamolnetr, 2004; van Leeuwen & Moed, 2002; Whitehouse, 2001; Zitt, 2012). In order to address the limitation of two-year impact factors (IF2s) of journals, since 2007 Thomson Reuters World of Science (WoS) database has started publishing their five-year impact factors (IF5s) in addition to their classical two-year impact factors (IF2s).

Several studies have shown that WoS, Google Scholar and Scopus databases have different coverage of publication titles (Abrizah, Zainab, Kiran, & Raj, 2012; Bar-Ilan, 2008; Leta, 2012; Meho & Rogers, 2008; Mingers & Lipitakis, 2010; Mingers, Macri, & Petrovici, 2012). Consequently, the values of various scientometric measures, including h-index of authors and IF of journals, based on these databases significantly differ from each other. In the case of IF of journals, its definition rests on robustness and accuracy of the data on "citeable items" (without capture errors, mismatches, duplication, etc.), but the concept of citeable items is unclear. Thomson Reuters' Journal Citation Reports (JCR) consider all citations to the journal primary research articles and review articles, but serious discrepancies in the number of citations and designation of citable items have been reported (Rossner, Van Epps & Hill, 2007). It is not a flaw of IF as a measure but it is the vulnerability of the measure to changes, including manipulation, by issues such as the type and the number of documents fetching citations (Zitt, 2012). In a study of citations in the field of business and management, Mingers and Lipitakis (2010) found that WoS is more accurate and rigorous than Google Scholar.

Most of the publications included in WoS databases until recently had been from English-language journals. This resulted in severe gaps of WoS databases in comparison with other databases for citations of papers in non-English-language journals and article sources such as conference proceedings and books. Moreover, several studies have shown that citations per paper of non-English journals are lower than those of English-language journals (Garfield, 1978; Gonzalez-Alcaide, Valderrama-Zurian & Aleixandre-Benavent, 2012; Liang, Rousseau & Zhong, 2012; Mueller, Murali, Cha, Erwin & Ghosh, 2006; Poomkottayil, Bornstein & Sendi, 2011; Sangwal, 2012b; van Raan, van Leeuwen & Visser, 2011). Sangwal (2012b) found that the citability of papers published by physics, chemistry and technical sciences professors in Poland decreases with increasing fraction of the papers in volumes/issues of journals as proceedings of conferences and in non-English language journals. Therefore, the impact factors of journals, which are calculated from the total number of citations received by the papers published in them, and the ranking of a journal in its scientific discipline are determined by the journal language and the data source. During the last five years, Thomson Reuters WoS has successively expanded its databases by including new English, non-English and multilingual journals published in different countries across the World (see Table 1). This enables one to analyze the relationship between English- and non-English language journals and their citation behavior (Gonzalez-Alcaide et al., 2012; Leta, 2012).

Advantages and limitations of the journal impact factor (IF) have been debated over years in the literature. In a recent article, Vanclay (2012) severely criticized Thomson Reuters for errors, inaccuracies and limitations in the calculated IF of journals and suggests to abandon IF and "to replace it with a system that is better aligned with quality considerations in scientific publication". After the publication of this article a fresh debate on IF has burst again. According to Zitt (2012), despite a huge amount of critical matter accumulated in the literature, the IF still persists probably "through a magic mix of parsimony principle and market power" and "if we were to pick up the most successful indicators in scientometrics, we might come up with the impact factor, the h-index and the ARWU (Shanghai) ranking". In his opinion, all these indicators are "parsimonious in their framework, quite vulnerable to criticism and rather seductive to users". Moed et al. (2012) observed that "citation-based indicators of journal performance are appropriate tools in journal assessment provided that they are accurate and used with care and competence". According to Vinkler (2012), IF represents the most valuable part of the information in journals quantitatively and may, therefore, be regarded as a reliable impact indicator. Podovkin and Garfield (2012) emphasized that "there is no other measure that can compare with IF in accuracy, transparency of calculation, ease of use and interpretation, width and time depth of journal coverage". A survey of the opinion of 1704 researchers from 86 countries in all continents, engaged in all major scientific fields, on the topic of IF revealed that for about 90% of the researchers IF is important or very important for the evaluation of the scientific performance in their country (Buela-Casal & Zych, 2012).

Distribution of the number of citations, papers, authors, journals, journal impact factors by their rank and size is an important area of research in informetrics (for example, see: Campanario, 2010, 2011; Egghe & Waltman, 2011; Mansilla, Köppen, Cocho, & Miramontes, 2007; Redner, 1998; Sangwal, 2013a). Size- and rank-order distributions may be defined in terms of information production processes (Egghe & Rousseau, 1990). An information production process consists of sources which produce or have items. A country where N journals are published which receive L citations is such an example. An information production process may be considered as a system or set of sources generating items. However, it is important as well as interesting to understand mechanisms and factors responsible for the generation of items by a system of sources.

Rank-order distributions of items in various scientific disciplines have traditionally been described by empirical laws such as Lotka's and Zipf's laws (Egghe and Rousseau, 1990; Egghe and Waltman, 2011; Mansilla et al., 2007; Naumis & Cocho, 2007). The main limitations of these laws are that they contain adjustable parameters and poor fitting at very high or very low rank (Mansilla et al., 2007; Naumis & Cocho, 2007). However, in recent years, several new mathematical functions containing parameters attributed to some physical processes have been proposed to describe the rank-order distribution of different types of items (Mansilla et al., 2007; Naumis & Cocho, 2007; Guerrero-Bote, Zapico-Alonso, Espinosa-Calvo, Gomez-Crisostomo & Moya-Anegon, 2007; Sangwal, 2013a; Simkin & Roychowdhury, 2007; Tsallis & de Albuquerque, 2000; Vieira & Gomes, 2010).

Campanario (2011) studied the distribution of IF2 and IF5 of journals from the JCR database published by Thomson Reuters' WoS for three years: 2007, 2008 and 2009. He found that the distributions of IF2 and IF5 were very similar each year and between years. This author also found that both IF2 and IF5 distribution of journals follows a beta function with two exponents, previously proposed by Mansilla et al. (2007). Franceschet (2010) analyzed IF2, IF5, eigenfactor and article influence, and found that the rankings of journals according to IF2, IF5 and article influence were similar but differed from the ranking based on eigenfactor. This last ranking is similar to that obtained from the total number of citations received by the journals.

In an earlier paper, Sangwal (2013a) analyzed the citation distribution of papers of different selected authors using five mathematical functions. Two of these, the power law and the extended exponential function, are well known in the citation literature, whereas the remaining three are novel mathematical functions. Among the new functions, the logarithmic function proposed for the analysis is similar to that used by Guerrero-Bote et al. (2007) and Lancho-Barrantes, Guerrero-Bote, and Moya-Anegon (2010) for their iceberg hypothesis. The new mathematical functions proposed in the above work were derived following the concepts of growth kinetics of crystals in the presence of additives which act as inhibitors of growth. An additional aim of the previous study was to propose a possible mechanism of the citation rank-order distribution in terms of physical processes at the elementary level. The main conclusion drawn from the above study is that Zipf-type power law and logarithmic function previously proposed by Guerrero-Bote et al. (2007) for their iceberg hypothesis are inadequate to describe the citation distribution of individual papers of the authors, and that the new stretched exponential, Langmuir-type and empirical binomial mathematical functions can be employed for these citation distributions.

The citation distribution of journals published in individual countries is a subject which has not been investigated so far. The present paper is addressed to this topic. The aim of the paper is three-fold: (1) to analyze of the distribution of citations, two- and five-year impact factors and citation half-lives of journals published in different selected countries using the newly proposed Langmuir-type function and its modification, (2) to investigate the physical significance of the effectiveness parameter α of this function, and (3) to trace a relationship, if any, between the Langmuir constant K of the distributions and the number N of journal published in different countries.

2. Mathematical functions

In this section the relevant mathematical functions for the analysis of distributions of items generated by a set of sources are briefly described.

For sufficiently large values of n the relation between the number y_n of items and the rank n of the source is described by

$$y_n = y_0 \exp\left[-\left(\frac{n}{n_0}\right)^{\beta}\right], \quad \text{stretched exponential function,} \tag{1}$$

where y_0 denotes the number of items generated by the maximally active source, and β and n_0 are empirical constants. The constant $\beta \leq 1$. For real citation distributions analyzed in the literature, β is found to lie between 0.39 and 0.57 (Laherrer & Sornette, 1998; Redner, 1998; Wallace et al., 2009). The parameters β and n_0 may be obtained empirically by performing a least-squares fit over all values of n using Eq. (1).

Following the concepts of adsorption processes involved during crystal growth proposed by the author (Sangwal, 2013a) to describe the distribution of citations of papers of individual authors, the relation between the number y_n of items and the rank n of the source may be described by the following functions:

$$y_n = y_0\left[1-\alpha\left(\frac{Kn}{1+Kn}\right)\right], \quad \text{usual Langmuir-type (LT) function,} \tag{2}$$

$$y_n = y_0(1-k_1n^p+k_2n^{2p}), \quad \text{binomial relation.} \tag{3}$$

In Eqs. (2) and (3) y_0 is the extrapolated value of the number y of items when $n = 0$, and K, α, k_1, k_2 and p are positive constants, which may be considered as fitting parameters for the analysis of the items distribution data. In Eq. (3) when $k_1n^p \gg k_2n^{2p}$ and $k_1 = \alpha_1$, it reduces to the form

$$y_n = y_0(1-\alpha_1n^p), \quad \text{decreasing power law,} \tag{4}$$

where $k_1 = \alpha_1$.

Langmuir-type function (2) and decreasing power-law relation (4) may be derived following the concepts of adsorption processes involved during crystal growth. Eq. (2) is obtained when the adsorption of possible adsorption sites follows Langmuir adsorption isotherm relating coverage θ of adsorption sites, defined as the ratio of the number of adsorbed (inhibited) sites to the total number of possible adsorption sites, is given by

$$\theta = \frac{Kn}{1+Kn}, \tag{5}$$

where the parameter K, defined as Langmuir constant, characterizes the behavior of items generated by the sources generating them. However, the units of K are inverse of source rank (i.e. source-rank^{-1}) and are determined by the way the source rank n is expressed. In Eq. (5) one can define a dimensionless source rank $x = n/N_0$, and a new dimensionless Langmuir constant $K' = KN_0$, where N_0 is the number of sources which generate items. Then the dimensionless Langmuir constant K' for items of different source-items systems is related to their corresponding dimensionless differential energy Q by

$$K' = KN_0 = \exp Q. \tag{6}$$

Eq. (3) is obtained when the coverage θ follows Freundlich adsorption i.e.

$$\theta = p\left(\frac{n}{n_0}\right)^p, \tag{7}$$

where n_0 is the value of rank n when θ approaches unity whereas the constant $p < 1$ and is related to the distribution of energies of adsorption sites. Binomial function (3) is an extended form of decreasing power law (4) when the total surface coverage θ decreases with increasing coverage from an initial value θ_0.

The fitting parameter α, called effectiveness parameter, of Eq. (2) is given by

$$\alpha = 1 - \frac{y_i}{y_0}, \tag{8}$$

where y_i is the number of inhibited items generated by a source. The value of α lies between 0 and 1. The highest value of unity for α is achieved when $y_i = 0$. It occurs when the active sites for adsorption are inhibited completely (see Fig. 1). As explained before (Sangwal, 2013a), the fitting parameters α_1 and p of Eq. (4) have clear physical interpretation.

Here we recall the basic concepts used in the derivation of Eqs. (2) and (4). Their derivation is based on the following postulates (cf. Sangwal, 2013a):

(1) All N_0 sources have the same number $s_{\max}$ of possible active sites.
(2) The y_0 items belonging to the rank $n = 0$ of a source are produced by $s_{\max}$ possible active sites. However, for $n > 0$, of the $s_{\max}$ sites, s_{ad} sites are completely inhibited (open circles) but the remaining $(s_{\max} - s_{\text{ad}})$ sites remain completely uninhibited (filled circles), as shown in Fig. 1.
(3) Inhibition process during the process of generation of items may be described by the usual adsorption isotherms.
(4) The rank n of a source is a measure of inhibition of the probability of generation of items by the source. This assumption means that the number of y_n items generated by the nth rank source decreases with increasing value of n whereas y_0 items are produced by the source with rank $n = 0$.

Assumption (4) implies that the degree of uncovering of completely inhibited adsorption sites is a measure of the number of the items generated by the source. The uncovering process is determined by the properties of the source-items system such as quality of the source and accessibility of its contents. Accordingly, as seen from Eq. (2) for example, for $\alpha = 1$, no items

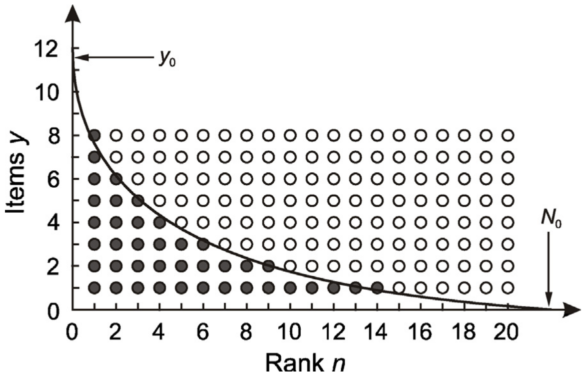

Fig. 1. Graphical illustration of the number y of items produced by a set of n sources. Filled and open circles denote inhibited (blocked) and uninhibited (uncovered) active sites of items, respectively. Dependence of y_n items on rank n of sources is shown by the curve starting from items y_0 at rank $n = 0$ and terminating at rank $n = N_0$. Note that N is the maximum number of items corresponding to $n = 14$ sources in the figure.

are generated by a source when $\theta = 1$ but a maximum number y_0 of items is generated when $\theta = 0$. In general however, items are not generated (i.e. $y = 0$) when $\alpha\theta = 1$, implying that $\theta > 1$ when $\alpha < 1$ (cf. Eq. (2)).

It should be mentioned that, in the case of adsorption of gas or solution molecules on the surface of a solid, Langmuir adsorption isotherm (5) is followed only at low coverages $\theta < \theta_c$ of active adsorption sites when adsorption is no more than one molecule thick (Hamil, Williams, & MacKay, 1966, chap. 12; Ośik, 1982, chap. 3). In other words, each active site is likely to be adsorbed by individual adsorbing molecule (entity). However, at coverages $\theta > \theta_c$, multimolecular adsorbed layer is developed. In this case, active sites can be adsorbed by larger entities in the form of aggregates of adsorbing entities. In the language of generation of items by a source, the above ideas of multimolecular adsorption mean that the process of uncovering of items is rendered difficult in comparison with the situation when Eq. (5) holds. In other words, the generation of items by the set of sources is retarded in this situation possibly by hindered dissemination of contents of the journals published in a country.

Citations received during a particular time window by the papers of various journals published in a country is a typical example of a set of sources generating items. Here citations L are the items, journals are the sources and all journals published in the given country form the set of sources. However, impact factors (IFs) and cited half-lives (λ) of journals are items "derived" from citations. Thus, citations L, IF2s, IF5s and cited half-lives λ of journals published in a given country are, irrespective of their origin, the items whereas journals are the sources.

Denoting the reference year by Y, IF2, IF5 and λ of a journal are defined as follows:

IF2(Y) = total number of citations to papers published in the previous 2 years ($Y - 2$) and ($Y - 1$) divided by the number of papers published in the previous 2 years ($Y - 1$) and ($Y - 2$);
IF5(Y) = total number of citations to papers published in the previous 5 years from ($Y - 5$) to ($Y - 1$) divided by the number of papers published in the previous 5 years from ($Y - 5$) to ($Y - 1$);
Cited half-life λ for a journal is the number of publication years from the year Y that accounts for one-half of citations received by the journal. It is the median age of its papers cited in the year Y.

3. Citation data of selected countries and their characteristics

We analyzed the citation data of journals published in the following 14 countries divided into the following two groups: (A) Brazil, Croatia, Czech Republic, Italy, Poland, Romania, Slovakia, Spain and Turkey, and (B) Australia, India, New Zealand, Singapore and South Africa. The countries of the two groups were selected from a consideration of the languages of publication of the journals published in them. In the countries of group A, English is not their national language, and a high percentage of journals is published in their national languages in different scientific disciplines. In contrast to this, in the countries of group B, except in the case of South Africa where there are seven multilingual journals out of 37, all journals are published in English.

Due to their geographical, political and economic background, the above countries represent different publication cultures and organization of research work. For example, in group A countries like Czech Republic, Poland, Slovakia and Romania research work is carried out in universities as well as institutes of their national academies of sciences but practically in all of the other countries there are also independent research institutes. The group B countries, on the other hand, represent similar publication culture and research organization. In these countries research activities are mainly confined to universities and specialized research institutes. Among these different countries, Brazil, India and South Africa are rapidly developing economies in South America, South Asia and Africa, whereas Australia, New Zealand and Singapore are developed economies.

We used Journal Citation Reports (JCR) of Thomson Reuters' ISI Web of Knowledge data source (2011 JCR Science Edition) covering the period 2002–2011, to collect appropriate bibliometric data about the journals, such as their cumulative citations

L, IF2s, IF5s and half-lives λ. We selected 2011 JCR database in view of expanded coverage of journals from different countries (see Table 1). These data were collected between 10 and 20 October and between 10 and 14 December 2012.

In the 2011 JCR list the total number of journals from the countries considered in this study is 933 (see Tables 1 and 5). Practically all these journals have their IF2s but only 483 of them have their IF5s. This means that 48% of the journals published in the countries analyzed in this study were included in the ISI Web of Knowledge database only recently. The ratio of the number of journals with IF5 to that of IF2 may be considered as a measure of “established” journals. According to this criterion, New Zealand and Singapore have the highest percentage (90%) of the established journals in contrast to Romania with the lowest percentage (19%) of the established journals. Australia, Italy, Slovakia and South Africa also have high percentage of established journals whereas Brazil, Croatia and Turkey have relatively low percentage of the established journals.

The above findings are consistent with the increasing number of journals indexed in successive years since 2008 in the JCR databases, summarized in Table 1. From this table it may be seen that, with the exception of Australia and Singapore, the number of journals has steadily increased for all countries since 2008. However, the relative increase in the number of journals since 2008 is relatively low for group B countries than that for group A countries. The relative increase lies between 1.15 and 2.2 for group B countries with Singapore and India as the lower and upper limits, and between 1.5 and 6.75 for group A countries with Czech Republic and Turkey as the two limits. Obviously, since 2008 the relative increase in the number of indexed journals in group A countries is much higher than that in group B countries. This is a consequence of inclusion of an overwheming number of national-language journals in JCR databases from group B countries in recent years.

Table 2 presents a summary of the scientific fields and publishers of top 20 journals published in the above selected countries. The scientific fields are listed in the order of their appearance from the top journal published in a country whereas the publishers of two or more journals are listed in the order of their decreasing number. In column 1 of the table E, NE and ML denote the number of English, non-English and multilingual journals, respectively. It may be seen that, except in the case of Singapore, the top journals in these countries are in the areas of medical sciences, medicine, biology, biochemistry, chemistry, sport sciences, astronomy and astrophysics, plant sciences, forestry, horticulture, environmental science, zoology, food science and technology, and multidisciplinary sciences. The number of the main publishers of the top journals varies from one for Singapore to several for the remaining countries and is not related to the total number N of the journals published in a country.

4. Results and discussion

Nonlinear least-squares fitting, involving chi-square residual, of the citation and two-year and five-year impact factor data was carried out with Macrocal^{TM} “Origin 4.1” package. This package yields values of the fitting parameters, their standard deviations and the corresponding “dependency” for each parameter of an equation. This fitting procedure is described in detail in the previous paper (Sangwal, 2013a).

As mentioned before (Sangwal, 2013a), we observed empirically that for a simple two-parameter equation the “dependency” is related to the goodness-of-the-fit parameter R^2, i.e. dependency$^{1/2} \approx R^2$, but the values of the fitting “dependency” for different parameters of a nonlinear mathematical function are different for a dataset. Therefore, we considered the lowest value of the “estimated” goodness-of-the-fit parameter R^2 from the set of the “dependencies” corresponding to the best-fit parameters of a mathematical equation used for the analysis of a given dataset. However, since our analysis program does not give the values of the goodness-of-the-fit parameter R^2 directly, the “estimated” R^2 values are given below in different tables merely for reference purposes. The standard deviations for different parameters are denoted by “$\pm$” sign in the tables. While analyzing the data with four-parameter functions such as relation (12) when interdependence between two parameters did not lead to attain the best fitting, the values of the best-fit parameters were determined on the basis of the lowest value of the chi-square residual (see Section 4.3).

4.1. Group A countries

4.1.1. Citation distribution data

The data of the distribution of citations of journals published in three arbitrarily selected group A countries (namely: Brazil, Poland and Turkey, with different number N of published journals) were analyzed first using stretched exponential relation (1), Langmuir-type relation (2) and binomial equation (3). It was found that the three mathematical relations describe the $L_n(n)$ data satisfactorily practically in the entire n range of the journals. Minor differences in the course of the plots were noted for n below 1 or 2 and, in some cases such as Poland, for relatively high n. A similar behavior of the best fit of the $L_n(n)$ data for individual authors was observed before (Sangwal, 2013a). In view of this, the data for different countries were analyzed according to Langmuir-type relation (2) alone to follow the behavior of the Langmuir constant K and the effectiveness parameter α.

Fig. 2 illustrates the plots of citations L_n from journals published in the selected group A countries as a function of journal rank n. The curves are drawn with the best-fit values of the constants L_0, α and K of usual Langmuir-type function (2) listed in Table 3.

It may be noted from Table 3 that the value of the effectiveness parameter α is approximately unity for the citations of journals published in most of the countries. Exceptions of α much higher than unity are Slovakia and Romania with relatively

Table 2
Scientific fields and publishers of top 20 journals published in selected countries.

Country (E, NE, ML)	Fields	Main publisher(s)
Australia (20, 0, 0)	Medical sciences, medicine, biology, biochemistry, chemistry, sport sciences, astronomy and astrophysics, plant sciences, forestry, horticulture, environmental science, zoology, food science and technology.	CSIRO, Wiley-Blackwell, Ivysprings, others
Brazil (11, 5, 4)	Medicine, medical sciences, health sciences, biology, zoology, multidisciplinary sciences, biodiversity	Miscellaneous
Croatia (15, 2, 3)	Medicine, food science, health care, biotechnology, geophysics, chemistry (multidiscipl.), forestry, plant sciences, biochemistry, engineering (chemical), geosciences, mathematics, marine biology, engineering (multidiscipl.), veterinary science.	Medicine Publ., others
Czech Republic (12, 0, 8)	Chemistry (mulidiscipli.), plant sciences, biotechnology, microbiology, mathematics, agronomy, veterinary sciences, zoology, agriculture (dairy and animal sciences), food sciences, geochemistry and geosciences, computer science and cybernetics, biology	CzASc, Springer, others
India (20, 0, 0)	Astronomy and astrophysics, medicine, medical sciences, biology, energy and fuel, chemistry (multidiscipl.), biochemistry and molecular biology, biophysics, neurosciences, multidisciplinary sciences	MedKnow, IASc, NISCAIR, ICMR
Italy (18, 0, 2)	Medical sciences, physics (particles and fields), medicine, health care, public health, physics (multidiscipl.), neurosciences, radiology	Springer, Elsevier, Biolife, Minerva Medica, others
New Zealand (20, 0, 0)	Medical sciences, medicine, public health, plant sciences, ecology, biology, nanoscience and nanotechnology, multidisciplinary sciences	ADIS, Dove, others
Poland (17, 2, 1)	Medical sciences, medicine, biology (reproductive), astronomy, environment science, engineering (environmental), agronomy, microbiology, biotechnology, biochemistry and molecular biology, paleontology, oceanography	PASc, Versita, Via Medica, others
Romania (15, 3, 2)	Medical sciences, medicine, nanoscience and nanotechnology, environment science, mathematics (general, applied), physics (multidiscipl.), zoology, plant sciences, chemistry, materials science, history and philosophy of science, agronomy, automation operation research, computer science (electrical engg), biology (development)	RASc, NIM, others
Singapore (20, 0, 0)	Computer science and information systems, physics (applied, interdiscipl., mathematical, nuclear, particles and fields), mathematics (general, applied, interdiscipl.), materials science (interdiscipl.), multidisciplinary sciences, statistics and probability, engineering (multidisciplinary)	World
Slovakia (17, 0, 3)	Biology, medical sciences, chemistry (multidiscipl.), biochemistry, biophysics, geosciences (multidiscipl.), mathematics (general), physics (multidiscipl.), materials science, metallurgy, Engineering (electrical and electronic), instrumentation and measurements, materials science (paper and wood), food sciences and technology, computer science, mining and mineral processing, water resources, astronomy	Versita, SlASc, others
South Africa (16, 0, 4)	Medical sciences, medicine, water resources, public health, zoology, ecology, plant sciences, sport sciences, public health, food science and technology, biodiversity, marine science	NISC, others
Spain (9, 6, 5)	Medical sciences, medicine, biochemistry and molecular biology, geology, chemistry (multidiscipl., applied), public health, food science and technology	Doyma, others
Turkey (16, 2, 2)	Environmental engineering, energy and fuels, radiology, engineering (chemical), plant sciences, chemistry (multidiscipl., applied, medicinal), geoscience, biology, sport science, egronomy, zoology, mathematics, veterinary science	TRC, others

Abbreviations: CSIRO, Council of Scientific Research Organisation; NISC, National Inquiry Services Centre; PASc, Polish Academy of Sciences; RASc, Romanian Academy of Sciences; NIM, National Institute of Materials; World, World Scientific; NISCAIR, National Institute of Science Communication and Information Resources; SlASc, Slovak Academy of Science; CzASc, Czech Academy of Sciences; TRC, Turkish Research Council.

small data sizes. Moreover, omission of a few initial points such as $n = 1$ or 2 from the citation data for a country leads to significant changes in the values of L_0 and K but relatively minor changes in the value of α. If the omission of these points from the citation data of a country leads to a decrease in α, the values of both L_0 and K are increased. Both L_0 and K usually follow a reverse trend when the omission of point(s) leads to an increase in α. The fit of the data of citation distribution of journals improves when a few top-ranked journals are omitted from analysis.

The above features of the citation distribution of journals published in different individual countries are similar to those obtained before by the author from the analysis of the citation distribution data of papers of individual authors (Sangwal, 2013a). In fact, omission of data for a few top-ranked positions is a common practice during the analysis of various distributions (Campanario, 2011; Laherrer & Sornette, 1998), and such “outliers” have been called “king effect” (Laherrer & Sornette, 1998).

4.1.2. Distribution of data of two-year and five-year impact factors

Fig. 3 shows the plots of $IF2_n$ of journals as a function of journal rank n for different group A countries according to usual Langmuir-type function (2) whereas the curves are drawn with the values of the best-fit constants listed in Table 4. It may be seen that, except for the data for very low n less than 2–3 top journals and very high n corresponding to the IF2 tail of

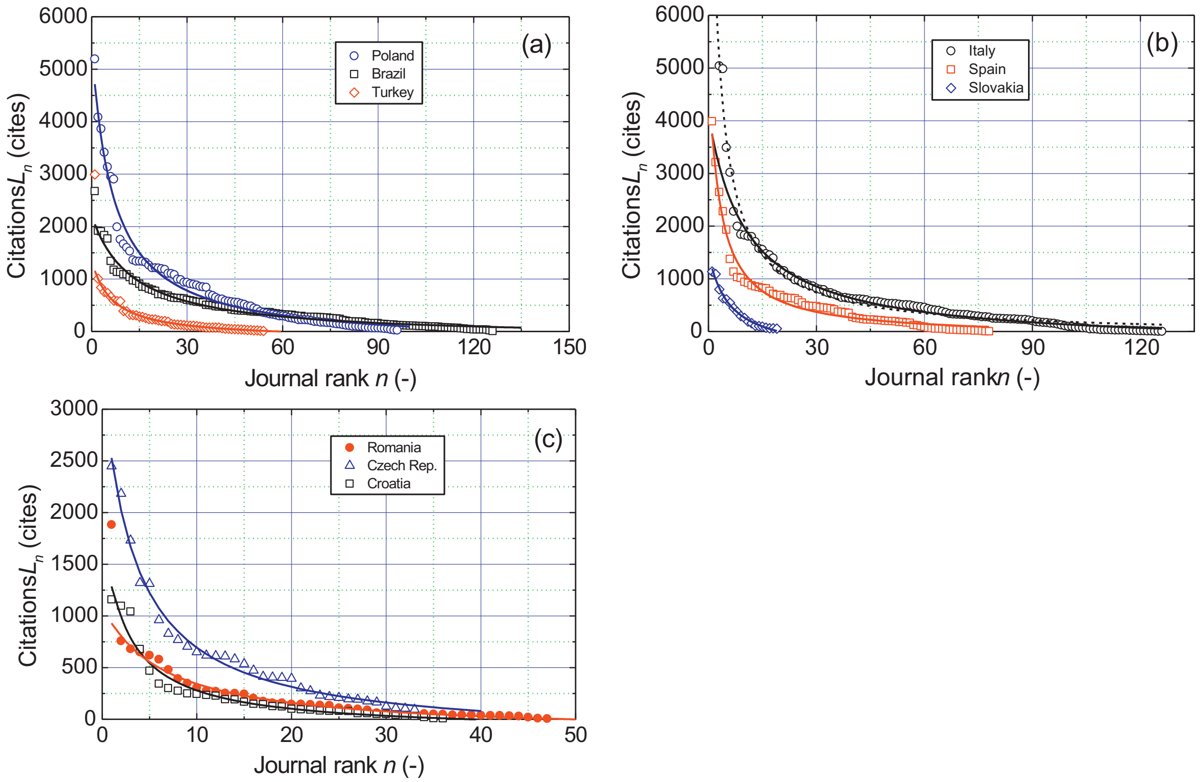

Fig. 2. Data of citations L_n from journals as a function of journal rank n for selected group A countries: (a) Poland, Brazil and Turkey, (b) Italy, Spain and Slovalia, and (c) Romania, Czech Republic and Croatia. Curves are drawn with the best-fit values of constants, indicated by arrows in Table 3, obtained by usual Langmuir-type function (2). In (b) dashed curve represents best fit for $n \geq 3$.

the data for practically all countries, the fit is indeed good. Moreover, the initial values of n and the tail part of the range of n, where the best fit of the $\text{IF2}_n(n)$ data is somewhat poor, increase with an increase in the value of the total number N of journals. The initial and the tail parts of the data with poor fit are about 2–3 and 10% of N, respectively. This feature may be seen from the plots of IF2_n against n for journals published in Italy in Fig. 3b, where the plots are drawn for the data with $n \geq 3$ (solid curve) and $n \geq 6$ (dashed curve).

Table 3
Estimated parameters of Langmuir-type function (2) for real $L_n(n)$ data for different group A countries.[a]

Country	N (jrnls)	N_{IF5} (jrnls)	Data	L_0 (cites)	α	K (rank^{-1})
Poland	126	55	All	2580 ± 63	1.028 ± 0.007	0.109 ± 0.007
			All	2767 ± 68	1	0.141 ± 0.006
			$n \geq 2 \rightarrow$	2212 ± 52	1.059 ± 0.008	0.0776 ± 0.0047
Italy	123	78	$n \geq 3 \rightarrow$	12,651 ± 1213	1.006 ± 0.002	0.488 ± 0.066
			$n \geq 6 \rightarrow$	4115 ± 177	1.069 ± 0.008	0.0956 ± 0.0078
Brazil	96	32	All	5881 ± 166	1.038 ± 0.006	0.172 ± 0.011
			$n \geq 2 \rightarrow$	5459 ± 210	1.049 ± 0.008	0.149 ± 0.012
Spain	76	39	All	5554 ± 225	1.016 ± 0.008	0.377 ± 0.034
			$n \geq 2$	5706 ± 449	1.015 ± 0.005	0.393 ± 0.052
			$n \geq 3 \rightarrow$	5014 ± 566	1.021 ± 0.008	0.324 ± 0.059
			$n \geq 6$	1562 ± 40	1.384 ± 0.036	0.0344 ± 0.0028
Turkey	54	12	$n \geq 2 \rightarrow$	1360 ± 44	1.108 ± 0.012	0.156 ± 0.012
Romania	47	9	All	4503 ± 897	1.001 ± 0.004	1.549 ± 0.450
			All	4644 ± 749	1	1.626 ± 0.348
			$n \geq 2 \rightarrow$	1098 ± 45	1.129 ± 0.018	0.156 ± 0.015
Croatia	36	11	All →	1835 ± 170	1.065 ± 0.021	0.391 ± 0.078
Czech R	33	23	All →	3341 ± 144	1.058 ± 0.014	0.299 ± 0.032
			$n \geq 2$	4087 ± 380	1.031 ± 0.012	0.428 ± 0.072
Slovakia	19	12	All →	1479 ± 73	1.290 ± 0.061	0.176 ± 0.029
			$n \geq 3$	1450 ± 165	1.282 ± 0.088	0.178 ± 0.049

[a] The R^2 coefficient was between 0.90 and 0.99 for all countries.

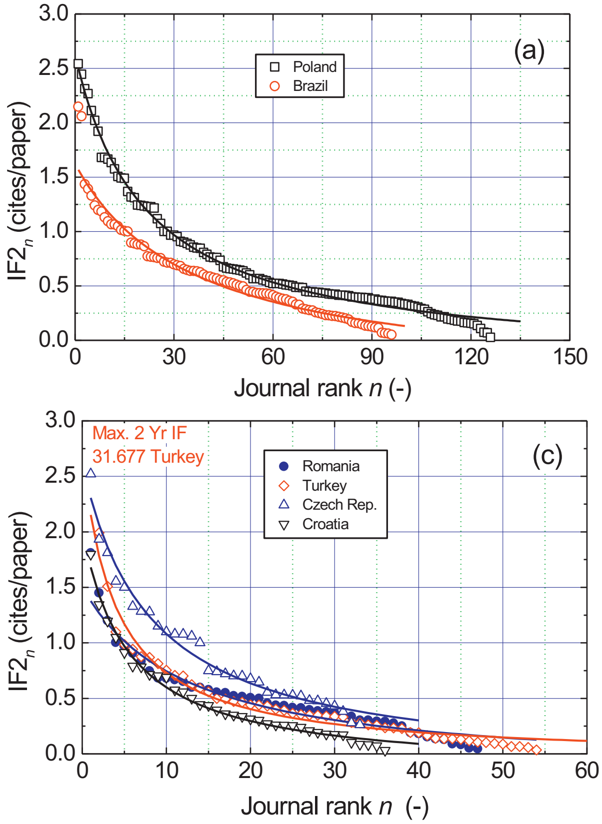

Fig. 3. Plots of $IF2_n$ of N journals as a function of journal rank n for different group A countries according to usual Langmuir-type function (2): (a) Poland and Brazil, (b) Italy, Spain and Slovakia, and (c) Romania, Turkey, Czech Republic and Croatia. Values of best-fit constants for the plots are indicated by arrows in Table 4. Dashed curves in (b) represent best fit for $n \geq 6$.

Fig. 4 presents plots of $IF5_n$ of journals as a function of journal rank n for different countries according to usual Langmuir-type function (2). The curves are drawn with the best-fit values of the constants given in Table 5. As in the case of $IF2_n(n)$ data for different countries, the fit of the data improves when the initial parts of the data are omitted from the analysis. This feature may be noted from the plots of $IF5_n$ against n for Italy and Spain shown in Fig. 4b. In general, the initial and the tail parts of the data with poor fits are about 5 and 10%, respectively. It seems that the $IF5_n(n)$ data for journals published in

Table 4
Estimated parameters of Langmuir-type function (2) for real $IF2_n(n)$ data for different group A countries.[a]

Country	N (jrnals)	Data	$IF2_0$ (cites)	α	K (rank^{-1})
Poland	126	All →	2.627 ± 0.028	1.082 ± 0.007	0.047 ± 0.002
Italy	123	All	7.855 ± 0.204	1.031 ± 0.006	0.128 ± 0.008
		$n \geq 3$ →	9.333 ± 0.464	1.015 ± 0.005	0.175 ± 0.016
		$n \geq 6$ →	6.027 ± 0.354	1.060 ± 0.013	0.083 ± 0.010
Brazil	96	$n \geq 2$	1.623 ± 0.044	1.248 ± 0.047	0.028 ± 0.003
		$n \geq 3$ →	1.502 ± 0.020	1.502 ± 0.049	0.016 ± 0.001
Spain	76	All	3.369 ± 0.079	1.121 ± 0.018	0.070 ± 0.005
		$n \geq 3$ →	2.987 ± 0.081	1.198 ± 0.026	0.050 ± 0.004
		$n \geq 6$ →	2.639 ± 0.093	1.305 ± 0.046	0.035 ± 0.004
Turkey	54	$n \geq 2$ →	2.708 ± 0.203	1.020 ± 0.012	0.252 ± 0.039
Romania	47	All	1.941 ± 0.103	1.009 ± 0.021	0.169 ± 0.026
		$n \geq 2$ →	1.506 ± 0.080	1.123 ± 0.048	0.082 ± 0.015
		$n \geq 2$	1.772 ± 0.094	1	0.152 ± 0.014
Croatia	36	All	2.022 ± 0.069	1.084 ± 0.018	0.185 ± 0.018
		$n \geq 2$ →	1.678 ± 0.053	1.171 ± 0.025	0.116 ± 0.011
Czech R	33	All	2.610 ± 0.101	1.066 ± 0.036	0.122 ± 0.018
		$n \geq 2$ →	2.204 ± 0.074	1.224 ± 0.062	0.068 ± 0.010
Slovakia	19	All →	3.049 ± 0.222	1.052 ± 0.024	0.426 ± 0.077
		$n \geq 3$	1.914 ± 0.209	1.259 ± 0.105	0.145 ± 0.045

[a] The R^2 coefficient was between 0.85 and 0.99 for all countries.

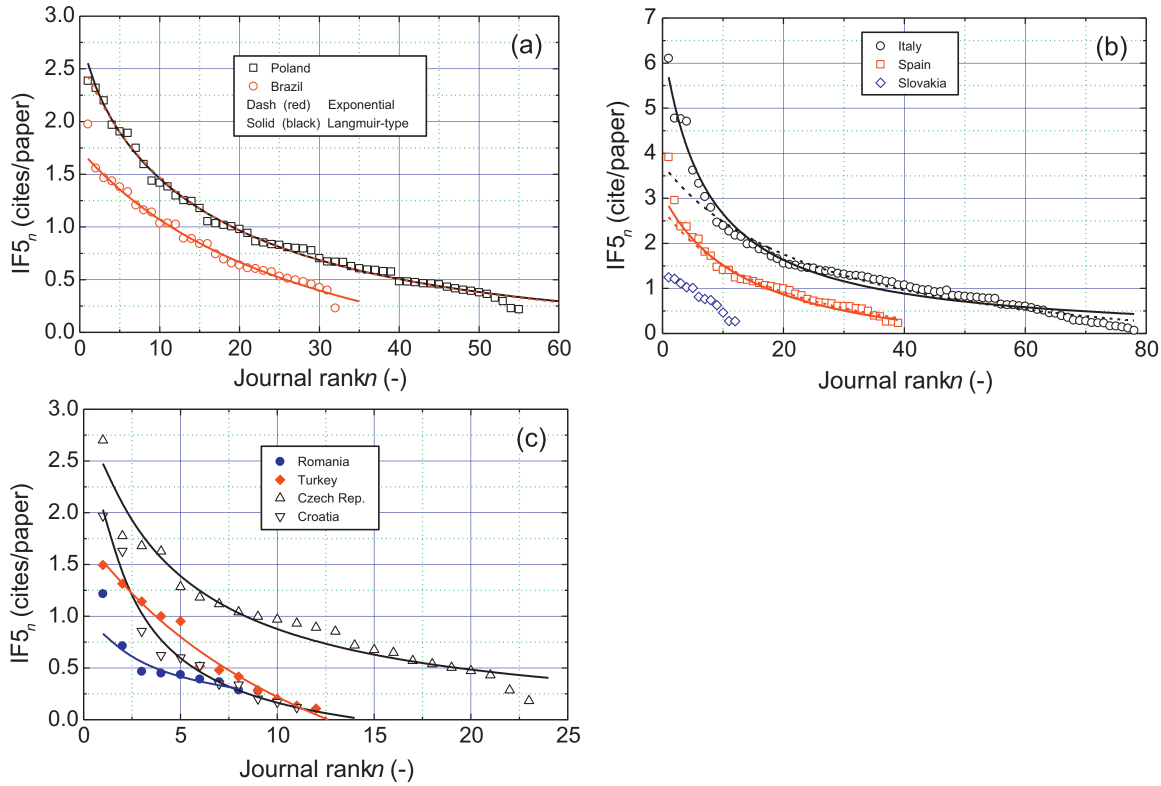

Fig. 4. Plots of IF5$_n$ of N journals as a function of journal rank n for different group A countries according to usual Langmuir-type function (2): (a) Poland and Brazil, (b) Italy, Spain and Slovakia, and (c) Romania, Turkey, Czech Republic and Croatia. Values of best-fit constants for the plots are indicated by arrows in Table 5. Data could not be fitted for Slovakia. In (a) dashed curve for Poland is drawn according to stretched exponential (1) with best-fit values of parameters: IF5$_0$ = 2.809, n_0 = 18.44 and β = 0.70.

Turkey, Romania and Slovakia cannot be described by Eq. (2) due to small data sizes. From Tables 4 and 5 one also finds that usually $K_{IF2} < K_{IF5}$ for different countries.

4.1.3. Distribution of half-life data

Fig. 5 presents the data of cited half-life λ_n of journals from different countries as a function of rank n of journals. These trends of the cited half-lives λ_n of journals are completely different from those of $L_n(n)$, IF2$_n(n)$ and IF5$_n(n)$ data for different countries. In the case of journal half-lives, there are one (Czech Republic and Croatia), two (Slovakia, Turkey, Poland and Romania) or three linear regions (Brazil, Spain and Italy), which are drawn in the figures as reference lines. In most of the

Table 5
Estimated parameters of Langmuir-type function (2) for real IF5$_n(n)$ data for different group A countries.[a]

Country	N_{IF5} (jrnls)	Data	IF5$_0$ (cites)	α	K (rank^{-1})
Poland	55	All →	2.603 ± 0.035	1.125 ± 0.017	0.063 ± 0.004
		All	2.821 ± 0.057	1	0.102 ± 0.004
Italy	78	All	6.699 ± 0.217	1.014 ± 0.009	0.149 ± 0.017
		$n \geq 2$	6.174 ± 0.263	1.028 ± 0.012	0.124 ± 0.013
		$n \geq 3$ →	6.491 ± 0.387	1.020 ± 0.123	0.138 ± 0.018
		$n \geq 6$ →	3.746 ± 0.159	1.241 ± 0.049	0.037 ± 0.005
Brazil	32	$n \geq 2$ →	1.735 ± 0.036	1.556 ± 0.123	0.033 ± 0.005
Spain	39	All	4.264 ± 0.178	1.022 ± 0.019	0.180 ± 0.023
		$n \geq 2$	3.411 ± 0.128	1.119 ± 0.033	0.098 ± 0.013
		$n \geq 3$ →	3.081 ± 0.126	1.195 ± 0.049	0.072 ± 0.011
		$n \geq 6$ →	2.765 ± 0.198	1.303 ± 0.106	0.053 ± 0.013
Turkey	12	All →	1.774 ± 0.112	2.161 ± 0.581	0.068 ± 0.031
Romania	9	All	2.362 ± 0.448	1	1.013 ± 0.293
		$n \geq 2$ →	1.108 ± 0.197	1	0.334 ± 0.057
Croatia	11	All →	3.409 ± 0.063	1.204 ± 0.076	0.565 ± 0.245
Czech R	23	All →	3.059 ± 0.241	1.025 ± 0.046	0.229 ± 0.059
		$n \geq 2$	2.070 ± 0.102	1.508 ± 0.204	0.055 ± 0.016

[a] The R^2 coefficient was between 0.9 and 0.98 for all countries.

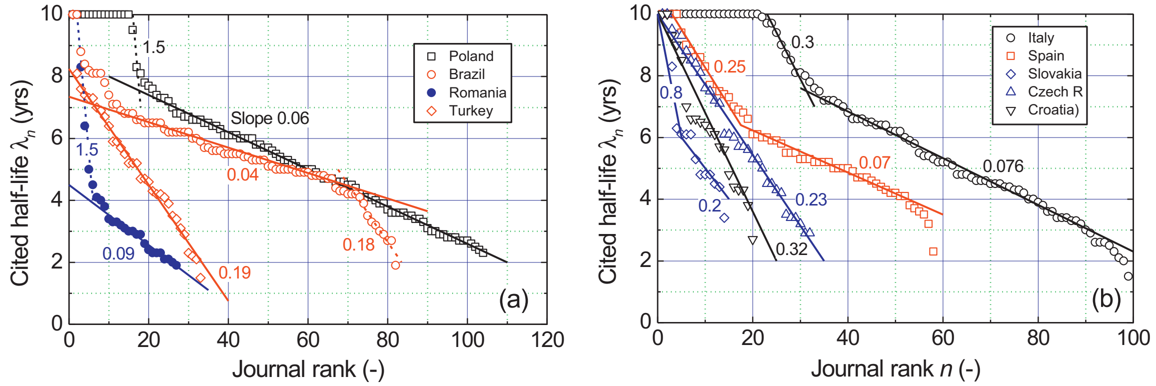

Fig. 5. Data of cited half-life λ_n of journals from different group A countries as a function of rank n of journals: (a) Poland, Brazil, Romania and Turkey, and (b) Italy, Spain, Slovakia, Czech Republic and Croatia. Large ranges of cited half-life with linear dependence on journal rank may be noted for practically all countries. Lines with different slopes are shown for visual reference.

cases there are initial steep slopes as high as 1.5 for Romania and Poland (Fig. 5a) and relatively low slopes lying between about 0.25 and 0.8 (see Fig. 5b). In some cases there are also steep slopes for the lowest-rank journals, as noted for Brazil, Italy and Spain. The longest linear regions with slopes of about 0.06 and 0.076 are observed in the case of Poland and Italy, respectively. These are the countries in which the highest number of journals are published.

Langmuir-type function (2) predicts a linear relationship between λ_n and journal rank n when $Kn \ll 1$, i.e.

$$y_n = y_0(1 - \alpha K n), \tag{9}$$

where y_n now denotes λ_n. This equation is similar to Eq. (6) when $p = 1$. According to Eq. (9) the slope of the plots of λ against n for a country is equal to αK. In several cases the values of the slope αK for the countries, especially in the long central n regions, are comparable with the values of K obtained from IF2(n) data (see Table 4). Since both IF2 and λ are based on the same number n of journals published in a country, the above observation suggests that α is close to unity in the case of half-life data.

4.2. Group B countries

As in the case of the above group A countries, the distributions of $L_n(n)$, $\mathrm{IF2}_n(n)$ and $\mathrm{IF5}_n(n)$ data for the group B countries were analyzed using usual Langmuir-type function (2). Fig. 6 shows the data of citations L_n from journals as a function of journal rank n for different group B countries. The best-fit values of the data with differently selected data are listed in Table 6. The curves are drawn with the best-fit values of constants indicated by arrows in Table 6.

Fig. 7 illustrates the $\mathrm{IF2}_n$ of journals for group B countries as a function of journal rank n whereas the best-fit values of the constants of Eq. (2) are given in Table 7. The curves are drawn with the values of the fitting parameters indicated by arrows in the table. The dashed curves in Fig. 7b represent best fit for $n \geq 6$. Fig. 8 shows plots of $\mathrm{IF5}_n$ of journals as a function of journal rank n for the above countries according to Eq. (2) whereas the values of best-fit constants for the data are listed

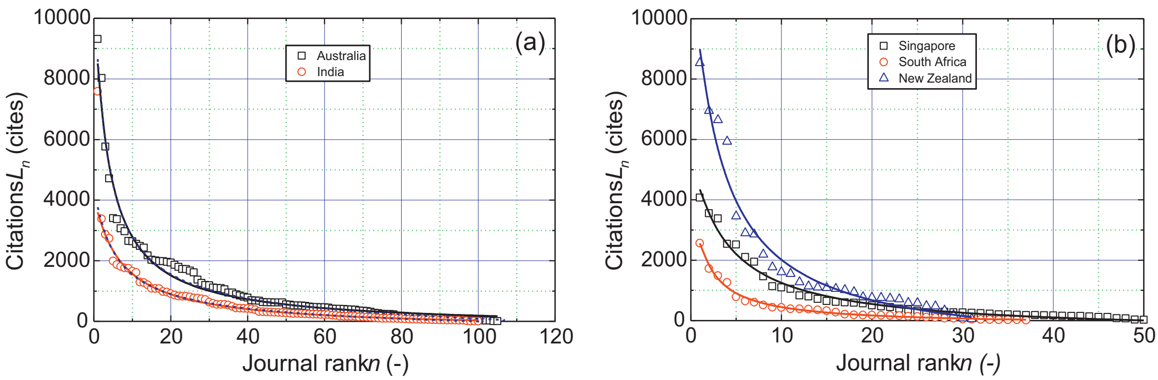

Fig. 6. Data of citations L_n from journals as a function of journal rank n for selected group B countries: (a) Australia and India, and (b) Singapore, South Africa and New Zealand. Curves are drawn with the best-fit values of constants, indicated by arrows in Table 6, obtained by usual Langmuir-type function (2). In (a) dashed curves are drawn with best-fit values of parameters according to Eq. (12).

Table 6
Estimated parameters of Langmuir-type function (2) for real $L_n(n)$ data for different group B countries.[a]

Country	N (jrnls)	N_{IF5} (jrnls)	Data	L_0 (cites)	α	K (rank^{-1})
Australia	105	69	All	12,148 ± 459	1.017 ± 0.004	0.327 ± 0.025
			All	13,131 ± 68	1	0.401 ± 0.025
			$n \geq 2 \rightarrow$	10,878 ± 655	1.019 ± 0.008	0.271 ± 0.030
			$n \geq 2$	13,441 ± 905	1	0.414 ± 0.040
			$n \geq 3$	6716 ± 272	1.072 ± 0.010	0.116 ± 0.010
			$n \geq 3$	10,069 ± 770	1	0.286 ± 0.031
India	100	47	All	14,124 ± 1400	0.997 ± 0.002	1.039 ± 0.159
			$n \geq 2 \rightarrow$	4165 ± 98	1.063 ± 0.005	0.141 ± 0.007
Singapore	50	46	All →	5581 ± 220	1.077 ± 0.011	0.259 ± 0.023
			All	6854 ± 555	1	0.500 ± 0.065
South Africa	37	22	All →	4340 ± 232	1.035 ± 0.006	0.656 ± 0.065
			$n \geq 6$	5935 ± 660	1	1.245 ± 0.193
New Zealand	31	28	All →	12,421 ± 945	1.085 ± 0.024	0.340 ± 0.060
			All	15,992 ± 2273	1	0.710 ± 0.142
			$n \geq 2$	16,952 ± 3227	1.046 ± 0.020	0.558 ± 0.017

[a] The R^2 coefficient was between 0.90 and 0.99 for all countries.

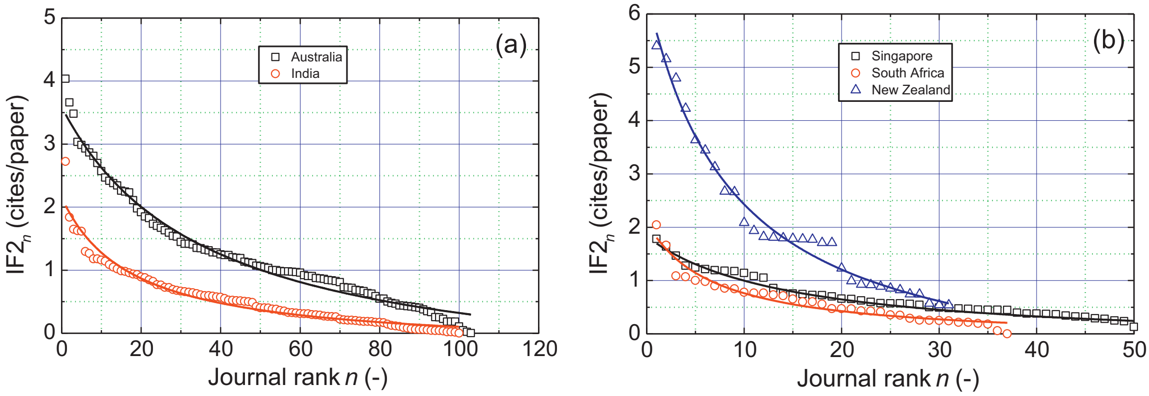

Fig. 7. Plots of $\mathrm{IF2}_n$ of N journals as a function of journal rank n for different group B countries according to usual Langmuir-type function (2): (a) Australia and India, and (b) Singapore, South Africa and New Zealand. Values of best-fit constants for the plots are indicated by arrows in Table 7. Dashed curves in (b) represent best fit for $n \geq 6$.

in Table 6. The curves are indicated by arrows in Table 7. From Table 7 one finds that $K_{IF2} < K_{IF5}$ for India and Singapore but $K_{IF2} \approx K_{IF5}$ for Australia, South Africa and New Zealand.

The above results are similar to those for group A countries. For example, the plots of $L_n(n)$, $\mathrm{IF2}_n(n)$ and $\mathrm{IF5}_n(n)$ for Poland and Spain resemble the corresponding plots for Australia and India.

Fig. 9 shows the data of cited half-life λ_n of journals from different group B countries as a function of journal rank n. As in the case of group A countries, here also one encounters large ranges of cited half-life with practically linear dependence

Table 7
Estimated parameters of Langmuir-type function (2) for real $\mathrm{IF2}_n(n)$ and $\mathrm{IF5}_n(n)$ data for different group B countries.[a]

Country	IF2/IF5	Data	$\mathrm{IF2}_0$, $\mathrm{IF5}_0$ (cites/paper)	α	K (rank^{-1})
Australia	IF2	All	3.749 ± 0.064	1.194 ± 0.024	0.0323 ± 0.0022
		All	4.240 ± 0.104	1	0.0660 ± 0.0032
		$n \geq 2 \rightarrow$	3.592 ± 0.062	1.239 ± 0.028	0.0277 ± 0.0020
	IF5	All	3.769 ± 0.094	1.348 ± 0.077	0.0265 ± 0.0037
		All	4.315 ± 0.134	1	0.068 ± 0.004
		$n \geq 3$	3.305 ± 0.071	1.914 ± 0.192	0.0124 ± 0.0022
		$n \geq 3$	4.186 ± 0.176	1	0.064 ± 0.005
India	IF2	All	2.152 ± 0.069	1.121 ± 0.023	0.057 ± 0.006
	IF5	All →	4.165 ± 98	1.063 ± 0.005	0.141 ± 0.007
Singapore	IF2	All →	1.824 ± 0.045	1.122 ± 0.034	0.068 ± 0.007
	IF5	All	1.752 ± 0.060	0.993 ± 0.034	0.083 ± 0.012
South Africa	IF2	All →	2.092 ± 0.141	1.064 ± 0.043	0.149 ± 0.033
	IF5	All	2.019 ± 0.75	1.140 ± 0.058	0.119 ± 0.020
New Zealand	IF2	All →	6.411 ± 0.226	1.170 ± 0.041	0.113 ± 0.015
	IF5	All	6.513 ± 0.140	1.205 ± 0.029	0.111 ± 0.009

[a] The R^2 coefficient was between 0.90 and 0.99 for all countries.

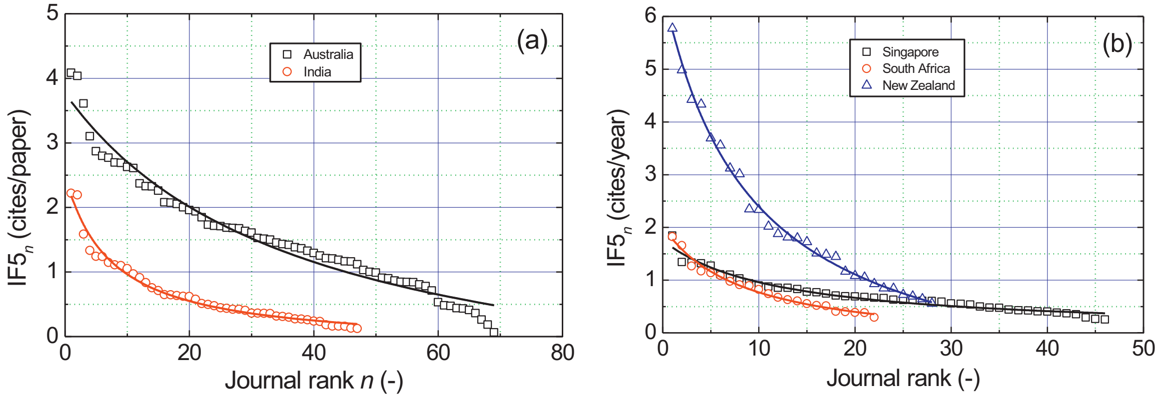

Fig. 8. Plots of IF5$_n$ of N journals as a function of journal rank n for different group B countries according to usual Langmuir-type function (2): (a) Australia and India, and (b) Singapore, South Africa and New Zealand. Values of best-fit constants for the plots are indicated by arrows in Table 7.

of different slopes on journal rank in the case of Australia and Singapore and India, which publish high number of journals. Regions of different slopes are drawn in the figures for visual reference.

In contrast to the group A countries like Poland, Romania and Slovakia where one observes very high slope up to 1.5 in low n range, the highest slope of about 0.6 is found for India in a narrow n range. A constant slope of about 0.43 is observed for New Zealand and South Africa practically in the entire n range and a constant slope of about 0.12 for India in a very wide n range practically covering the entire data. As mentioned in subsection 4.1.3, the observed linear dependence is predicted by Langmuir-type function (2) when $Kn \ll 1$ (see Eq. (9)).

4.3. Tail parts of distributions and physical significance of the fitting parameter α

As pointed out above, the best-fit plots of y_n (i.e. L_n, IF2$_n$ and IF5$_n$) as a function of journal rank n for different countries reveal that the tail parts of the data lie below the best-fit curves. In order to investigate the nature of these deviations the $y(n)$ data were analyzed again using the linearized form of Langmuir-type function (2) rewritten as

$$\frac{y_0}{y_0 - y_n} = \frac{1}{\alpha}\left(1 + \frac{n}{K}\right), \quad \text{linearized Langmuir-type function.} \tag{10}$$

This linearized Langmuir-type function (10) predicts a linear dependence of $y_0/(y_0 - y_n)$ on n for relatively large values of n, with intercept α^{-1} and slope $(\alpha K)^{-1}$. The values of the intercept and the slope enable to estimate the values of α and K. However, one requires a preassigned value of y_0 to estimate α and K from Eq. (10). A typical example is shown in Fig. 10a.

Fig. 10a illustrates typical plots of IF5$_0$/(IF5$_0$ − IF5$_n$) against $1/n$ according to Eq. (10) for the IF5$_n(n)$ data of different countries with the preassigned values of IF5$_0$ given in the insets. For Czech Republic the plots are drawn with two different values of IF5$_0$. As seen from the above plots, the linear dependencies appear to hold in a wide range of n^{-1} for different countries but the values of the intercept α^{-1} are less than unity (i.e. $\alpha^{-1} < 1$) for Czech Republic, Croatia and Slovakia with small N. A similar analysis of IF5$_n(n)$ data for the remaining four countries showed that the intercept $\alpha^{-1} < 1$ for Romania

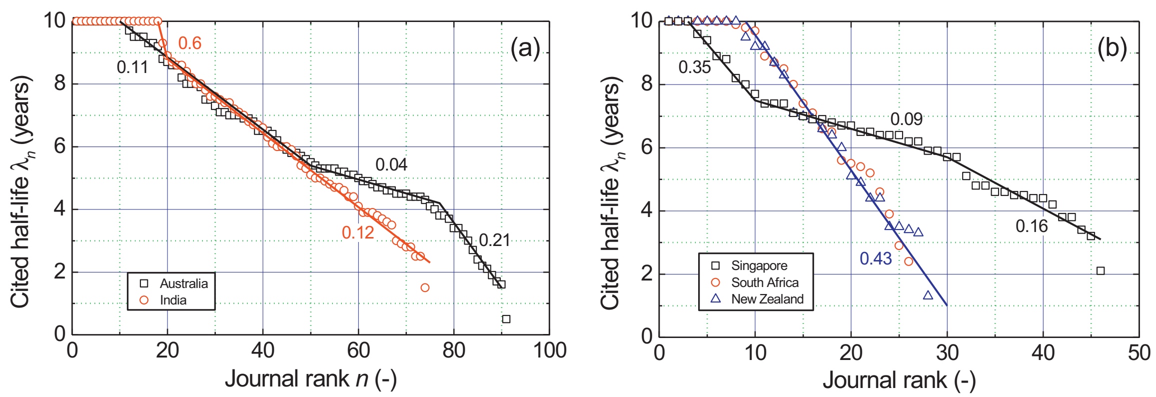

Fig. 9. Data of cited half-life λ_n of journals from different countries as a function of rank n of journals: (a) Australia and India, and (b) Singapore, South Africa and New Zealand. Large ranges of cited half-life with linear dependence on journal rank may be noted for practically all countries. Lines with different slopes are shown for visual reference.

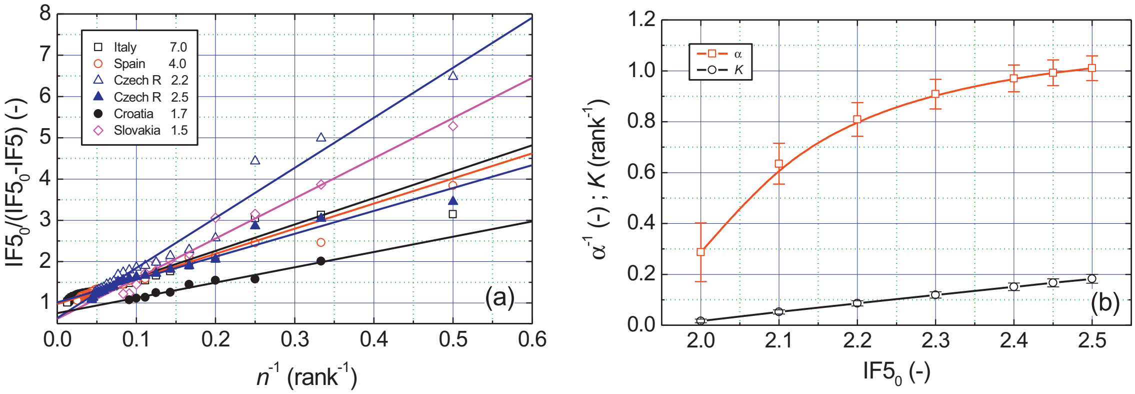

Fig. 10. (a) Plots of $IF5_0/(IF5_0 - IF5_n)$ against $1/n$ according to linearized Langmuir-type relation (10) of IF5 data for different group A countries. Values of $IF5_0$ used for best fit are given in insets. For Czech Republic plots are drawn with two different values of $IF5_0$ and (b) dependence of best-fit values of α^{-1} and K on pre-assigned values of $IF5_0$ for data of journals. Data of α^{-1} and K were obtained for data with $n \geq 2$.

and Turkey, which also have small number N of journals. The value of $\alpha^{-1} < 1$ implies that the effectiveness parameter α should exceed unity in these cases. This inference is against the postulate $\alpha < 1$ for the Langmuir-type relation, as described in Section 2.

Examination of the $L_n(n)$ data according to Eq. (10) for different countries revealed that the linear dependencies appear to hold mainly for n^{-1} below about 0.1 (i.e. n exceeding about 10) for most of the countries. Moreover, not only the slopes of the plots were different for the citation data of journals from different countries, but the value of the intercept α^{-1} also showed a tendency to decrease with decreasing N. This feature was observed clearly for countries like Romania, Croatia and Slovakia. Analysis of the $IF2_n(n)$ data revealed that the linear dependencies of the plots for most of the countries extend to n higher than those for the citation data and the value of the intercept α^{-1} was close to unity in this case.

The two plots with different values of $IF5_0$ for Czech Republic shown in Fig. 10a suggest that the value of the intercept α^{-1} increases and that of the slope K^{-1} decreases with an increase in $IF5_0$. Therefore, the dependencies of the intercept α^{-1} and inverse of slope K on $IF5_0$ were investigated in more detail for the $IF5_n(n)$ data of Czech Republic as an example, and the results are presented in Fig. 10b. It may be seen that, with an increase in the preassigned value of $IF5_0$, α^{-1} approaches a value of unity asymptotically at $IF5_0$ equal to about 2.45 but K increases linearly in the entire n range studied here, following the empirical relation: $K = -0.6478 + 0.3329 \times IF5_0$ with $R^2 = 0.9998$.

The above results indicate that the value of α exceeding unity for the $y(n)$ data of the journals published in a country is obtained when data from its tail part outweigh the effect of the initial part during their analysis. This "tail-part effect" becomes pronounced for countries with small sizes of $L_n(n)$, $IF2_n(n)$ and $IF5_n(n)$ data. Countries like Croatia, Czech Republic and Slovakia are typical examples of this effect. A direct consequence of the effect of data from the tail parts of various distributions is to give lower values of Langmuir constant K than those expected without them by using Eq. (2) when $\alpha = 1$.

As mentioned in Section 2, the tail-part effect may be attributed to high values of coverage θ where Langmuir adsorption isotherm (5) is poorly obeyed. Applying the concept of multimolecular adsorption involving the formation of adsorption complexes composed of more than one molecule to the generation of items by a source in a wide range of n, the present author (Sangwal, 2013b) proposed the following relation

$$y_n = y_0 \left[1 - \left\{\frac{K'x}{1+K'x}[1 + Bx(1-x)]\right\}\right], \tag{11}$$

where x is the fraction of items, K' is given by Eq. (6) and B is a retardation parameter for the process of generation of items. Since the items fraction $x = n/N_0$, Eq. (11) may be expressed in the form

$$y_n = y_0 \left[1 - \left\{\frac{Kn}{1+Kn}[1 + B_0 n(N_0 - n)]\right\}\right], \quad \text{modified Langmuir-type (MLT) function}, \tag{12}$$

where $B_0 = B/N_0$ and $K = K'/N_0$. Comparison of Eqs. (2) and (12) shows that the effectiveness parameter

$$\alpha = 1 + B_0 N_0 (n - n^2/N_0), \tag{13}$$

which is a constant quantity when $[n - (n^2/N_0)] = C$, which has a single real root of n when $C = N_0/4$.

According to Eq. (13), the values of $\alpha > 1$ are associated with a process that retards the generation of items (i.e. citations or impact factors). The difference $(\alpha - 1)$ may be attributed to the process of dissemination of contents of the journals published by a country. The lower the difference $(\alpha - 1)$ for a country, the higher is the dissemination process. However, from the values of $(\alpha - 1)$ for the $L_n(n)$, $IF2_n(n)$ and $IF5_n(n)$ data obtained for different countries in this study, it is difficult to establish the trends of this dissemination process.

Eq. (12) can be used to analyze the $L_n(n)$, $IF2_n(n)$ and $IF5_n(n)$ data for authors and countries. The best-fit plots of the $L_n(n)$ data for Australia and India according to Eqs. (2) and (12) are compared in Fig. 6a as an example, whereas the best-fit values

Table 8
Estimated parameters of MLT function (12) for real L_n, $IF2_n(n)$ and $IF5_n(n)$ data for two top countries of group B.

Country	L/IF2/IF5	Data	L_0; $IF2_0$, $IF5_0$ (cites; cites/paper)	K (rank^{-1})	B_0 (rank^{-1})	N_0 (rank)
Australia	L	$n \geq 2$	11,276 ± 587	0.303 ± 0.025	$(2.51 \pm 0.47) \times 10^{-9}$	10^5
		$n \geq 2$	11,271 ± 587	0.303 ± 0.025	$(2.51 \pm 0.47) \times 10^{-10}$	10^6
		$n \geq 2$	11,273 ± 587	0.303 ± 0.025	$(2.51 \pm 0.47) \times 10^{-11}$	10^7
	IF2	$n \geq 2$	3.688 ± 0.057	0.0403 ± 0.0017	$(1.71 \pm 0.14) \times 10^{-6}$	10^3
		$n \geq 2$	3.695 ± 0.56	0.0407 ± 0.0016	$(1.54 \pm 0.12) \times 10^{-10}$	10^7
	IF5	All	3.851 ± 0.089	0.0416 ± 0.0031	$(2.86 \pm 0.44) \times 10^{-8}$	10^5
India	L	$n \geq 2$	4461 ± 114	0.184 ± 0.009	$(2.71 \pm 1.93) \times 10^{-9}$	10^5
	IF2	All	2.220 ± 0.064	0.074 ± 0.005	$(1.06 \pm 0.15) \times 10^{-7}$	10^4
		All	2.220 ± 0.064	0.074 ± 0.005	$(1.05 \pm 0.15) \times 10^{-9}$	10^6
		All	2.220 ± 0.064	0.074 ± 0.005	$(1.05 \pm 0.15) \times 10^{-11}$	10^8
	IF5	All	2.539 ± 0.081	0.158 ± 0.011	$(2.76 \pm 0.65) \times 10^{-6}$	5×10^2
		All	2.540 ± 0.080	0.158 ± 0.011	$(1.32 \pm 0.31) \times 10^{-6}$	10^3
		All	2.541 ± 0.080	0.158 ± 0.011	$(1.27 \pm 0.30) \times 10^{-7}$	10^4

of the parameters of Eq. (12), calculated using the lowest value of the chi-square residual, for different values of arbitrarily selected values of N_0 are listed in Table 8. In fact, the lowest value of N_0 when the chi-square residual does not change may be considered as the correct value of N_0. The calculated values of the B_0N_0 term are given in Table 9.

From Tables 5–8 it follows that, for a given set of data, the value of K calculated by Eq. (12) is comparable with or insignificantly lower than that calculated by Eq. (2). This implies that our approach of attributing α to the retarded generation process of items is correct. However, estimation of K for a given data by Eq. (12) is more reliable than that by Eq. (2).

For a given set of data the B_0N_0 term is a constant quantity independent of the chosen value of N_0 (see Table 9). For a given country, the values of B_0N_0 for the $IF2_n(n)$ and $IF5_n(n)$ data are comparable, but the values for its $L_n(n)$ are lower than those of the $IF2_n(n)$ and $IF5_n(n)$ data by a factor of about 10. This observation is associated with the difference in the values of N_0 in the two cases. As seen from Table 8, the value of N_0 for the $L_n(n)$ data is higher than that for the $IF2_n(n)$ and $IF5_n(n)$ data.

For a given set of data the value of the $(\alpha - 1)$ parameter obtained by using Eq. (2) is higher than the value of B_0N_0 estimated by Eq. (12) by the factor $C \approx 100$ (cf. Tables 3–7 and 9). This value of C is equal to the number N of journals published by the countries considered above.

4.4. Relationship between Langmuir constant K and the number N of journals

In this section the relationship between the Langmuir constant K and the total number N of the journals published in different countries is discussed. We assume that the total number N of journals is equal to the extrapolated number N_0 of journals when $y = 0$, although in reality $N < N_0$ (see Fig. 1). For this purpose we consider the best-fit values of K obtained from analysis of the $L_n(n)$, $IF2_n(n)$ and $IF5_n(n)$ data of journals from different countries by using: (i) empirical Langmuir-type (ELT) relation (2) with the effectiveness parameter α as a fitting parameter, and (ii) modified Langmuir-type (MLT) function (12). Values of K obtained by using usual Langmuir-type (LT) relation (2) with $\alpha = 1$ are not considered in the analysis. These data on K are taken into account due to the following reasons:

(1) Practically for all datasets the parameter $\alpha > 1$ and for a given dataset the values of K estimated by using ELT function with the best-fit $\alpha \neq 1$ are lower than those obtained from LT function with $\alpha = 1$.
(2) For a particular dataset the values of K estimated by using MLT function (12) are comparable with those obtained by using ELT function. In view of this, the values of K obtained by LT function are considered to be unreliable.

Fig. 11 shows the data of Langmuir constant K obtained from the $L_n(n)$, $IF2_n(n)$ and $IF5_n(n)$ data of the journals published in different countries as a function of the number N of the published journals in the form of plots of $\ln K$ against $\ln N$. The solid lines are drawn with a slope of unity with intercept $\ln K_0$, given here merely for reference purpose, equal to 2.5, 1.5 and 1.0.

It should be mentioned that, depending on the omission of initial data for analysis, the values of K can vary enormously. These enormously different values of K are especially obtained from the $L_n(n)$ data, as seen, for example, for Spain (Table 3) and Australia and India (Table 6). A similar behavior is observed for the values of K obtained from the $IF5_n(n)$ data for Australia

Table 9
Values of B_0N_0 for different data.

Country	N (N_{IF5})	Values of B_0N_0		
		$L_n(n)$	$IF2_n(n)$	$IF5_n(n)$
Australia	105 (69)	$(2.51 \pm 0.47) \times 10^{-4}$	$(1.63 \pm 0.14) \times 10^{-3}$	$(2.86 \pm 0.44) \times 10^{-3}$
India	100 (47)	$(2.71 \pm 1.93) \times 10^{-4}$	$(1.05 \pm 0.15) \times 10^{-3}$	$(1.32 \pm 0.31) \times 10^{-3}$

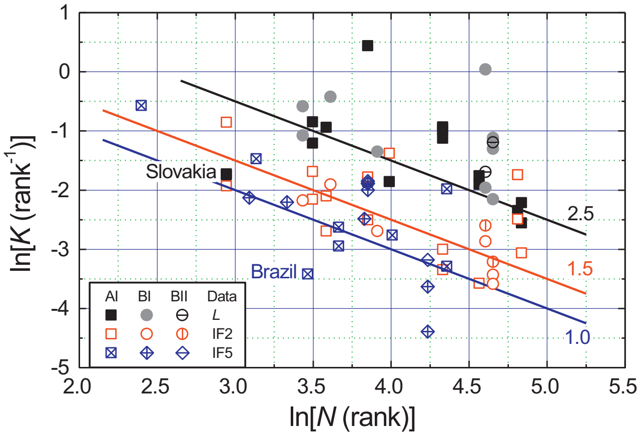

Fig. 11. Plots of ln K obtained for citations L, IF2 and IF5 against ln N for countries of groups A and B. Linear plots are drawn with slope unity and different intercepts indicated alongside the plots. Values of K obtained by Eqs. (2) and (12) are indicated by I and II, respectively, in the inset. See text for details.

(see Table 7). Very low values of K are also obtained from the $L_n(n)$ data for Slovakia (Table 3) and from the $IF5_n(n)$ data for Brazil (see Table 5) due to the values of α much greater than unity. If these unusually deviating points associated with unusually low or high values of ln K are neglected, one finds that the ln K(ln N) data for $L_n(n)$ lie well above those for IF2s and IF5s, with intercepts of about 2.5 and 1.0, respectively, for the two.

The linear dependencies of ln K on ln N suggest that $\ln(KN) \approx 2.5$ and 1.0 for citations and for IF2s and IF5s of journals, respectively. Since $\ln(KN) = \ln K' = Q$ (cf. Eq. (6)), the constancy of the product KN for the processes of citations and two- and five-year impact factors of journals published in different countries may be attributed to their publication potential, which is characterized the pair of two parameters K and N for a given country.

5. Summary and conclusions

The data of the distribution of citations of journals published in different selected countries were analyzed according to Langmuir-type relation (2) to follow the behavior of the Langmuir constant K and the effectiveness parameter α.

The general features of the citation distribution of journals published in different individual countries are somewhat similar to the results obtained before using Langmuir-type function (2) by the author from the analysis of the citation distribution data of papers of individual authors (Sangwal, 2013a). It was found that the fit of the data of citation distributions of journals improves when the data for a few initial ranks are omitted and the value of the effectiveness parameter α is approximately unity for the citations of journals published in most of the countries. Exception of α significantly exceeding unity occurs in the case of countries like Czech Republic, Croatia and Slovakia with small data size. A similar behavior of the parameter α was observed in the case of IF2 and IF5 data of journals, but the IF5 data of journals published in Turkey, Romania and Slovakia cannot be described by Langmuir-type function (2) due to small data sizes.

The nature of the distribution curves of $L_n(n)$ and $IF2_n(n)$ data of journals published in different countries is similar and is not related to the country of their origin, publication language of the journals and the number N of published journals. However, the distribution curves of $IF5_n(n)$ data are significantly affected by the data size. The distribution curves of $IF5_n(n)$ data for journals published in Turkey, Romania and Slovakia are typical examples of this effect and are a result of small data sizes.

The trends of the cited half-lives λ of journals are completely different from those of citation, IF2 and IF5 data for different countries. In the case of journal half-lives, there are one (Czech Republic, Croatia, South Africa and New Zealand), two (India, Slovakia, Turkey, Poland and Romania) or three linear regions (Australia, Brazil, Singapore, Spain and Italy). In most of the cases there are initial steep slopes as high as 1.5 for Romania and Poland (Fig. 5a) and relatively low slopes lying between about 0.25 and 0.07 (see Figs. 5b and 9a, b). In some cases there are also steep slopes for the lowest-rank journals, as noted, for example, for Australia, Brazil, Italy and Spain. The longest linear regions with relatively low slopes are observed in the case of countries like Australia, India, Poland and Italy in which the highest number of journals are published. The observed linear dependence is predicted by Langmuir-type function (2) when $Kn \ll 1$ (see Eq. (9)).

Analysis of the $y_n(n)$ data of the journals published in a country by linearized Langmuir-type relation (10) revealed that the value of α exceeding unity for the $y_n(n)$ data of the journals published in a country is obtained when data from its tail part outweigh the effect of the initial part during their analysis. This "tail-part effect" becomes pronounced in the case of countries with small sizes of $L_n(n)$, $IF2_n(n)$ and $IF5_n(n)$ data. Countries like Croatia, Czech Republic and Slovakia are typical examples of this effect. A direct consequence of the effect of data from the tail parts of various distributions is to yield values of the Langmuir constant K lower than those expected without them by using Eq. (2) when $\alpha = 1$. The tail-part effect is associated with high values of coverage θ where Langmuir adsorption isotherm (5) is poorly obeyed. The values of $\alpha > 1$

can be explained in terms of retardation of generation of items (i.e. citations or impact factors), the difference ($\alpha - 1$) being related to the dissemination of contents of the journals published by a country.

The Langmuir constant K obtained from the $y_n(n)$ distributions decreases linearly with increasing number N of journals published in a country, following the relation: $\ln(KN) \approx 2.5$ and 1.0 for citations and for IF2s and IF5s of journals, respectively. The constancy of the product of the Langmuir constant K and the number N of journals for the processes of citations and two- and five-year impact factors of journals published in different countries is related to their publication potential and is represented by the pair of two parameters K and N for a given country.

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