Science Communication: Research Productivity and Data Analytics using Open Source Software

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Lecture 19: Bradford's Law

Dear Learners, welcome to our NPTEL course on Science Communication, Research Productivity and Data Analytics using Open Source Software.

Now we are going to cover Bradford's Law of Scattering. This law was formulated by Samuel C. Bradford in 1934. Bradford's Law basically describes the distribution of scientific productivity particularly in the context of journals. As in the case of Lotka's law, we saw that it was scientific productivity in the context of the author, but in the case of Bradford, he describes the scientific productivity in the context of journals.

This law is based on the observation that scientific literature in a particular field is concentrated to a very specific number of journals, those are known as core journals. When we go further then the number of scientific literature decreases. That means in any particular subject there are some core journals which contribute the most to the growth of that particular subject and most articles are concentrated in those core journals. The basic idea is that if you list the journals in decreasing order of the number of articles they contribute to a particular subject then, the distribution will follow a pattern and this pattern is similar to geometric progression. If you see in geometric progression, let us see there is a term A, next term is AR, another term is AR^2 then

$$AR / A = R$$

$$AR^2 / AR = R$$

That means the ratio of the succeeding term and the preceding term, the ratio of the succeeding term and the preceding term is always constant. This type of progression is followed in case of the journals also if we arrange in order in the decreasing number of articles they contain.

Let us consider the number of papers in a given subject that we expect to get after searching a collection of journals. By scanning the journals we expect the most number of papers would be concentrated in a certain group of journals and the relevant papers would be in the journals which are particularly dedicated to that particular subject. For

example, a specialist journal in the given subject area will have the most articles followed by the journals which publish a few articles related to that subject area, and that followed by two journals which have occasionally published the articles related to that particular area. Most of the journals will have no articles related to that particular subject. but here the point is that we cannot do a random search. Because a random search won't result in a fruitful conclusion. Hence we want to prioritize our search, we want to do the search in such a way that we get the maximum number of articles of that particular subject in the minimum number of journals.

Hence first of all we go through the journals or the pages of the journals, which are dedicated to that particular subject. And after that we move to other journals. At the end of the exercise we will have the list of the papers which are related to that particular area. we will have the complete list of the papers related to that particular area. Now let us see if you don't want to search a broad number of journals, if you don't want to search a large number of journals, if you want to decide that we may concentrate our search in some specialized journals. Because searching a vast number of journals, searching a large number of journals would be time consuming and a costly affair. Then it's very important to know which journals are relevant to that particular subject. Because at the beginning of our search we didn't have any idea about which journals have the maximum number of articles. Here Bradford's Law plays a very important role and Bradford gave his contribution to find out those journals which are effective in that particular area of interest.

Here Bradford made a very important contribution and began the ranking of the journals in order to the number of articles found in them. The intuitive procedure of searching can be facilitated by ranking journals to their productivity. Here productivity means how many relevant articles they contain. For example let us see if you are searching in a particular area, let us see artificial intelligence, use of artificial intelligence in libraries. We want to make a bibliography on that.

Then we should know which are the journals, which are contributing most to this particular field. In this case Bradford's Law of scattering can play a very important role. And by using this law we can find out which are the journals which are most relevant for us, or which are the journals which give us the maximum results. Bradford arranged all the journals in bibliography in descending order of productivity. When we talk about the descending order of productivity that means he put that journal which has the maximum yield that means having the maximum number of published articles at rank one and then he came down accordingly. He took the journals which contained the largest number of articles and placed it at the top of the list and gave it at first rank then the next journals would get the second rank, third rank and so on.

If it happens that the same number of articles are in two journals. For example, one journal contains 10 articles and another journal also contains 10 articles. That means if the two journals had the same rank then the next journals would have the R+2 rank. That means if the two journals having rank R let us see if the two journals having rank 20th then the next journals would be the rank 22 instead of 21. That means the rank R of any journal indicates that there are R-1 journals, which have the higher productivity. For example, if you have at 25th rank we have journals having the contribution of 18 articles, at 26th rank we have the journals contributing 16 articles, again at 26th rank we have a journal contributing the same number of articles. hence the next ranking would be 28th instead of 27. That means the rank R of any journal indicates that there are R-1 journals which have the higher productivity. This means in the case of 28th rank, here this indicates that there are 27 journals which have higher productivity, or which have more articles as compared to the journals which are put at 28th rank in this case. Now having obtained the rank list of journals arranged in decreasing order of productivity, Bradford divided the list of journals into three parts. And those parts are usually called zones. And each Zone each part contains approximately the same number of articles. That means what Bradford did, Bradford arranged the journals in descending order based on the number of articles they published. And then he divided the journals into three zones or three parts such that each part or each Zone will have approximately the same number of articles. The first Zone or the first part would be the most productive journals. The next part would be the less productive journals. The last part would have the least productive journals. In order to add the same number of articles, Zone 2 will have the more number of journals as compared to Zone 1 and Zone 3 will have more number of journals as compared to Zone 2. That means the main Zone which is Zone 1, which is the most important Zone for that particular subject area is the nucleus basically. That is the core Zone which contains the core journals which publish the maximum number of articles pertaining to that particular field.

When we move further then we will have the number of journals which are more in number but contain less number of articles. That means they are in Zone 2 and Zone 3. Bradford formulated his law after studying a bibliography of geophysics covering 1332 articles from 326 journals in the field of geophysics. He discovered that 9 journals contain 429 articles, 59 journals contain 499 articles and 258 journals contain 404 articles. Based on the results he obtained, he found that 9 journals contributed approximately one third of the articles because the total number of articles is 1332. 1332/3 = 444. That means approximately 9 journals contribute 429 articles which is approximately one third of 1332. In the next phase he found that 9x5 that means 45 to produce the next one third. Here in the actual scenario, 59 journals produced 419 articles. And the next 9x5x5 that means 225 journals produced the next one-third 404 articles. Here 258 journals produced 404 articles. That means approximately what he concluded that one-third of the articles is produced by 9 journals, followed by one-third produced by

next 59 journals, and approximately one-third produced by 258 journals. There is a relationship between 9, 59 and 258.

Based on that he expressed his law of scattering in the following way. He said if scientific journals are arranged in order of decreasing productivity of articles we have seen what is the order of decreasing productivity of articles we are arranging the journals in descending order that means the journals which are contributing maximum articles would have at the first place and so on. On a given subject they may be divided into a nucleus of periodicals or journals more particularly devoted to a subject and save the other groups or zones containing the same number of articles as the nucleus. What Bradford is saying here Bradford found that if we are arranging the journals in order of decreasing productivity of articles on a particular subject they may be divided as a nucleus and various other zones, which have the same number of articles, but the more number of journals. The number of journals of periodicals in a nucleus and succeeding Zone will be in the ratio of A=1, 1:N:N*N.

Because we have seen the geometrical progression that means it would be like A is a nucleus then after that it would be A:AN:AN^2. If you divide the succeeding term into the previous one, if you divide the successor to the predecessor we will get a constant ratio. For example, if AN/A, we will get A. If AN^2/AN we get N. That means if AN is divided by A, we are getting N; if AN^2 is divided by AN, we are getting N. That means this ratio is always fixed.

The value of the Bradford multiplier is not fixed and it varies from one bibliography to another bibliography. Bradford found that different bibliographies have a different number of core journals and the journals which are related to that particular subject. Bradford's Law is often expressed in three zones that means core journals, secondary journals and tertiary journals. As the name indicates, the core journals are those journals where the most important and significant articles in the field are published. They are always small in number. And this particular Zone that means core Zone contains a very high number of articles. Now the second Zone which has the larger number of journals publish articles related to that particular subject. And the third Zone will have the larger number of journals as compared to Zone 2 publish very few articles related to that particular subject. Garfield when he studied Bradford's Law, he made a physical analogy of the situation described by Bradford. like it would be a cornet with a dense nucleus representing the core journals. maximum number of journals to that particular subject and sparse parts representing the additional journals as sometimes published materials relevant to the field and these are known as the peripheral journals.

In the Garfield analogy, we can say that Zone 1 of Bradford is basically the cornet which is very dense and publishes the maximum number of articles related to that particular subject in that particular field. And the succeeding two fields the succeeding two zones

are basically the periphery journals which contain less number of articles which are sparse in nature which are not dense. Let us understand the Bradford's Law example. For example, if you want to compile the bibliography on a particular subject you are getting 100 articles and those 100 articles are published in 10 journals. The next 100 articles are published in 50 journals and the next 100 articles are published in 250 journals. As for the Bradford this 50 there is a relationship between 10 and 50, 50 is equal to 10*5, 250 is equal to 10*5*5 that means if we are taking as 5 as N, so this is 10*N this is 10*N*N.

If you divide 10*N by preceding term 10, we are getting N. That means a ratio here and if you divide 10*N*N by 10*N which is the preceding term of this particular one we are getting the ratio N here also. That means the ratio is constant. In this example this is an ideal example. Usually this does not happen because I have explained this with a very simple example in which the number of articles is constant. The number of articles is equal 100, 100 in all cases and the journals are also varied in multiplication of 5 to the preceding term. but this usually doesn't happen in real scenarios. Let us see in example 2 which is something in a real situation which describes a real situation. We are compiling a bibliography on a particular subject. And we found that 18 journals published 125 articles on that particular subject to get approximately the same number of articles. That means approximately the same number of articles as 125 we found that it contains in 114 journals. And again approximately the same number of articles we found that is contained in 753 journals. If you see the ideal relation like in the case of 114 journals.

114 / 18 = 6.66.

That means if you see as for the Bradford multiply it should be 18*6 but in actuality it is 6.33. Similarly in the next Bradford multiplier would be 18*6*6 but it is approximately 18*6*7. It happens because the actual number of journals varies because when we are compiling bibliography approx the number of journals we are calculating and by that way we are finding the core journals which contain the maximum number of articles and the peripheral journals which contain the least number of articles. Now what are the conditions for Bradford's Law? Actually for Bradford's Law to be implemented Brookes suggests that there should be the strict conformity with Bradford's Law certain conditions have to be imposed on the bibliography.

If we want to apply Bradford's Law then there should be certain conditions that should be applied on the bibliography. The first condition is that the subject bibliography must be well defined. It should be complete, that means all the relevant papers and serials must be limited and bibliography must be of limited time span. so that all contributing serials have the same opportunity of contributing paper. Hence we are finding here the 3 important conditions let down by Brookes for Bradford's Law. First the bibliography should be well defined, the second all the relevant papers should be included in the bibliography should be complete in all aspects, and the third the time span should be

defined so that all the journals periodicals and other technical papers should have the equal opportunity to be included in the bibliography.

Now we have covered what Bradford's Law is, what is the condition for Bradford's Law. There are various applications of Bradford's Law.

Now we are discussing the applications of Bradford's Law. The first very important application of Bradford's Law is the collection development in the library. We know that libraries acquire different types of materials and there is always a requirement of funds, there is always a crunch of budget. Hence Bradford's Law can be applied for developing a good collection. Because with the help of Bradford's Law we can come to know or library professionals can come to know, a librarian can come to know what are the core journals, what are the core publications, which are relevant to a particular field and only those publications can be acquired.

Hence Bradford's Law can be used for collection development. Another use of Bradford's Law is indexing and abstracting services can take the advantage of Bradford's Law in the development of good indexing and abstracting services in the implementation of good indexing and abstracting services. Because with the help of Bradford's Law indexing and abstracting services can easily find out the core journals which are most productive in nature. And those can be included in their database for the providing of services.

Another application of Bradford's Law is budgeting and funding decisions. As we know that academic institutions, many decision making bodies make budgetary decisions and Bradford's Law can be used for allocation of resources. By identifying the core journals the resources can be allocated and optimally utilized.

Another application of Bradford's Law is information filtering and recommendation services. When we talk about information filtering and recommendation services that means with the help of Bradford's Law this system can prioritize content from core journals offering users more targeted and relevant recommendations based on the distribution of articles. We see there is a flood of information. there is an explosion of information. It is very tough to get relevant information. it is very tough to give relevant information to the user. Now Bradford's Law can help in the information filtering and recommendation system. Because based on Bradford's Law the system can prioritize the journals and recommend the information which are relevant to the user instead of recommending the information which are irrelevant or not relevant to the user.

Bradford's Law can also be used for information retrieval by search engines. We know a good search engine gives good results. That means a search engine which gives the pinpointed result or the result which is required by the user is termed as a good search engine. One of the characteristics of a good search engine that means it has good precision is the pinpointed information. Here Bradford's Law can be applied for

information retrieval by the search engine. Because the search engine can make the ranking of the journals based on the information content to them in any particular field and accordingly can provide the more relevant result to the users.

Bradford's Law can also be used for research impact assessment. Based on the Bradford's Law institution can find out in which particular journals the researchers are publishing or the department is working with and by that way the research can be evaluated and the department can assess the result of a researcher.

Bradford's Law can be applied in information overload. We know that information explosion is everywhere. We are loaded with information. Here to get the relevant information the application of Bradford's Law is very important by understanding the need of the researcher by knowing the good quality of information that Bradford's Law can assist in understanding information overload.

Bradford's Law can also be used for the research planning and strategic planning and research collaboration. Bradford's Law can be used for strategic planning and research collaboration. By studying Bradford's Law we can find out the core journals of a particular subject. Researchers in that particular subject can collaborate with the scholars, the people who are publishing in those particular journals and there would be a collaboration among the different institutions, collaboration among the researcher there would be the development of a collaboration network.

Bradford's Law can also be used for the literature review. As we know, literature review is a very important step for research. Bradford's Law can be used for the literature review. Because Bradford's Law gives the core journals which are relevant to a particular subject area and a researcher, a scholar can use those journals first for the review of literature. Because he or she knows that those core journals are the journals which have the maximum number of articles related to a particular subject.

What are the limitations of Bradford's Law? Bradford's Law has some limitations. Although we know that Bradford's Law is a very important law for collection development, for decision making, for fund allocation, this is not a strict rule and may have variations in application depending upon the specific characteristics of different disciplines and evolving patterns of scholarly communication. In the beginning of our lecture, in the beginning of my lecture I explained how science communication is evolving, science communication is dynamic in nature. Bradford's Law is basically not a strict rule that should be followed.

Since science is evolving, science is dynamic, science communication is dynamic and there are different aspects of science, there are different disciplines of science which are ever growing, ever increasing. Hence Bradford's Law having some limitation in applying as a rule of thumb to every subject area, every discipline of science.

Thanks for your patient hearing. Thank you.