

# A Scientometric Analysis of Knowledge Output Performance of NSFC Supported Projects: A Case Study of Oceanography

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[Abstract]

Scientometric and bibliometric analysis techniques are increasingly being used to analyze and evaluate the research output performance of projects supported by grant funding agencies. This article presents a novel bibliometric approach to carry out funding acknowledgement analysis which links research outputs with their funding sources. With this approach, journal articles funded by NSFC in Ocean Science are analysed as a case. Firstly we got all the projects information supported by NSFC, and the NSFC-supported articles were identified through acknowledgement of NSFC support or grant numbers through Web of Science. Secondly, the article puts forward the 4-dimension to evaluate the performance of the projects supported by funding agencies, i.e., activeness of articles publishing of the projects, research impact of the projects, the cost of the journal articles of the projects and the cost of research impact of the projects. Thirdly, with TDA, the paper analyzes the performance of the different kind of projects supported by NSFC in the field of oceanography from 2008-2013. In particular, based on presenting the number and origin of funds per articles, the paper analyze the phenomenon that multi-funds of articles. And lastly, the paper discusses the advantage and disadvantage of bibliometrics method to analysis the impact of research grant funding on scientific productivity.

[Keywords] Scientometric Analysis, Knowledge Output Performance of NSFC supported projects, oceanography

## 1.Introduction

NSFC(National Natural Science Fund of China) is responsible for directing, coordination and making effective use of the national natural science fund to support basic research and stimulate free exploration, identify and foster scientific talents, as well as to promote progress in science and technology and the harmonious socioeconomic development for the nation. Along with the continuously increasing investment in basic research by the government, NSFC's annual budget has increased from 80 million RMB in 1986 to 17 billion RMB in 2012.

In recent years, performance-based foundation evaluation has been payed much attention to stake-holders. Although describing the advancement of the research by the projects and peer-review have been the valuable ways to evaluate the performance of the projects, scientometrics method provides an proof-based evaluation of the performance of the projects supported by the foundation.

How to evaluate the knowledge output performance of research foundation is arousing interest in the field of scientometrics and S&T management.

## 2. Research Background

Scientometrics methods have often been used to analyze publications supported by grant-funding agencies like NSFC.

According to metrics on science foundation and its knowledge output, there are many studies in the number of projects supported, granted money, distribution of subject, affiliation and region. Some studies focus on macro-level( Leydesdorff 2009<sup>1</sup>, Xianwen Wang, 2012<sup>2</sup>), some study focus on evaluation of the performance of the projects supported by the foundation, Chris W. Belter, 2013<sup>3</sup> made a bibliometric analysis on NOAA's foundation. The US National Institutes of Health(Boyack, 2011<sup>4</sup>), The UK Multiple Sclerosis Society(Rangnekar, D. 2005<sup>5</sup>), The Health Research Council of New Zealand(Gunn, A. J, etc. 1999)<sup>6</sup>, the Spanish Society of Cardiology and Spanish Heart Foundation (Benavent, R. A., etc. 2011)<sup>7</sup> have all sponsored bibliometric evaluations of their funding programs. Bibliometric analysis has also been used to measure the impact of the foundations(Zhao, D Z 2010<sup>8</sup>, Hall, K. L., etc. 2012)<sup>9</sup>. In China, many scholars pay attention to the performance of different foundations(Zhou Ping, etc, 2012)<sup>10</sup>, (Shi Xiaomin, etc. 2004)<sup>11</sup>, (Shang Huping, etc, 2012)<sup>12</sup>. There are still needs a set of rational, objective and practical methods and analysis dimension to combine the research output and the funding information to evaluate knowledge output performance of foundation.

From 2008, Web of Science provides funding acknowledgement information, this gives us a way to analysis funding performance in knowledge output combined with the project information.

This article presents a novel scientometrics approach to carry out funding acknowledgement analysis which links research outputs with their funding sources. With this approach, journal articles published by projects funded by NSFC in ocean science are analysed as a case. Firstly we got all the projects information supported by NSFC, and the NSFC-supported articles in this analysis were identified through acknowledgement of NSFC support or grant numbers through Web of Science. Secondly, the article put forward the 4-dimension to evaluate the performance of the foundation, that are the activeness of articles publishing of the projects, research impact of the projects, the cost of journal articles of the projects, the cost of the research impact of the projects. Thirdly, with TDA, the paper analyze the performance of different kind of projects supported by NSFC in the field of oceanography from 2008-2013. In particular, based on the number and origin of funds per articles, the paper analyze the phenomenon that multi-funds of articles. And lastly, the paper discusses the advantage and disadvantage of scientometrics method to analysis the impact of research grant funding on scientific productivity.

## 3. Method and data source

(1) We get all the projects from Internet-based Science Information System of National Natural Science Foundation of China.<sup>13</sup> We downloaded the basic funding data by year. The information includes Grand no./Application no., name of the project, project leader, supporting affiliation, approved amount, period of the project. With a tool we designed we can combine the information of granted projects with the articles they published in WOS. We use TDA to analysis the bibliometrics indices of the

articles published by the projects in the field of oceanography by NSFC.

(2) We choose WOS as the source for the papers. As a study, journal article and monograph are main parts of the knowledge output of basic science. Journal articles forms more than 70% of the knowledge out of basic science. (Fuhu, 2000<sup>14</sup>). Because all the papers selected by WOS are peer-reviewed internationally, and the papers selected by WOS has relatively high impact in the world. We get the Grant Number from Internet-based Science Information System of National Natural Science Foundation of China. And then we can search WOS through "Grant Number". Because all the projects supported by NSFC are asked for signing the grant number when they publish papers, we think we can get almost all the papers published by the funding unless the author forget the grant number. We are informed from 2008, WOS has acknowledged information indexed, so we analysis the articles from 2008-2013 published by the projects granted from 2008-2012. We get 5088 articles from WOS, after delete duplicated items judging by titles and authors, we get 4728 articles.

(3) 4-dimension to evaluate the performance of the knowledge output of projects  
Combining the information of projects and articles, we try to evaluate the performance of the knowledge output of projects in 4-dimension.

#### **1) Activeness of knowledge output of the projects**

The number of articles published by the NSFC supported projects presents activeness of knowledge output of the projects. According to the number of projects of NSFC in the field of oceanography and the sum of the articles published by the projects, we can get the average articles published by each project hence we can get the activeness of knowledge output of the projects.

#### **2) Research impact of the projects**

It can be analyzed by the times cited of the articles and the impact factors of the journals where the articles are published. To some extent, the average times cited yearly of all the articles supported by NSFC in the field, comparing with the baseline of times cited yearly of all the articles in the related field, the impact factors of highly published top20 journals, percentage of zero-cited articles supported by NSFC in the field all these indices can represent the research impact of the projects supported by NSFC.

#### **3) The cost of the knowledge output of the projects**

According to the award amount of projects and the number of the articles marked the number of the projects of NSFC, we can get the cost of the knowledge output of each project.

#### **4) The cost of the research impact of the projects**

According to the sum of times cited of the project and the award amount of projects, we can get the cost of the times cited per projects.

#### **(4) Analysis of the phenomenon of multi-funds of the articles.**

We notice in the acknowledge field of WOS, many articles marked at least 1 or more projects number. We analyze the motivation and reason of the multi-funds of the articles.

#### 4. Activeness of article publishing performance of NSFC projects in the field of oceanography

##### 4.1 Projects and award amount in the field of oceanography granted by NSFC from 2008-2013

There are 2114 projects awarded in the field of oceanography( The apply code are D06 and subclasses of D06) from 2008-2013. From 2008 to 2012, the number of projects granted by NSFC in the field of oceanography increased gradually from 227 to 461, increased about 103%. The award amount per projects also has increased from 460 thousands Yuan RMB to 719 thousands Yuan RMB, increased about 61.5%. In 2013, the number of projects decreased slightly to 445. The award amount per projects decreased slightly to 658 thousands Yuan RMB. The sum of the award amount from 2008-2013 is 1291732.7 thousand Yuan RMB. In a word, the increase of the number and award amount of the projects shows the attention of China to the study of oceanography increased these years.

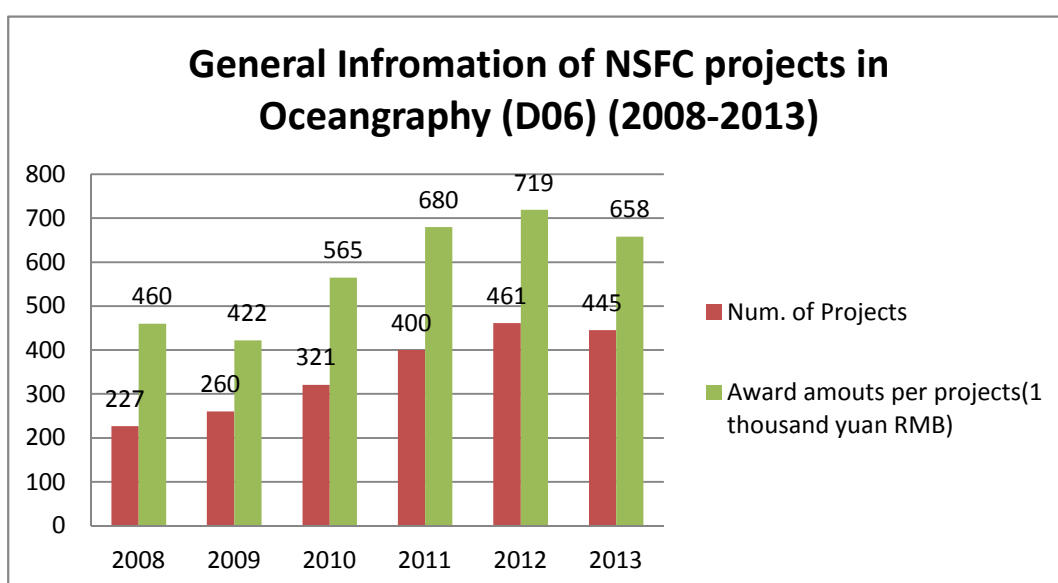


Fig4-1 General Information of NSFC projects in Oceanography (D06) (2008-2013)

##### 4.2 Activeness of article publishing of the projects

The number of articles published by the NSFC supported projects presents activeness of knowledge output of the projects. According to the number of projects of NSFC in the field of oceanography and the sum of the articles published by the projects, we can get the average articles published by each project hence we can get the activeness of knowledge output of the projects. The more the project published articles in journal, the higher the activeness of the project is.

##### 4.2.1 General trend of articles published by projects supported by NSFC in ocean science

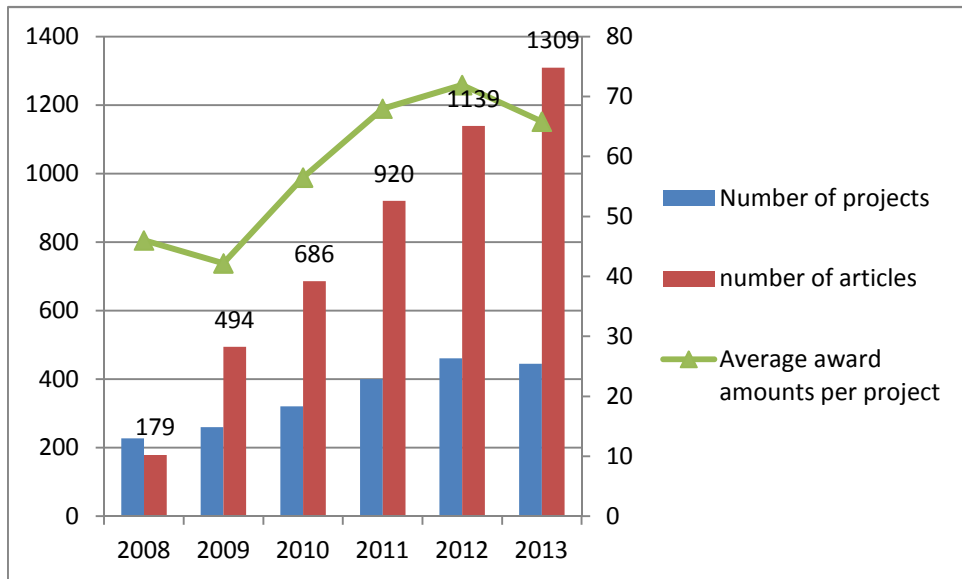


Fig4.2-1 Article published by projects granted by NSFC in the field of oceanography and time cited (2008-2013)

As Fig4.2-1 shows, from 2008-2013, the articles published by granted projects by NSFC in oceanography increased annually from 179 in 2008 to 1309 in 2013. The increase rate of articles is different with the variation rate of award amounts. Although there is a slightly decrease in award amounts in 2013, the momentum of articles growth keeps going on in 2013.

#### 4.2.2 Articles published per project according to different kinds of projects

Fig4.2-2 shows articles published by per project according to different kinds of projects supported by NSFC in ocean science. The most distinguished is Science Fund for Creative Research Groups(CRG). This kind of projects are most active in publishing articles, the average number of articles per project is 32. Key Program(KP) and Major Program(MP) are also active with 14 articles per project and 12 articles per project. On average, 2 articles are published per project supported by NSFC in earth science from 2008-2013.

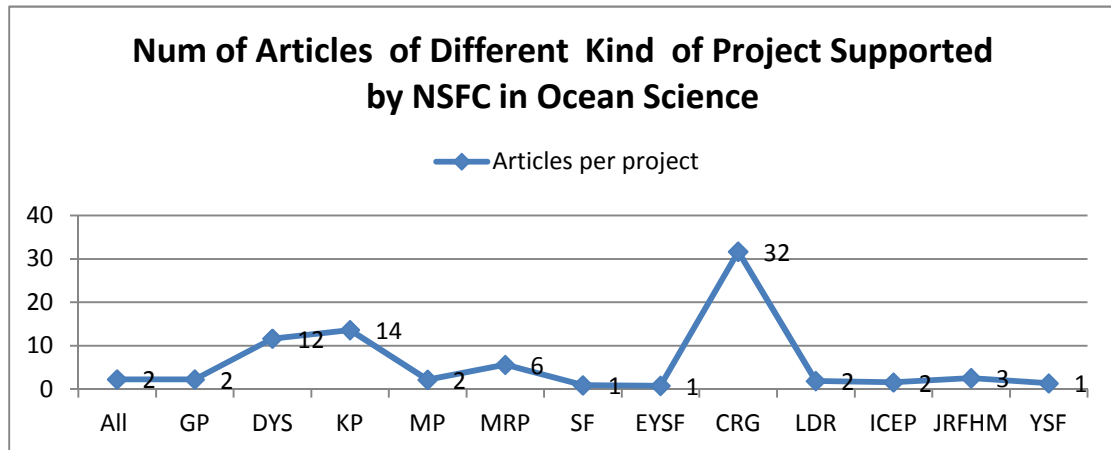


Fig4.2-2 Num of Articles of Different Kind of Project Supported by NSFC in Ocean Science

Tab4.2-2 Abbr. and description of different kind of NSFC projects

Abbr.	Full Name of Different Kind of NSFC Project
All	All NSFC supported projects in ocean science(2008-2013)
GP	General Program
DYS	NSF for Distinguished Young Scholars
KP	Key Program
MP	Major Program
MRP	Major Research Plan
SF	Special Funds
EYSF	Excellent Young Scientists Fund
CRG	Science Fund for Creative Research Groups
LDR	Fund for Less Developed Regions
ICEP	International Cooperation and Exchange Programs
JRFHM	Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao
YSF	Young Scientists Fund

#### 4.2.3 Articles of top20 highly published projects supported by NSFC in ocean science

Fig4.2-3 shows the top20 highly published projects supported by NSFC in ocean science (2008-2013), these projects are most active in publishing articles among projects supported by NSFC in ocean science (2008-2013). Project 40821004 published 75 articles locates 1<sup>st</sup>. Projects 40876010 and 41076059 published 52 articles. Although the award amount of some projects, for example project 40876010, 41076059, 21075019, 41176079, is just below 50 thousands Yuan RMB, but all of them published more than 50 articles. These projects are active in articles publishing.

As our analysis, there are 35 projects supported by NSFC with award amount more than 4 million Yuan RMB, the sum of the articles published by these projects is 476. The average number of articles published by these projects is 13.6.

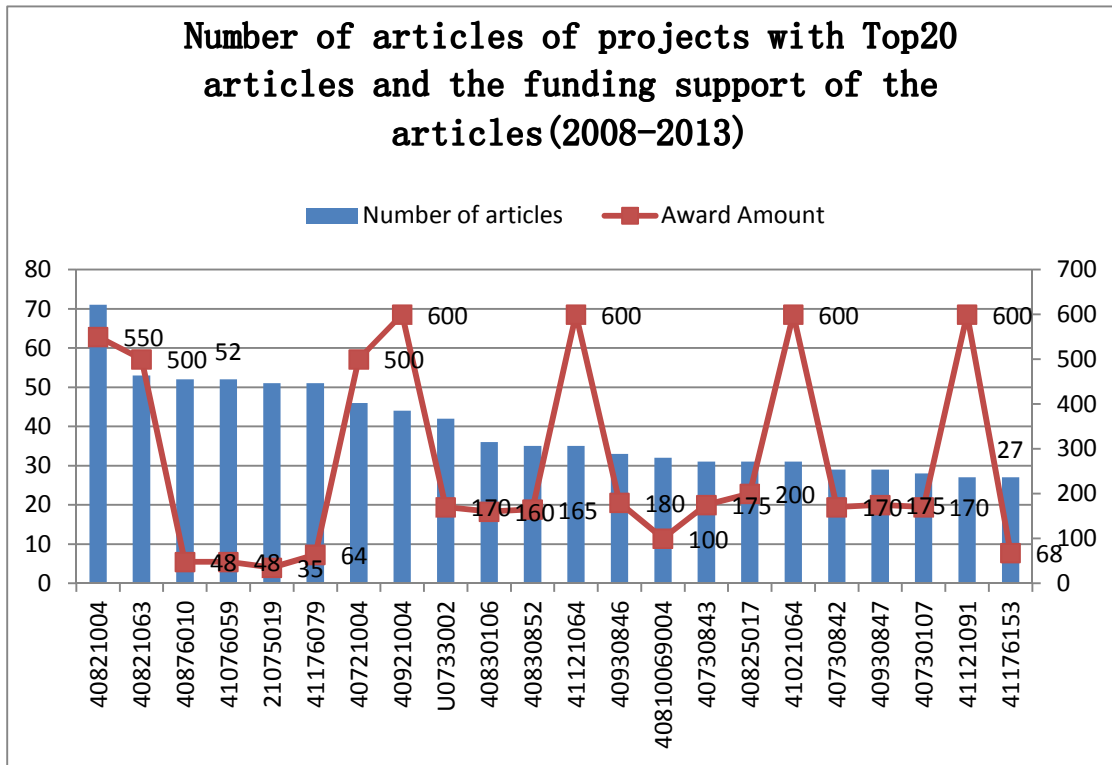


Fig4.2-3 Top20 highly published projects supported by NSFC in ocean science  
( 2008-2013 )

### 4.3 Research impact of the projects supported by NSFC based on the journals and cited times

We carry out analysis of research impact in the average times cited yearly of all the articles supported by NSFC in the field, comparing with the baseline of times cited yearly of all the articles in the related field, the impact factors of highly published top20 journals, percentage of zero-cited articles supported by NSFC in the field. We think these factors can represent the research impact of the articles published by NSFC supported projects.

### 4.3.1 Research impact Status of projects supported by NSFC according to times cited

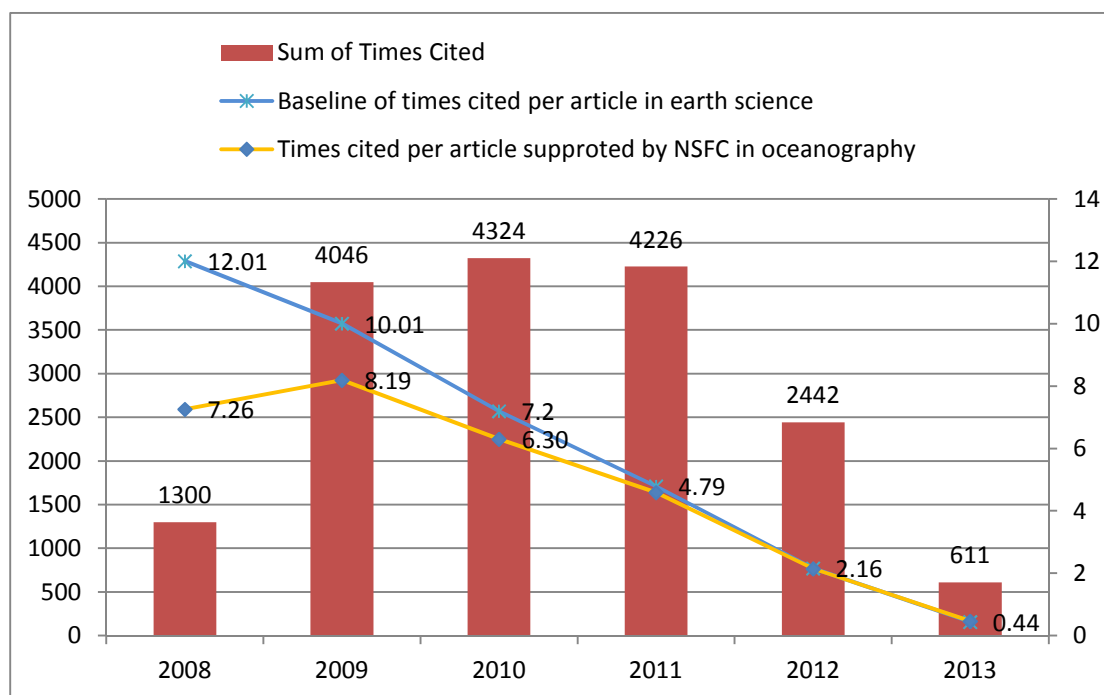


Fig4.3.1 Times cited of articles supported by NSFC 2008-2012

According to Fig4.3.1, comparing times cited per article supported by NSFC in oceanography with the baseline of times cited per article in earth science 2008-2012, we can see times cited per article of NSFC supported (7.26) is lower than that in earth science(12.01) in 2008. During 2008-2012, the average times cited per article of NSFC supported is 3.58, while that of articles in earth science is 6.102. In 2011, the average times cited per article of NSFC supported is 4.57, that of articles in earth science is 4.79. There is a trend that the times cited per article of NSFC supported is getting near to the baseline in earth science from 2011 to 2013. We can conclude that although the research impact of articles supported by NSFC is lower than the baseline in earth science, the catch up tendency is emerging.

### 4.3.2 Times cited per project/article according to different kinds of projects



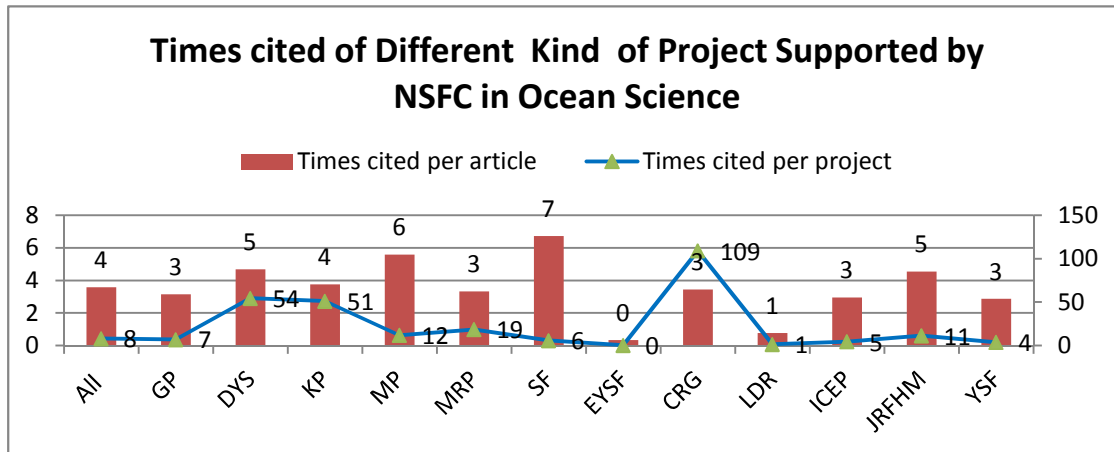


Fig 4.3.2 Articles published per project according to different kinds of projects

As our analysis, from 2008-2013, the 2114 projects supported by NSFC in ocean science published 4727 articles, the articles are cited 16949 times, time cited per article is 3.58, time cited per project is 8.017.

According to times cited per project, CRG(Science Fund for Creative Research Groups) is at the 1<sup>st</sup> place with 109 times cited per project. Then comes DYS(NSF for Distinguished Young Scholars) and KP(Key Program).

According to times cited per article, SF(Special Funds) comes the 1<sup>st</sup> with 7 times cited per article, then MP(Major Projects) is the 2<sup>nd</sup> with 6 times cited per article, and DYS(NSF for Distinguished Young Scholars) is at the 3<sup>rd</sup> place with 5 times cited per article.

According to EYSF(Excellent Young Scientists Fund), times cited per article and times cited per project are all close to 0, the reason of this is NSFC began to support this kind of project from 2013, from 2012 to 2013, there are 8 projects in sum.

For LDR(Fund for Less Developed Regions), times cited per article and times cited per project are close to 1. In fact these projects support researchers from less developed regions, the research impact is not so high.

In brief, the projects of CRG (Science Fund for Creative Research Groups), DYS(NSF for Distinguished Young Scholars) and KP(Key Program) have high research impact. The projects of SF(Special Funds), MP(Major Projects) and (NSF for Distinguished Young Scholars) published some articles with relative high research impact. The projects of LDR(Fund for Less Developed Regions) is relatively low in research impact.

### 4.3.3 Top20 highly cited articles

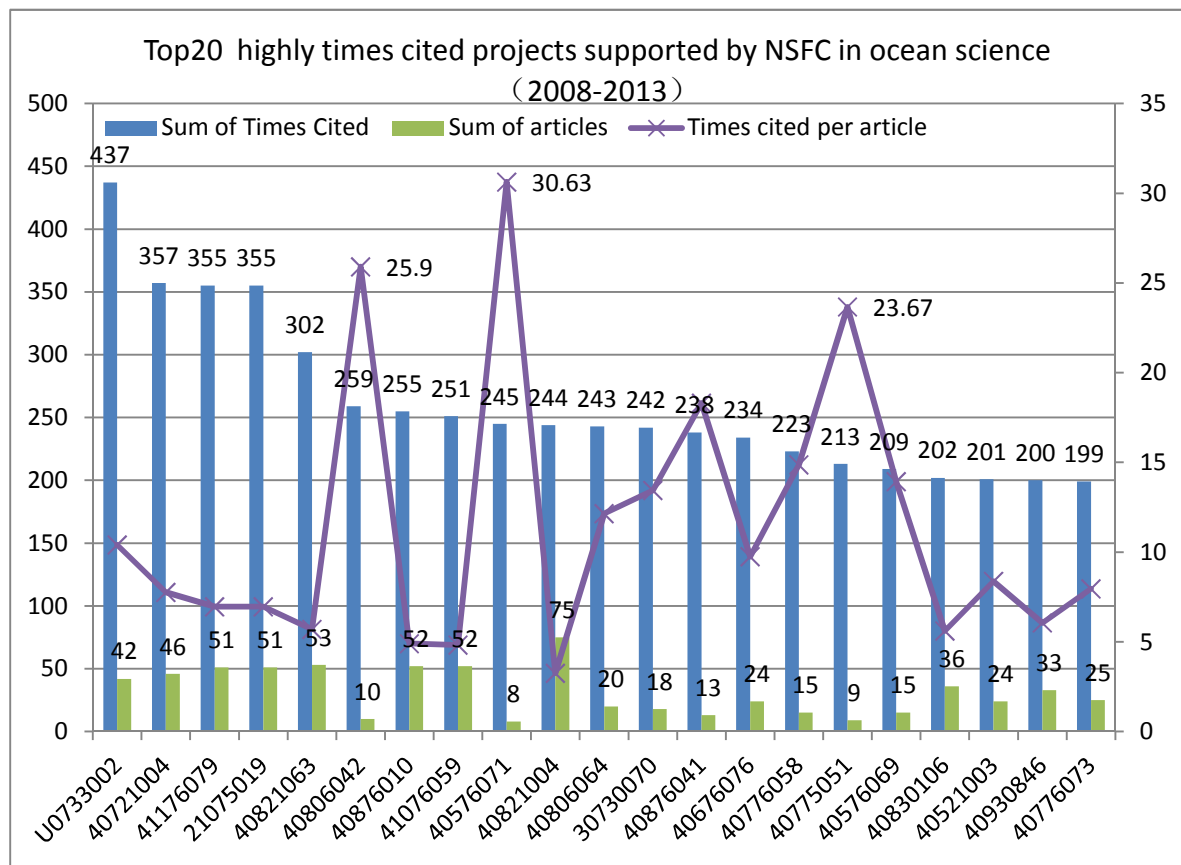


Fig4.3.3 Top20 highly times cited projects supported by NSFC in ocean science (2008-2013)

Arrange the projects supported by NSFC in ocean science (2008-2013) by the sum of times cited, we will get the top20 highly times cited projects. Project U0733002 published 42 articles which are cited 437, which is the 1<sup>st</sup> according to the sum of times. Project 40721004 published 46 articles which are cited 357, which locates 2<sup>nd</sup> according to the sum of times. According to the times cited per article, although project 40576071 only published 8 articles, but the times cited per article is 30.63 which located the 1<sup>st</sup>. Project 40806042 published 10 articles which are cited 259 times, which comes the 2<sup>nd</sup> with the times cited per article is 25.9. Project 40775051 published 9 articles with times cited 23.67, locates the 3<sup>rd</sup> according to the times cited per article.

### 4.3.4 Highly published top20 journals

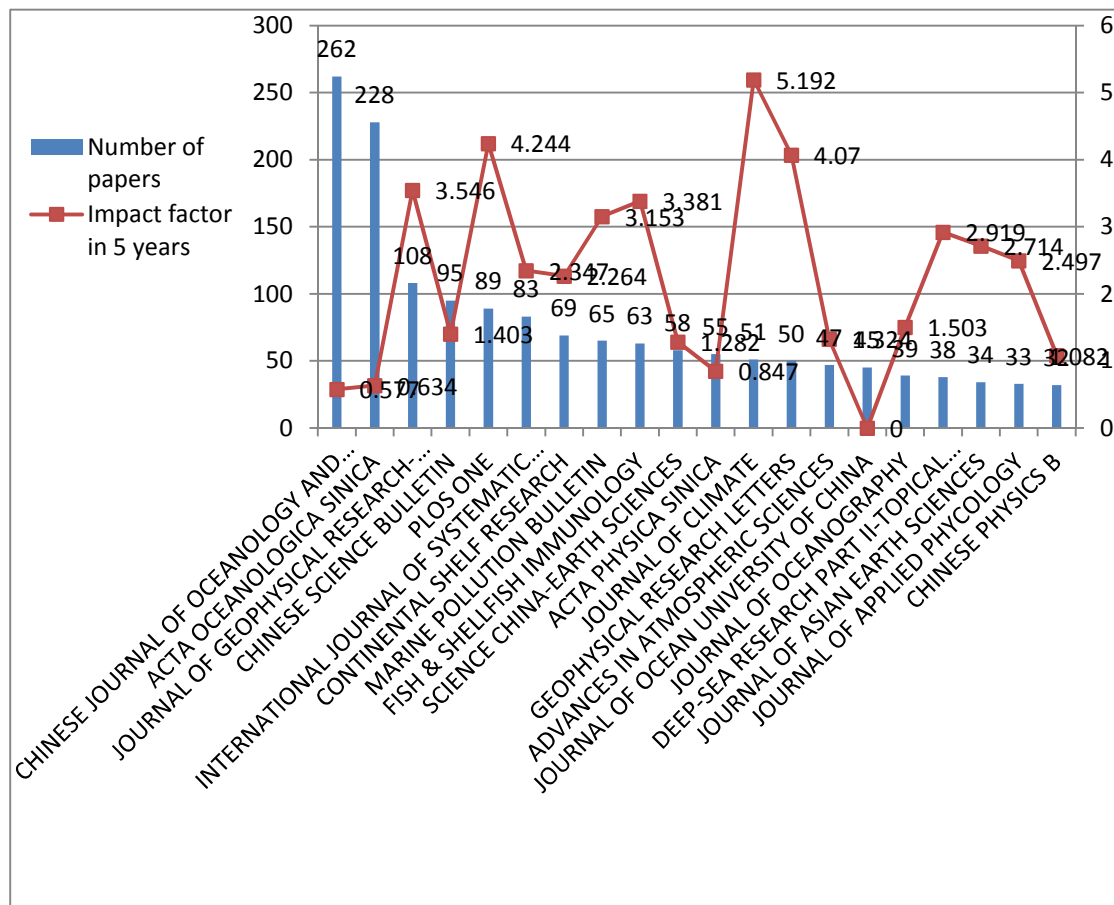


Fig4.3.4 Highly published top20 journals for NSFC supported articles

According to the journals of NSFC supporting articles, we analyze the source of the highly published top20 journals. CHINESE JOURNAL OF OCEANOLOGY AND LIMNOLOGY published 262 articles( Impact factor is 0.577), ACTA OCEANOLOGICA SINICA published 228 articles.(Impact factor is 0.634). These two journals are the first and the second journals in published articles supporting by NSFC in the field of oceanography. Plos One( impact factor is 4.244) published 89 articles comes the 5th and Journal of Climate(impact factor is 5.192) is the 12th. The average impact factors of the Highly published top20 journals for NSFC supporting articles in the field is 2.24895.

The authors often publish articles in Chinese journals. At the same time, some authors publish articles in high impact factor such as PLOS One and Journal of Climate. In general, the articles supported by NSFC should be published in journal with higher impact factor to promote the research impact in the field.

### 4.3.5 Highly cited top20 journals

In order to compare with the journals of highly published top20 journals, we analyze the highly cited top20 journals of NSFC supported articles.

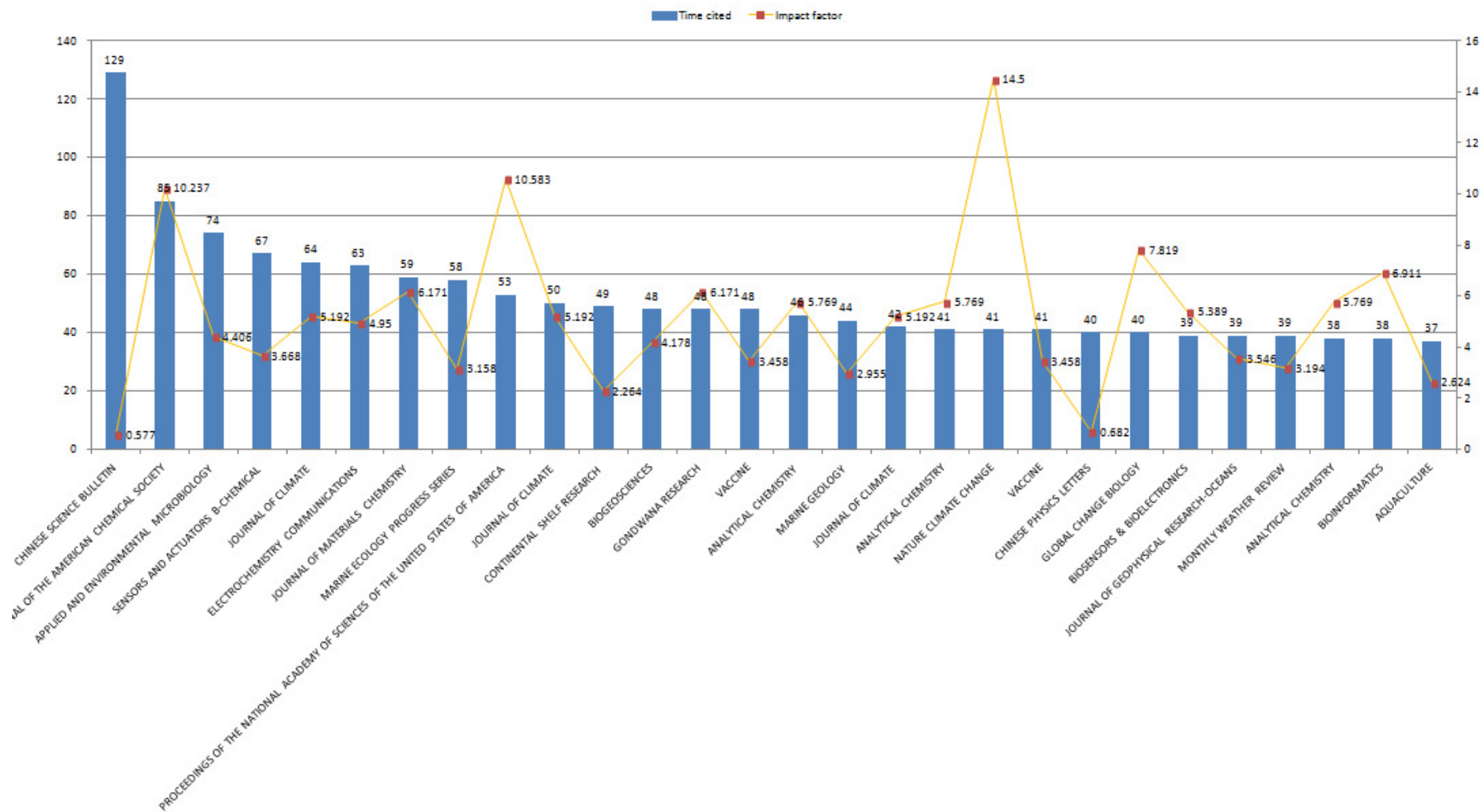


Fig4.3.5 Highly cited top20 journals for NSFC supported articles

As Fig4.3.5 shows, The average impact factor of highly cited journals is 5.135, which is higher than that of highly published journals. The first highly cited article is cited 129 times in Chinese Science Bulletin, the impact factor of which is 0.577. The highest impact factor of these journal is 14.5, Nature Climate Change, the article is cited 41 times. The average times cited is 50.344, which is much higher than 6.102, the average times cited in earth science. So, we conclude that the articles of highly cited top20 articles supported by NSFC in oceanography have relatively higher research impact in the field of oceanography in the world.

#### 4.4 Cost of journal articles of the projects

##### 4.4.1 General status of cost of journal articles of the NSFC supported projects in ocean science from 2008-2013

Based on our analysis, from 2008-2013, there are 2114 projects supported by NSFC in ocean science, the award amount in the field is **1291.733** Million Yuan RMB, there are 4727 articles published during that period. The average number of articles published by each projects is about 2.237. The cost of per article is 0.27 Mil Yuan RMB.

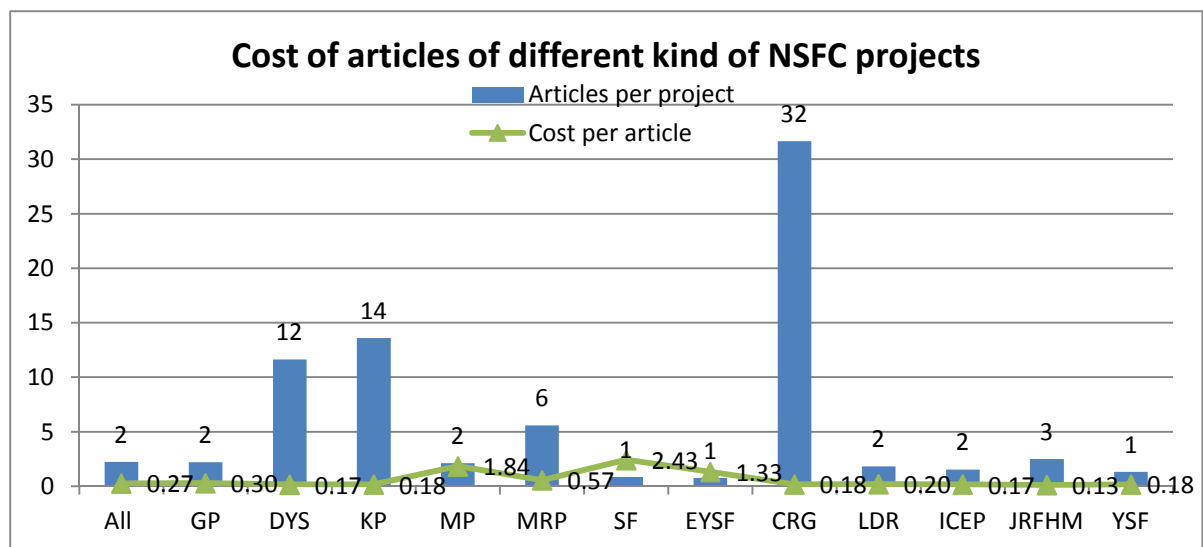


Fig4.4-1 Cost of different kind of NSFC projects supported by NSFC in ocean science (2008-2013)

According to performance of project funding in article publishing, we consider the cost per article and articles per project. Performance of project funding of CRG(Science Fund for Creative Research Groups) is the highest, of which the cost per article is 0.18 Mil Yuan RMB, and this kind of project published 32 articles per project. KP(Key Projects) and DYS(NSF for Distinguished Young Scholars) locates the 2<sup>nd</sup> and 3<sup>rd</sup> place. KP published 14 articles per project with the cost per article is 0.18 Mil Yuan RMB. DYS published 12 articles per project with the cost per article is 0.17 Mil Yuan RMB.

When it comes to YSF(Young Scientists Fund), the article per project of which is

1.31 and SF(Special Funds) ,the article per project of which is 0.86, while the cost of YSF is 0.18 Mil Yuan RMB is a little lower than the cost of SF is 0.57 Mil Yuan RMB. The performance of project funding in article publishing of YSF is higher than that of SF.

GP(General Projects) and MP(Major Projects) have almost the same articles,2 articles per projects, the cost article of GP is 0.30 Mil Yuan RMB while the cost of article of MP is 1.84 Mil Yuan RMB. The performance of project funding in article publishing of GP is higher than that of MP.

Because from 2012 NSFC has begun to set EYSF, there are only 8 projects, because the period of the projects are 4 years, the articles published and times cited are few, it seems the cost is high, but this is temporary with the project proceeding, the situation will be changed.

#### 4.4.2 Cost of journal articles of Top20 highly published projects

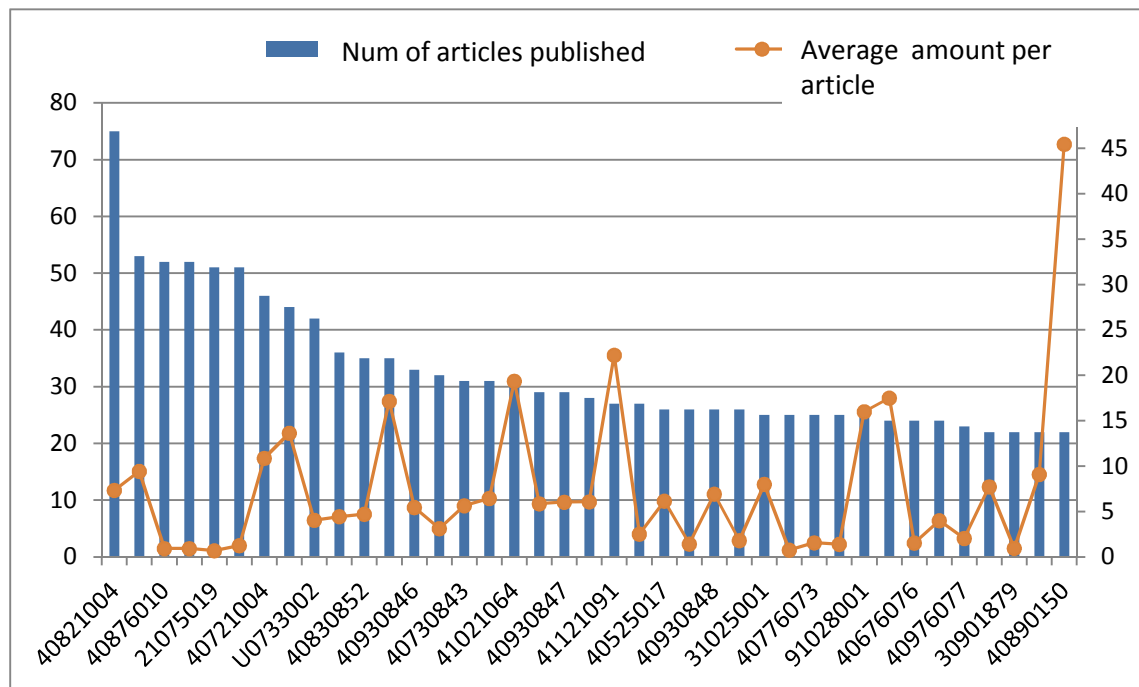


Fig4. 4. 2-1 Cost per articles of the Top20 highly published projects supported by NSFC in ocean science (2008-2013)

Fig4.4.2-1 shows the top20 highly published projects supported by NSFC in ocean science during 2008-2003. These projects are the most active projects with highly capability of articles output.

According to the supporting performance in journal articles, the Top20 highly published projects published 1278 articles, the amount awards is 89.86 Mil Yuan RMB. The cost per article is 0.07 mil Yuan RMB.

Project 40821004 published 75 articles with the amount award 5500 thousands Yuan, the cost per article of Project 40821004 is 73.3 thousand Yuan RMB. The amount award of project 40876010, 41076059, 21075019, 40706046, 30901879 is below 0.520 mil Yuan RMB, the articles of these projects is above 22, and the cost of these projects is about 10 thousand Yuan per articles. It comes to the conclusion that these projects are active in publishing articles, and the funding performance of these projects in publishing articles is high.

The project 40890150 with award amount 10000 thousands Yuan, published 22 articles, the cost per article is 0.46 mil Yuan(45.5 万), which is above the average cost of NSFC projects in ocean science, 0.27 mil Yuan (27.33 万) . Project 41121091, 41021064 with award amount 6 mil Yuan, published about 30 articles, the cost per article is about 0.2 mil Yuan. These projects are active in publishing articles but the cost per article is relatively high.

#### **4.4.3 Cost of journal articles of Top20 highly cited projects**

Fig 4.4.3-1 shows the cost of articles of top20 highly cited projects supported by NSFC in 2008-2013.

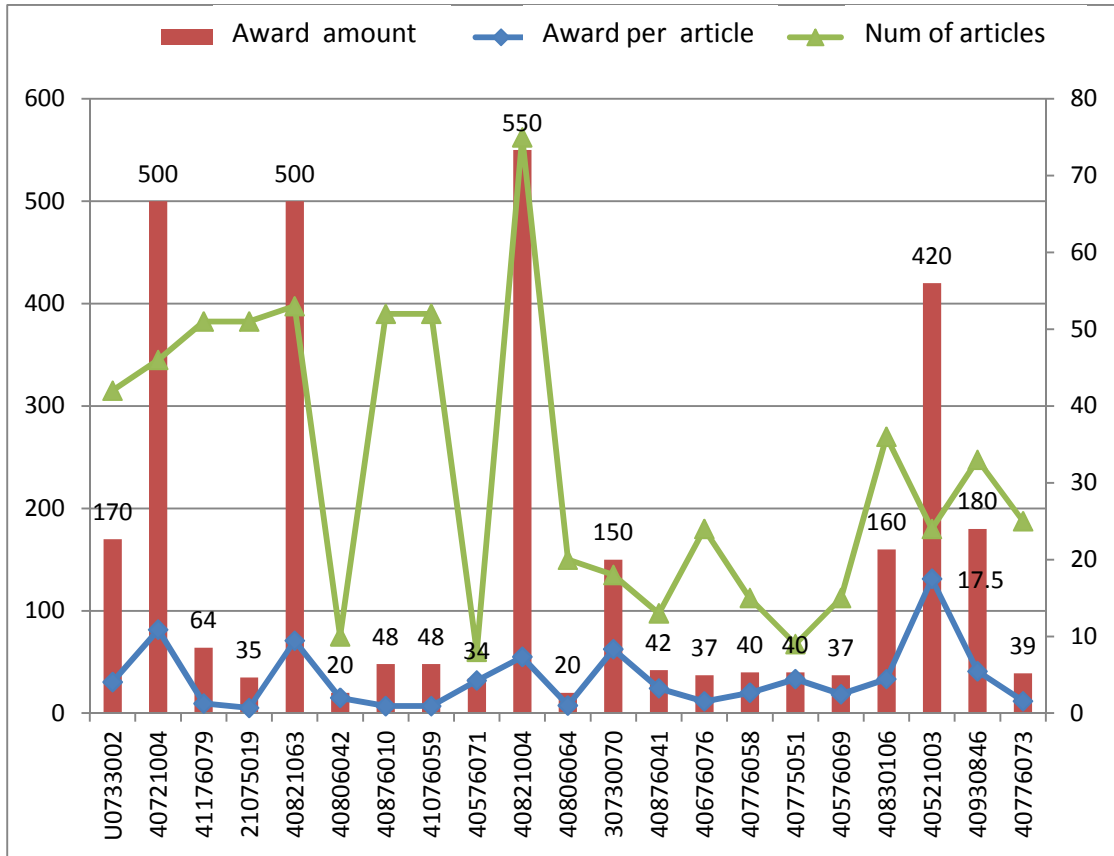


Fig4.4.3-1 cost of articles of top20 highly cited projects supported by NSFC (2008-2013)

(1)Project with award amount more than 4 million Yuan (RMB) in Top20 highly publish projects

Project 40521003 published 24 articles with award amount 4.2 million Yuan RMB, while the cost per article is 0.175 mil Yuan RMB. Project 40821004 published 75 articles with award amount 5.50 million Yuan(RMB), while the cost of articles is 0.073 mil Yuan(RMB)(7.33 万); project 40821063 published 53 articles with award amount 5 million Yuan(RMB),while the cost of articles is 94.3 thousands Yuan(RMB).

(2)Projects with award amount lower than 500 thousands Yuan (RMB) in Top20 highly publish projects

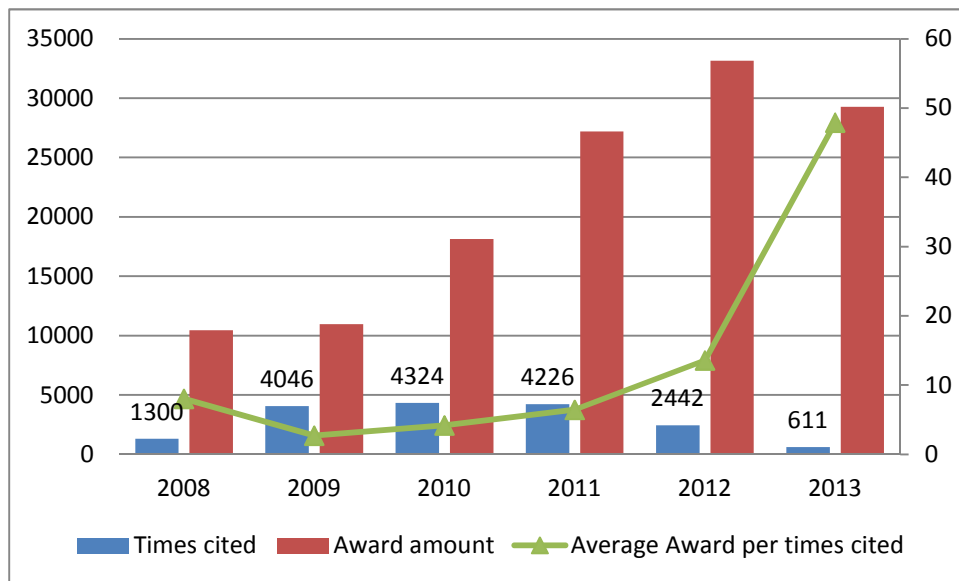
When it comes to cost of journal articles, we noticed in Fig 4.4.3-1 the projects with award amount lower than 0.5 mil Yuan (RMB), for example, project 21075019, 41076059, 40806064 and so on, the cost per articles is lower than 0.01 mil Yuan(RMB), which is much lower than that of the projects with award amount more than 4 mi Yuan(RMB).

**4.5 Cost of research impact of the projects**

Because to some extent times cited of articles represents the research impact of the articles, we analysis the cost of research impact of the projects according to the cost of per time cited of the projects supported by NSFC. If the cost of per time cited of the project is low, that means the performance of the research impact of the projects funding is high.

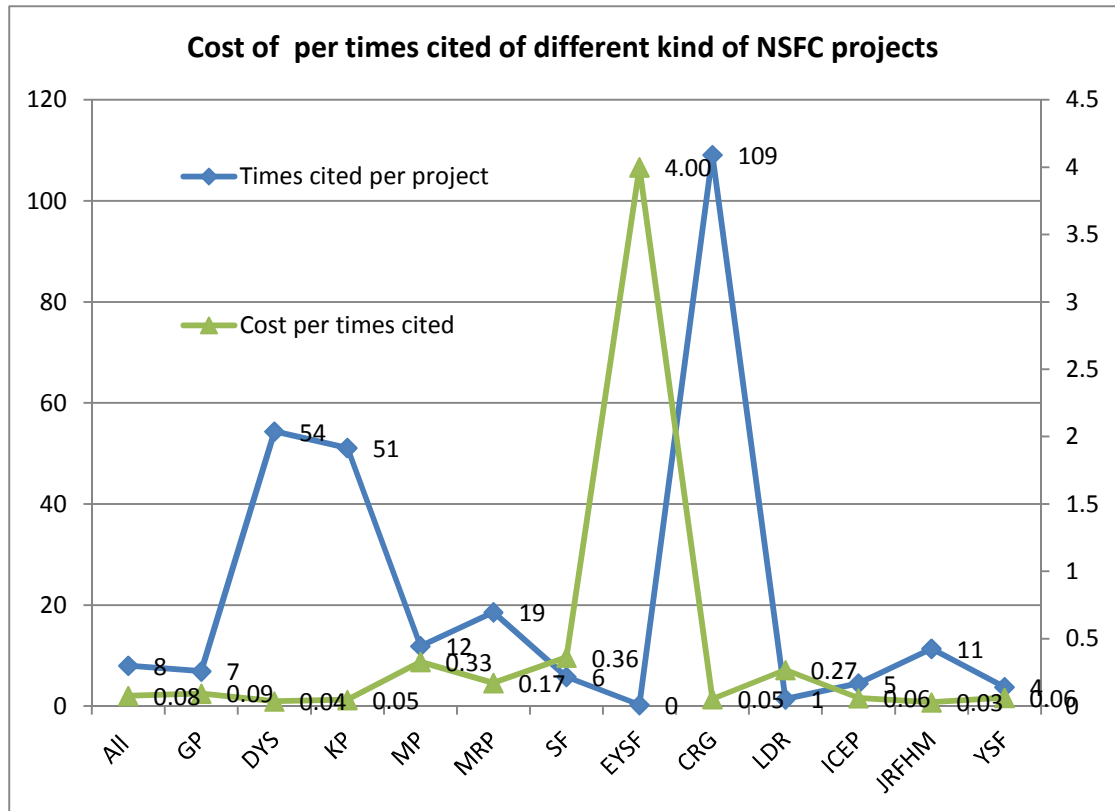


#### 4.5.1 General status of cost of research impact of the NSFC supported projects in ocean science during 2008-2013



*Fig4.5.1-1 Cost of time cited of projects NSFC supported in ocean science in 2008-2013*

During 2008-2013, the award amount of NSFC in ocean science is 1291.73million (129173.2715 万) Yuan RMB, the sum of time cited is 16949, the average award per times cited is 0.76 mil Yuan RMB (7.62 万). The lowest cost of research impact is in 2009 when the times cited is 4046, the award amount is 331.51 million Yuan RMB ( 33150.5 万 ), the average award per times cited is 0.027 mil Yuan RMB(2.71 万).



*Fig 4.5.1 Cost of per times cited of different kind of NSFC projects*

Projects of CRG have times cited per project is 109 times, the cost of per times cited is 0.05 mil Yuan RMB. Projects of DYS have 54 times cited per project, the cost of per times cited is 0.05. Projects of KP have 51 times cited per project, the cost of per times cited is 0.04. In brief, according to the performance of research impact of research fund, CRG comes the 1<sup>st</sup>, DYS is the 2<sup>nd</sup>, and KP is the 3<sup>rd</sup>.

It worth to notice is that projects of JRFHM(Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao) have 11 times cited per projects, while the cost per times cited is only 0.03 mil Yuan RMB. The cost per times cited is the lowest. The performance of research impact of research fund is relatively high.

The times cited per project of GP is 7, the cost per times cited of GP is 0.09. while the times cited per project of SF is 6, the cost per times cited of SF is 0.36. It is evident, according to the performance of research impact of research fund, GP is higher than SP.

#### **4.5.2 Cost of research impact of NSFC supported projects in ocean science during 2008-2013 with top20 times cited articles**

Fig 4.5.2-1 shows the cost of research impact of NSFC supported projects in ocean science with top20 times cited articles in 2008-2013.

(1) Projects with award amount lower than 500 thousands Yuan (RMB) in Top20 times cited projects

We noticed an interesting phenomenon. The projects whose times cited above 10 times almost have award amount lower than 4 million Yuan(RMB), most of them have award amount about 50 thousands Yuan (RMB). For example, Project 40806042 has average times cited 25.9 with award amount 200 thousands Yuan(RMB), the average award per time cited is 0.077, that means the performance of the research impact of the project funding is the first. Project 40806064 has average times cited 12.2 with award amount 200 thousands Yuan(RMB), the average award per time cited is 0.082, the performance of the research impact of the project funding is the second. Project 40576071 has average times cited 30.63( the highest average times cited) with award amount 340 thousands Yuan ( RMB ), the average award per time cited of the project is 0.139. It comes to the conclusion that some projects with small award amount published actively and have published some articles with good influence.

(2) Project with award amount more than 4 million Yuan (RMB) in Top20 times cited projects

Contrary to our expectation, the projects with award amount more than 4 million whose times cited located top20 in NSFC supported projects in ocean science( 2008-2013), the average times cited is all below 10. For example project 40821004 has award amount 5.5 million Yuan ( RMB ), the average times cited is 3.3. Project 40821063 has award amount 5 million Yuan(RMB), the average times cited is 5.67, the cost of per time cited is 22.5 thousands Yuan(RMB).Project 40721004 has award amount 5 million Yuan(RMB), the average times cited is 7.8, the cost of per time cited is 16.66 thousands Yuan(RMB). Although the cost of per time cited is below the average level of NSFC supported in ocean science(70.62 thousands Yuan RMB), that is higher than the projects with award amount about 50 thousands Yuan(RMB).

As our analysis, there are 35 projects supported by NSFC with award amount more than 4 million Yuan RMB, the sum of the articles published by these projects is 476, the articles are cited 1711 times, the average times cited is 3.59. This is lower than the average times cited per article of NSFC supported is 4.83. That means huge award amount is not necessarily mean high research impact.

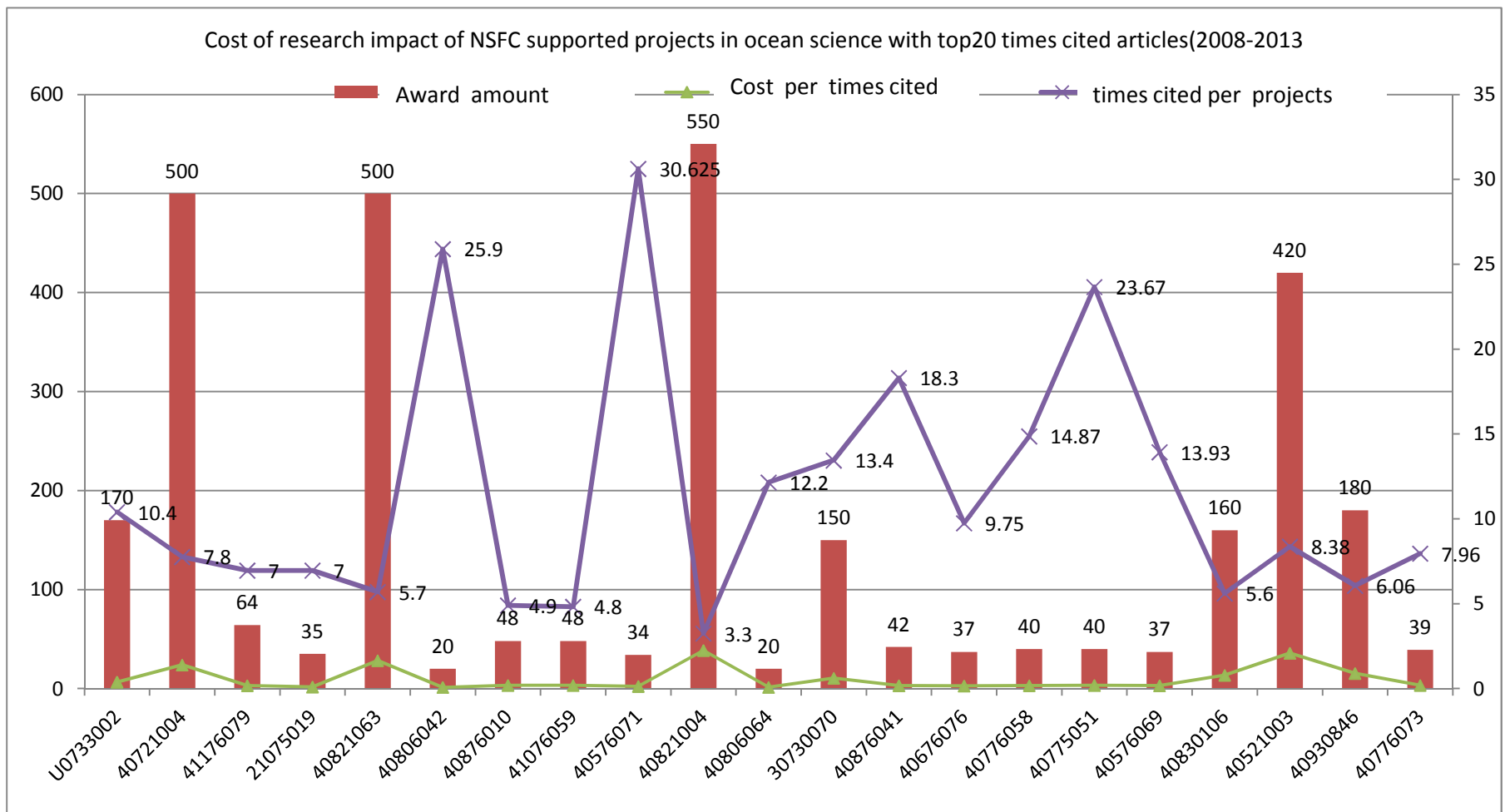


Fig4.5.2-1 Cost of research impact of NSFC supported projects in ocean science with top20 times cited articles in 2008-2013

projects per article. For top20 highly published projects, there are 1305 articles, there are 5.226 projects per article.

#### 4.6 Funding support information of the articles

##### 4.6.1 The general status of funding supports of the articles published by projects by NSFC in 2008-2013

As our statistics, there are 19517 funding number in the acknowledge field of the 4728 articles published by projects by NSFC in 2008-2013. That means, every articles is supported by 4.127 projects. There are 4 articles marked 19 funding projects. There are 104 articles marked more than 10 funding projects.

For top20 highly cited papers, every article is supported by 4.80 projects.

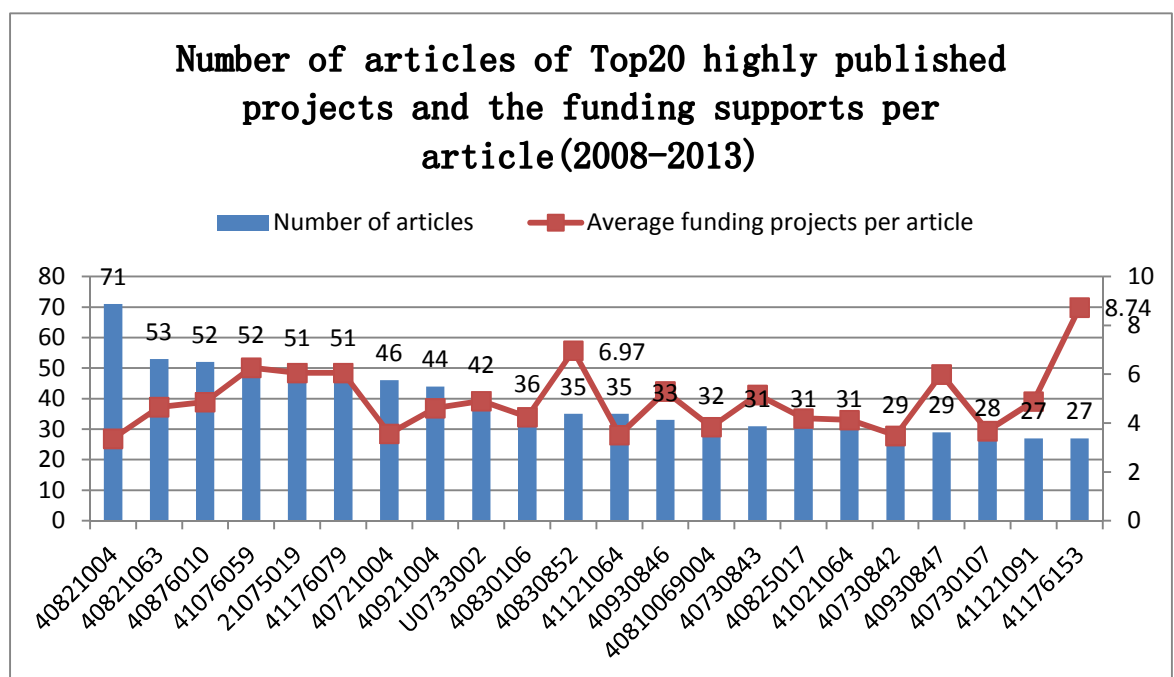


Fig4.6.1-1 Articles of Top20 highly published projects and the funding support per article(2008-2013)

As Fig4.6.1-1 shows, the projects 40821004 has published 71 articles, it is in the first place of projects supported by NSFC. The average funding projects per article of the project is 3.76 in 2008-2013. The project 41176153 has published 27 articles with every article marked average 8.74 funding projects. The project 40830852 published 35 articles, the average funding projects per article is 6.97.

#### 4.6.2 Funding supports of articles of Top20 highly cited papers

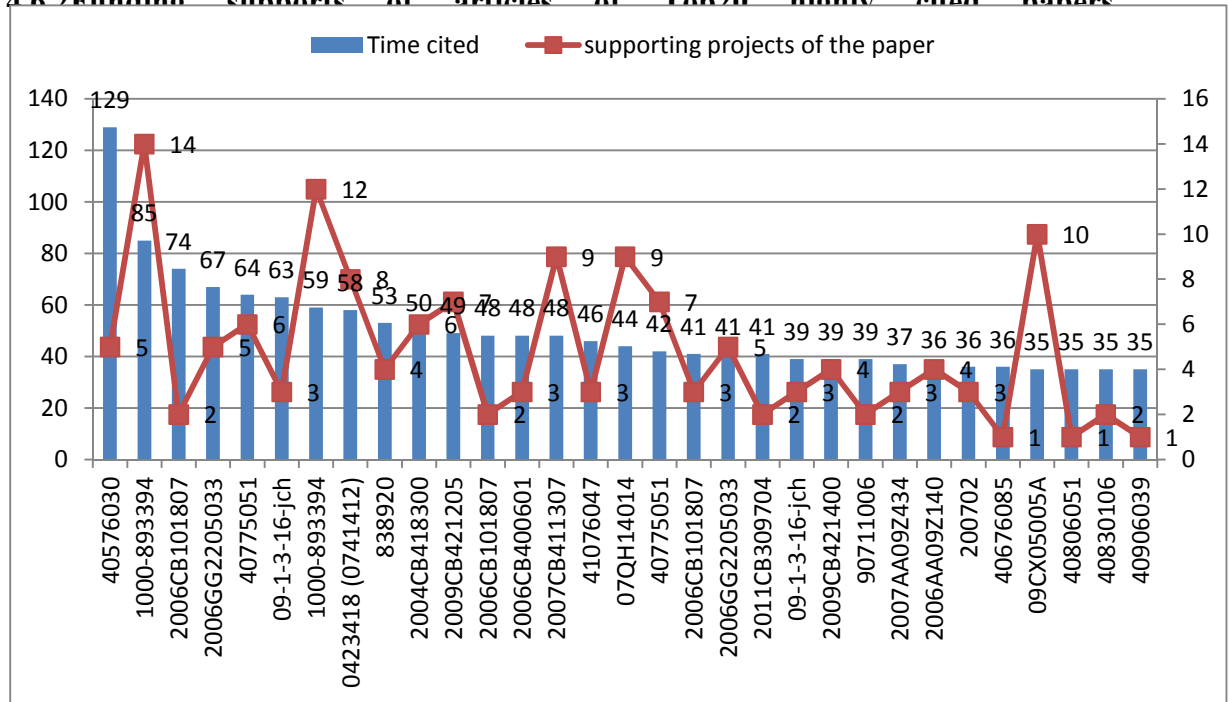


Fig.4.6.2.-1 Articles of Top20 highly cited papers and supporting projects of the paper.

The first highly cited paper is supported by 40576030 with 129 times cited and 5 supporting projects. In these articles, 10 articles has more than the average supporting projects 5.226. For example, one article of 1000-893394 is cited 85 times with 14 supporting projects, another article of 1000-893394 is cited 59 times with 12 supporting projects. The article of 09CX05005a is cited 35 times with 10 supporting projects. We noticed all these projects are not NSFC supported. At the same time, some articles with high cited time supported by 1 or 2 projects, for example, papers of 09CD05005A,40906039 are supported by 1 projects respectively with 35 times cited.

#### 4.6.3 The other foundations marked by the articles supported by NSFC

Tab.4.6.3 Top20 foundation marked by articles supported by NSFC(2008-2013)

Origin of the Foundation	Number of papers supported
973-National Basic Research Program of China(973)	1191
Chinese Academy of Sciences(CAS)	934
Ministry of Education(MOE)	761
Ministry of Science and Technology(MOST)	706
863-National High Technology Research and Development Program of China(863)	648
Shandong Province	434
State Ocean Administration(SOA)	281

Research and Development Special Fund for Public Welfare Industry	280
Guangdong Province	246
Fujian Province	200
NSF	195
Shanghai City	173
Zhejiang Province	148
Jiangsu Province	87
King Saud Univ	74
China Postdoctoral Science Foundation	66
China Ocean Mineral Resources R & D Association	62
NOAA	60
EU	58
NASA	54

In this table, there are many articles are supported by 973,863, Research and Development Special Fund for Public Welfare Industry are relatively, although all of them are from MOST, we treat them separately.

The articles supported by NSFC in the field of oceanography(D06) are also supported by other foundation. The most prominent positions are supporting from 973, Chinese Academy of Sciences, MOE, MOST, 863 and SOA. Some coastal province including Shandong, Guangdong, Fujian, Shanghai ,Zhejiang and Jiangsu, also provide support for these studies, because the development of these place has close relation to ocean. The oversea support including King Saud Univ., NOAA, EU, NASA shows the international cooperation with agencies supported by these foundations.

#### **4.6.4 Analysis to the phenomenon of multi-funding per articles**

According to the phenomenon that articles published by projects of NSFC have quite a few supporting foundation, we analyse there are several reasons.

Funding supports of an article shows the attention of the foundations to the study of the article. It embodies the capability of the authors to attract foundation. It also represents the cooperation with different affiliations supported by different foundation.

(1) In recent year, research projects in China have quite a few source of supporting sustentation fund with the development of economic in China.

(2) There are wide cooperation in different affiliations that are supported by different funding agencies.

(3) In order to deal with the check of the projects, some authors mark several projects that some are not relate to the study casually.

(4) To some extent, there is some kind of wasteful duplication of different foundations.

(5) The foundations have different role in supporting the study, for example, some

project of the university or institution support for the preparation for applying for national foundation. NSFC encourage exploration freely, has some function of talent cultivation. 863 and 973 embody the national top-level layout of important research and development direction.

Generally speaking, in order to enhance the benefits of input and output, information sharing and communication of different foundation is necessary to avoid wasteful duplication.

## **5. Result and Discussion**

Combining the information of projects and articles, we try to evaluate the performance of the knowledge output of projects in 4-dimension which includes the activeness of knowledge output of the projects, the research impact of the projects, the cost of the articles of the projects, cost of the research impact of the projects. With TDA and EXCEL, we analyze the performance of knowledge output of NSFC projects in the field of ocean science.

### **5.1 Result**

The general result is as below:

For projects supported by NSFC in ocean science, the number and award amount of funded projects show an increasing trend. From 2008-2013, the average number of articles published by each projects supported by NSFC in ocean field is about 2.237. The average award of each articles is 273.209 thousand Yuan RMB per article. The average articles per project published is 2.24.

(1) Based on the research impact analysis, we find the research impact of NSFC supported article has a space to enhance, and there are a tendency of catch-up of the research impact of NSFC supported article in the field of oceanography.

(2) According to research activeness, projects of Creative Research Groups(CRG). are most active in publishing articles, the average number of articles per project is 32. Key Program(KP) and Major Program(MP) are also active with 14 articles per project and 12 articles per project. On average, 2 articles are published per project supported by NSFC in earth science from 2008-2013. Project 40821004 published 75 articles locates 1<sup>st</sup>, this project is the most active project in article publishing, Projects 40876010 and 41076059 published 52 articles, locate the 2<sup>nd</sup> place.

(3)According to research impact, from 2008-2013, the projects supported by NSFC in ocean science published 4727 articles, time cited per article is 3.58 which is below the average times cited per article in earth sciece, time cited per project is 8.017.

According to times cited per project, CRG(Science Fund for Creative Research Groups) is at the 1<sup>st</sup> place with 109 times cited per project. Then comes DYS(NSF for Distinguished Young Scholars) and KP(Key Program). According to times cited per article, SF(Special Funds) comes the 1<sup>st</sup> with 7 times cited per article, then MP(Major Projects) is the 2<sup>nd</sup> with 6 times cited per article.

(4) The average number of articles published by each NSFC projects in ocean science 2009-2013 is about 2.237. The cost of per article is 0.27 Mil Yuan RMB.

According to performance of project funding in article publishing, we combine the number of articles and the cost per article.



Performance of project funding of CRG(Science Fund for Creative Research Groups) is the highest. KP(Key Projects) and DYS(NSF for Distinguished Young Scholars) locates the 2<sup>nd</sup> and 3<sup>rd</sup> place.

The performance of project funding in article publishing of YSF is higher than that of SF.

The performance of project funding in article publishing of GP is higher than that of MP.

That means CRG(Science Fund for Creative Research Groups) has high performance not only in article publishing, but also in research impact. The performance of some Big project is not higher than Small project for example GP or YSP.

(5) Based on our analysis, we find some Small projects with award amount below 0.05 mil Yuan RMB have excellent performance not only in activeness of article publishing and research impact, these managers have the potential to make good achievement, they should be payed much attention in the future by the funding agency.

(5)There is multi-funding phenomenon. The phenomenon multi-funding of the articles presents that there are relatively sufficient funding, wide cooperation of research projects. At the same time, there is some kind of duplication of different foundation of different origin. In order to enhance the benefits of input and output, information sharing and communication of different foundation is necessary to avoid wasteful duplication. And the foundation should ask for the articles explain the different role of different foundation supporting the study of the article. The action to mark the irrelevant projects should not be encouraged.

## **5.2 Discussion**

(1)Bibliometric analysis can be an evidence-based supplement to evaluate the performance of the funding.

Bibliometric method can be evaluated activeness and research impact of projects. According to the cost of article published and the research impact, we limit the study scope to the award of the foundation. This is practical for evaluate the performance of the project. When it comes to evaluate the cost of article published and the research impact of a researcher or affiliation, it will be much complex because the cost will relate to the block funding and competitive funding.

(2) Article publishing and research impact based on citation is only one side of the performance of the science projects. It should be combined with the analysis of the aim and achievement of the projects when evaluate the performance of the project. Peer review, experiment facilities, talent training, research report of field survey, patents and so on, are all should be taken into consideration. But when it comes to patents, it will be difficult to judge if the patent is supported by some funds, only when the project manager submit prescription of the patent to the funding agency.

(3) Because there is multi-funding phenomenon, the real cost of the article is difficult to judge unless we can get enough information of all the projects. In order to analyze

the funding information, the name of the foundation and the number of the foundation should be normalized to decrease the difficulty of data cleaning.

(4) In this article we have just carry out study of the knowledge output performance of the NSFC supported projects in the field of oceanography as a case. In the future we will carry out study in the other field of projects supported by NSFC, and carry out some comparing study with other foundation.

#### Acknowledge

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