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The Matthew effect in China's science: evidence from academicians of Chinese Academy of Sciences

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Abstract Utilizing a unique dataset of the Chinese Academy of Sciences academicians (1993–2013), this paper investigates the Matthew effect in China's science. Three indicators, namely the concentration index, the Matthew index and the coefficient of variation, are adopted to measure the uneven distribution of academicians of the Chinese Academy of Sciences among different regions and disciplines. The empirical analysis demonstrates the existence of the Matthew effect in China's science for the above two dimensions. Yet, this effect has weakened for all regions with the exception of Beijing. We argue that this uneven distribution of the nation's brightest minds makes scientifically competitive regions and disciplines even more competitive while putting those less developed regions and research domains at further disadvantage.

Keywords Matthew effect · Science and technology policy · Academicians of Chinese Academy of Sciences

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Introduction

The origin of the term "Matthew effect" can be traced back to the New Testament. In the Gospel of Matthew, it is written: "*For unto everyone that hath shall be given, and he shall have abundance; but from him that hath not shall be taken away even that which he hath*" (ST. MATTHEW 25:29). In the 1970s, Robert Merton (1968) coined the term "the Matthew effect" for this implied phenomenon of "the rich get richer and the poor get poorer" when he observed psychosocial processes affecting an unequal allocation of rewards to scientists for their contribution. He defined this effect as a mechanism that may heighten the visibility of contributions to science by eminent scientists and reduce the visibility of comparable contributions by less known authors (Merton 1968, 1988, 1995).

Following Merton's seminal work, the Matthew effect, later often called "cumulative advantage," has been widely explored in many research domains. Some studies focus on understanding the multidimensional features of the Matthew effect. Accordingly, the quantitative measurement of the Matthew effect has been conducted at country, journal, and individual paper levels. In a series of papers, Bonitz, together with his German colleagues, proposed and investigated the "Matthew Effect for Countries" (MEC) based on a macro-level redistribution of paper citations from different nations. They found that a minority of the countries are getting more citations than expected at the cost of others (Bonitz et al. 1997). At the journal level, Biglu (2008) found a positive correlation between the number of "citations of one journal and the number of times that this journal is cited by other sources" (p. 461). Hou et al. (2011) provided evidence in support of the Matthew effect in selected Chinese demography journals. Within the same journals, Pislyakov and Dyachenko (2010) investigated the Matthew effect in relation to the misallocation of citations in Russian papers in the fields of chemistry and physics.

Some researchers endeavored to identify the existence of the Matthew effect. Drawing upon organizational co-publication, Khosrowjerdi et al. (2012) observed that top Iranian universities tend to collaborate with those of similar ranking. Tang et al. (2014) found the "clubbing" effect in China's surge in research citations to its most influential papers. Some Chinese scholars observed that a Matthew effect exists in domestic and international collaborated research (Chen et al. 2006). Another stream of Matthew effect research focuses on the characteristics and roles of the Matthew effect. Wang (2014) decomposed the Matthew effect in citations into the components of networking, prestige and appropriateness. Strevens (2006) gave compelling arguments on the good and bad sides of the Matthew effect in scientific enterprises and society as a whole. He posited that the Matthew effect conforms to the rule of allocating credit in proportion to the contribution in Science's reward system, but its effect is provisional for society. By treating the Matthew effect as a dependent variable, Brown (2004) explored the moderating role of the World Wide Web on the Matthew effect on citations in the Annual Reviews series. Focusing on its boundary conditions, Bothner et al. (2010) tried to understand when and under what circumstances the Matthew effect occurs.

The Matthew effect is not confined only to science. Antonelli and Crespi (2013) expanded the examination into enterprise domain. Built upon evidence from Italian firms, they differentiated virtuous and vicious Matthew effects on the discretionary allocation of public R&D subsidies. Wang and Hu (2011) also found striking evidence of the Matthew effect measured by the spatial layout of Chinese national Hi-Tech zones in the period of 2003–2008.

Built upon previous studies on the Matthew effect in science, this research intends to investigate a less explored topic, whether the Matthew effect exists in China's academician election. The novelty of this project is utilizing up-to-date data of China's brightest contemporary minds to explore the existence of the Matthew effect at the aggregated regional level[1] and its evolution over the last 20 years. Specifically, we aim to reveal the temporal and spatial patterns of academician election of the Chinese Academy of Sciences (hereinafter CAS). We also pay attention to the relationship of the number of academicians with both the regional GDP and invention patents, as suggested by previous literature. We anticipate that the results and suggestions will contribute to China's science policy formulation and implementation.

The remaining portion of this paper is organized as follows. The next section briefly documents the background of the CAS and its Academician elections. The section "Data and methodology" describes the data sources and methods used in this study. The "Analysis" section details the evidence of the Matthew effect in China's science from the perspective of region and discipline. The final section discusses implications of the results, as well as the contributions and limitations of this study.

CAS and its membership election

Headquartered in Beijing, the Chinese Academy of Sciences was established on November 1st, 1949, one month after the founding of the People's Republic of China. It is the largest national research institution under the administration of the State Council of China. Over decades, CAS has been the linchpin of China's drive to explore and harness high technology and the natural sciences. CAS has made significant contributions to modernization and is responding to a nationwide call to put innovation at the heart of China's development (Zhang et al. 2011). CAS is home to the largest concentration of scientific talents of China ranging from fundamental theories to applied research and cutting edge enterprises (Cao 1998; Tang 2013). Currently, CAS consists of 104 research institutes, a merit-based learned society (consisting of six Academic Divisions), three universities and a dozen support institutions[2] located in 23 provincial level regions across China (see Fig. 1). These institutes and affiliated national laboratories have a total staff of 63,000, including 49,000 professional researchers.

CAS academicians (also called CAS members before 1993) are scientists who have CAS membership, which is a lifelong honor and the highest academic accolade in the field of science and technology in China. CAS academicians are expected to have a tremendous impact on national and even global top-notch research development (Li et al. 2013). There are three types of Members, including Full, Emeritus and Foreign. These Members (excluding Foreign Members), known as CAS academicians, are grouped into the following six Academic Divisions: Mathematics and Physics, Chemistry, Biological and Medical Sciences, Earth Sciences, Information Technology Sciences and Technological Sciences.

The election regulations and detailed implementation rules of CAS academicians were conferred by the presidium of CAS in 1992 and have been revised nine times by the end of 2013. According to the rules, only the scientists of Chinese nationality who have made systemic and creative achievements together with major contributions in the field of science and technology can be elected as CAS academicians based on a rigorous biennial

[1] Currently, China has 28 provinces and autonomous regions, four provincial level municipalities (Beijing, Shanghai, Tianjing and Chongqing), and two special administrative regions (Hong Kong and Macau). Unless specified, the term "region" in this paper refers only to the regions from which CAS academicians were elected.

[2] For further information on CAS and the institutes, see "2014 Guide to CAS" (http://english.cas.cn).

Fig. 1 The distribution of CAS institutions in China (*source* http://english.cas.cn/CASI/)

election process.[3] Thus far, the presidium of the CAS has elected Members 15 times. At the end of 2013, there were a total of 1,245 CAS academicians[4] distributed in six academic divisions.

Data and methodology

Bearing in mind the hypothesis that the elected CAS academicians can best represent China's researchers, we use their information to document the Matthew Effect in China's science. All scientists' data used in this paper were extracted from the CAS website (http://www.cas.cn/). The overall election results from 1955 to 2013 are presented in Table 1.

As shown in Table 1, CAS election was rather sporadic in the early days, and the biennial CAS academicians election process was not restored regularly until 1991. Hence, to make our analysis consistent, only election data since 1993 were included. Population, technical and economic information were retrieved from the annual China Statistical Yearbooks (1993–2013) and matched with CAS academician data.[5] These data can be

[3] Please note that due to political reasons, prior to 1990, the election of CAS members occurred only three times.

[4] In addition, there were 88 Foreign Members at the end of 2013. In this paper, the Foreign Members were not taken into account.

[5] Each newly assigned CAS academician is assigned to only one region.

Table 1 The distribution of CAS academicians by divisions and elected years, 1955–2013

Year	Mathematics and Physics	Chemistry	Life Sciences and Medical Sciences	Earth Sciences	Information Technological Sciences	Technological Sciences	Total
1955	30	22	60	24	1	35	172
1957	6	2	5	3	0	2	18
1980	50	51	53	64	12	52	282
1991	38	34	34	35	24	44	209
1993	10	10	11	10	5	13	59
1995	10	9	12	10	7	11	59
1997	9	10	12	10	8	9	58
1999	10	8	11	10	8	8	55
2001	10	10	12	9	4	11	56
2003	10	10	11	10	7	10	58
2005	8	9	12	7	6	9	51
2007	6	6	7	4	1	5	29
2009	6	8	5	5	4	7	35
2011	9	7	9	10	7	9	51
2013	9	9	9	10	7	9	53
Total	221	205	263	221	101	234	1,245

obtained from the website of the National Bureau of Statistics of the People's Republic of China (http://www.stats.gov.cn/).

To measure the Matthew effect evidenced by CAS academician distribution, three indexes were adopted in our study: the concentration index (I) aims to gauge the *overall* redistribution of CAS academicians among different regions; the Matthew index (MI) is used to take into account the huge variance among regions and for distribution at the disciplinary level, taking academic division size into consideration; and the coefficient of variation (CV) is adopted to measure the distribution of CAS academicians among six divisions.

The concentration index

Based on the Lorenz curve, Lin (1985) proposed the Concentration index (I) to measure the degree of concentration of regional industrial distribution. Mathematically,

$$I = \frac{A - R}{M - R}$$

where A is the sum of different industries' accumulated percentage of output value from regional gross industrial output value (in descending numerical order), R is the sum of these industries' accumulated percentage of output value from regional gross industrial output value with equal distribution, and M is the sum of these industries' accumulated percentage of output value from regional gross industrial output value with concentrated distribution. In this paper, we use density of CAS academicians instead of industrial output value to measure the concentration degree of CAS academicians' distribution at regional level. Density is calculated as the ratio of the number of CAS academicians to the population at the end of 2013 with a unit representing one million capita.[6] Theoretically, the concentration index can range from 0 (i.e., complete equal distribution) to 1 (complete concentrated distribution).

The Matthew index

Developed by Pislyakov and Dyachenko (2010), MI is an indicator to measure the degree of citation redistribution. MI is defined as the ratio of count difference between observed citations (OC) and expected citations (EC) to the expected number of citations (EC). In this paper, we redefined MI as:

$$\mathrm{MI}_{ij} = \frac{\mathrm{OA}_{ij} - \mathrm{EA}_j}{\mathrm{EA}_j}$$

where OA_{ij} is the observed numbers of CAS academicians from region i in year j, EA_j is the expected numbers of CAS academicians calculated on the basis of average number in year j. If *MI* for some regions is positive ($\mathrm{MI} > 0$), it means that these regions are over-allocated with CAS academicians. On the contrary, if MI for some regions is negative ($\mathrm{MI} < 0$), it means that these regions are under-allocated with CAS academicians and are at a disadvantage in terms of being affiliated with the most eminent Chinese researchers.

The coefficient of variation

The third indicator we use, CV, is a statistical measure of the dispersion of a frequency distribution. It is defined as follows:

$$\mathrm{CV} = \frac{\sigma}{\mu}$$

where σ is the ratio of the standard deviation and μ is the mean. It shows the extent of variability in relation to the mean of the data. Large values of CV suggest greater dispersion and differentiation among divisions.

Analysis

General descriptive

Table 2 lays out the distribution of CAS academicians by province over the last 20 years. By the end of 1992, the total number of CAS academicians was 681, and after the 2013 election, the number peaked at 1,245 (http://scitech.people.com.cn/GB/25509/29829/). Please note, according to CAS election rules, the number of newly elected CAS academicians is no more than 60 in each election year. There is no requirement for a minimum threshold nor for average allocation by region.[7] Consequently, except in 2007 and 2009, the number of CAS academicians elected each time has remained rather stable within the above 20-year period.

[6] The illustration case is appeared in "Appendix".

[7] The allocation of province is based on the location of affiliation that CAS academicians work when they were elected.

As shown in Table 2, from 1993 to 2013 CAS academicians were elected from 27 out of 34 provincial level regions. Ranking these regions by total numbers of CAS academicians, 73 % CAS academicians are allocated in the top 20 % regions (type 1), i.e., 411 academicians in five regions,[8] and 27 % in the rest 80 % regions (type 2). This finding fits into the Pareto 80–20 Principle that roughly 80 % of the effects come from 20 % of the causes (Fig. 2 Panel A). This uneven distribution is even more apparent when it is normalized by regional population. As shown in Panel B of Fig. 2, 15 % of the population is associated with 73 % newly elected.[9]

Figure 3 further differentiates the density of CAS academicians in the above 27 provincial regions. As depicted in the bar chart, Beijing, a populous city with $\sim$12 million people, still stands out with the highest density of CAS academicians. This is followed by three other densely populated cities: Hong Kong, Shanghai and Tianjing. Qinghai elbowed out the rest regions by three academicians due to its sparse population. Furthermore, the line chart of accumulated percentage of density shows that the top four regions own 81.84 % out of 100 %. Even the logarithm equation with a high R squared value of 0.9472 has a flat slope of 0.1294. When we define the top 20 % provincial level administrative divisions as minor regions and the rest 80 % as major regions, a sharp difference of CAS academician distribution between minor and major regions is evident in the last 20 years.

The concentration index

The density of the number of CAS academicians per million capita each year[10] in 27 provincial level administrative divisions was used to calculate the concentration index. Figure 4 describes the values of I in each election year from 1993 to 2013. In this figure, we note that all values of I are larger than 0.85, with two peaks of 0.92 in 1993 and 2007. There are 4 years when the values of I are under 0.9 (1997, 2003, 2009, 2011), with the bottom of 0.86 in 2011. In general, a declining trend of the concentration index appears in our observation period in spite of ups and downs.

The downward trend of the I indices suggests that the concentration degree of regional CAS academician distribution seems relieved gradually. However, without taking into account the distribution of CAS academicians among regions and its trend, we are not able to draw a definite conclusion that the Matthew effect in China's science is weakening. Therefore, we next calculated the Matthew index of each region since 1993. MI for CAS academicians in a particular region may be positive (there are more CAS academicians in this region than the regional average) or negative (there are less CAS academicians in this region than the regional average). Figure 5 shows the distribution of the numbers of regions with positive and negative indices for all 27 provincial level administrative divisions.

Two observations arise from Fig. 5. Over the investigated 20 years, the proportion of regions with negative MI is consistently lower than 90 %. Even for the year of 2013, there

[8] As 564 CAS academicians were elected from 27 provincial level regions over the examined period, the top 20 % regions is calculated by 27 $\times$ 20 % which including approximate five regions compared with the rest 22 regions (27 $\times$ 80 %). Ranking by descending numerical order of elected CAS academicians within the 20 year period, these top 20 % regions are Beijing (265), Shanghai (67), Jiangsu (37), Hong Kong (22) and Anhui (20) in proper order.

[9] The number refers to the population at the end of 2013. The data source is the official website of National Bureau of Statistics of China (http://www.stats.gov.cn/).

[10] Here, we used the 27 provincial level administrative divisions year-end population data when there were CAS academicians elected from 1993 to 2013.

Table 2 The distribution of CAS academicians by provinces, 1993–2013

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	Total
Anhui	3		5		1	4	2	1	1	1	2	20
Beijing	31	30	23	23	28	26	21	14	17	24	28	265
Fujian	1		1	1	1	1	1	1		1	1	9
Gansu	1	1	1				1		2	1	1	8
Guangdong	2		1	1	1	1	2		3		1	12
Guizhou										1		1
Hebei		1		1	1							3
Henan				1		1			1			3
Heilongjiang					1							1
Hubei	2	2	3	2	1		1	1	1	4	2	19
Hunan	1			1		1			1	1		5
Jilin	1	2	2	1	1		2	1			3	13
Jiangsu	3	8	3	3	3	3	5	3	1	3	2	37
Jiangxi										1		1
Liaoning	2	1	5			3	1		1	1	2	16
Neimenggu	1											1
Qinghai		1	2									3
Shandong	2	1	2		2		1	1			1	10
Shanxi						1						1
Shaanxi			2	1		1	1	1	2	3	2	13
Shanghai	7	6	6	10	6	6	11	3	2	5	5	67
Sichuan		2		2	1	1			1	2	2	11
Tianjin	2	2	1		1	1		3	1	1		12
Hong Kong		1		5	6	4	2		1	2	1	22
Xinjiang					1							1
Yunnan				2		2						4
Zhejiang		1	1	1	1	2						6
Total	59	59	58	55	56	58	51	29	35	51	53	564

are still over 65 % regions that have an MI of less than zero. On the other hand, we do see an upward trend indicating that more regions have a positive distribution of CAS over time. Out of these 27 provincial-level administrative divisions, 33 % of the regions have a positive MI in 2013 compared with the minimum of 11 % in 1995 and 15 % in 1993, 1999, 2001 and 2007. This apparent trend explains the decrease in the concentration index in Fig. 4. However, when we further analyze the regions that have a positive MI over ten times from 1993 to 2013, an interesting phenomenon appears, as shown in Fig. 6.

Figure 6 illustrates the MI trend for the top three regions with the most newly elected CAS academicians. Interestingly, two different patterns emerged. Among the three regions, Beijing tops both Shanghai and Jiangsu throughout the overall period. This may also echo previous findings that CAS institutes in Beijing and Shanghai performed better than institutes in other regions (Zhang et al. 2011). As shown, Beijing's lowest MI of 9.7 is still twice as large as the highest MI of the other two. In 2013, Beijing reaches the maximum MI of 13.26. In spite of its existing advantages, a slightly rising trend of MI can be still

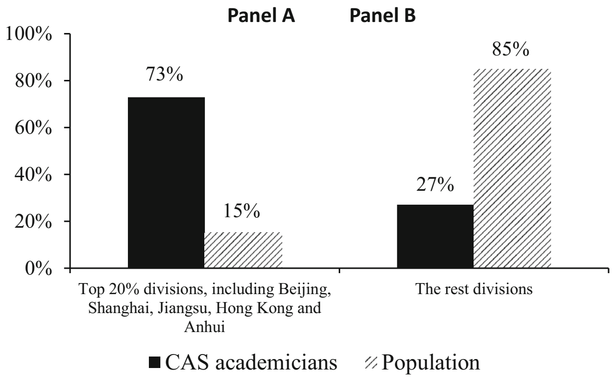


Fig. 2 Comparison of CAS academicians' percentage and population percentage from two types of provincial level administrative divisions

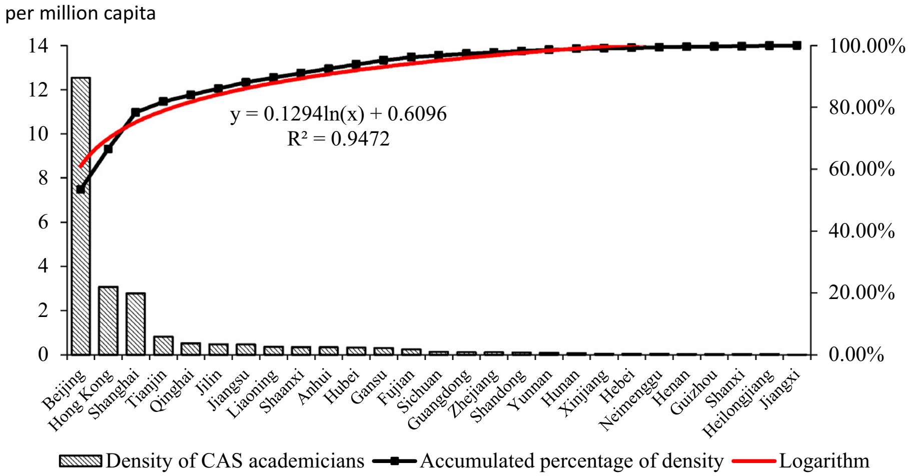
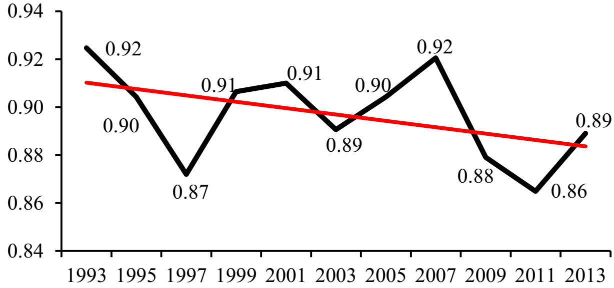


Fig. 3 Density of gross CAS academicians per million capita and accumulated percentage of density in different regions, 1993–2013

Fig. 4 The values of the concentration index, 1993–2013



observed from Beijing. In contrast, neither Jiangsu nor Shanghai has an MI > 5, and the overall trend of the Matthew index for both regions is declining. This is particularly true for Jiangsu, whose MI touches the bottom with 0.019 in 2013.

It is reasonable to conclude that *nationwide* the redistribution of CAS academicians led by the Matthew effect in China's science has become less concentrated in the last 20 years. Although the Matthew effect is strengthened in Beijing, the centralized distribution of CAS academicians has gradually loosened in 26 provincial level administrative divisions. A possible reason for that is the distribution of scientific resources in China. As the capital, Beijing has more educational and scientific resources than any provincial level administrative divisions elsewhere (Tang and Shapira 2011a, b).

Several tentative explanations have been provided for the Matthew effect. One is path dependency—eminent researchers tend to work in environments where other eminent researchers also work. Stimulated by the work of Chen and Xu (2011), we extracted and plotted the places of CAS academicians for birth, study, and work. From the spatial and migration pattern of 564 CAS academicians demonstrated in Fig. 7, a significant correlation exists between the place where CAS academicians studied and worked at the election time which may reflect their professional growth throughout their career path. Since 1993, there are 317 elected CAS academicians who have been studying or working in Beijing. This accounts for 56.2 % of the total number. Among 317 CAS academicians, one-third finished their undergraduate study and worked in Beijing, the capital of China. At the same time, Jiangsu and Shanghai have small peaks as study and work places. This further supports the findings illustrated in Fig. 7.

The second explanation is the co-evolution of science and economics as discussed by Bonitz (2005). To test whether this holds for China, we examine the relationship between the Matthew effect in China's science and two economic indicators: Gross Regional Product (GRP) and domestic invention patent applications granted at the regional level. Following common practice, per capita GRP is used to measure the level of regional economic development by the Chinese government.[11] Inventions[12] filed at the State Intellectual Property Office of China (SIPO), which is deemed as accurately representing the level of innovation in technology domains (Breschi et al. 2003; Nerkar and Shane 2007; Chen et al. 2013) is used as the 2nd indicator. Their relationship is plotted in Fig. 8.

In addition to a highly unbalanced China in terms of geographical distribution of science, innovation, and talents, the key message conveyed from Fig. 8 is that the Matthew effect in China does highly correlate with the economy and innovation. Regions with a larger number of invention patents and higher per capita GRP are often habituated with CAS academicians.

Figures 9 and 10 shows a rise grossly as the number of CAS academicians increases from different regions. In other words, for a certain region, the more CAS academicians are elected from there, the more per capita GRP it has and the more domestic invention patent applications granted per 1,000 persons, and vice versa—like the situation of "the rich get richer and the poor get poorer." This phenomenon is what Merton called the Matthew effect. Here, we observed this effect existing in China's academician election system.

In particular, in Fig. 10, the correlation of domestic invention patent applications granted is clearly a function of the number of CAS academicians. A linear equation was fitted with a high R squared value of 0.8959. A possible explanation for the difference between CAS academicians' relation to per capita GRP and domestic invention patent

[11] See annual China Statistical Yearbook compiled by National Bureau of Statistics of China.

[12] There are three types of patents in SIPO: Invention, Utility Model, and Design.

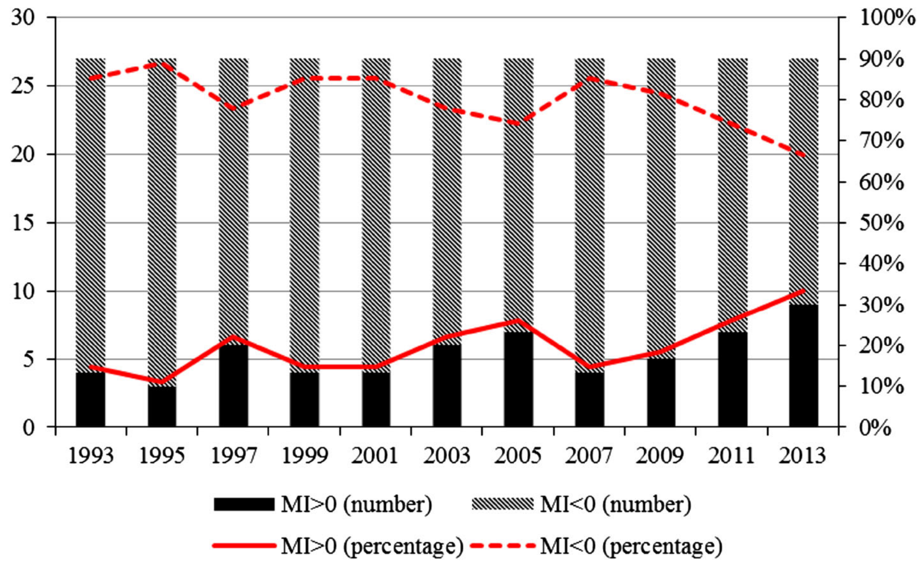


Fig. 5 The number and percentage of regions with a positive or negative Matthew index for CAS academicians, 1993–2013

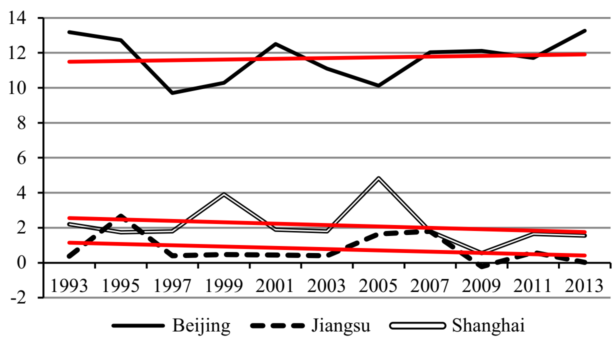


Fig. 6 The Matthew index for CAS academicians of Beijing, Jiangsu and Shanghai, 1993–2013

applications granted per 1,000 persons might be the gap between research and commercialization. Compared with invention, which is one form of the scientific research achievements, commercializing the research and then contributing to the local economy is decided by many factors, including the industry mix, the geographical location, policy interventions, and the like (Tang et al. 2014). It also might be explained by open innovation (Chesbrough 2003) in which an increasing number of firms use external technology from other regions instead of doing research alone or search locally (Wang et al. 2014).

Likewise, when we put gross CAS academicians and regional determinants such as GRP, domestic invention patent applications granted and others into a regression using a stepwise method, the results are revealed in Table 3, illustrating the specific extent of the Mathew effect's existence, as is shown in Figs. 9 and 10.

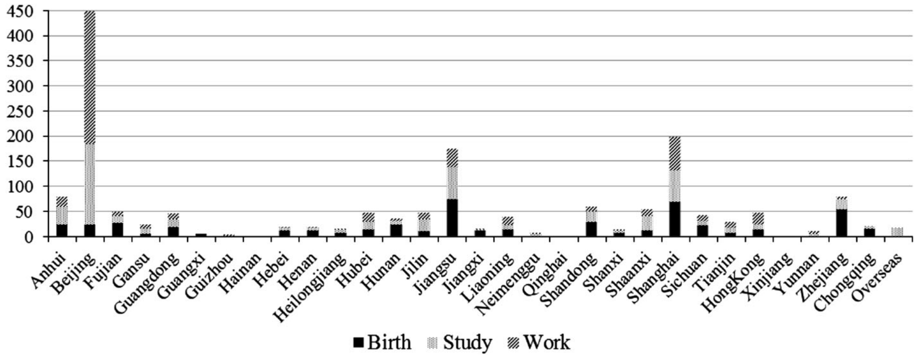


Fig. 7 Distribution of CAS academicians by their places of birth, study and work. Study places are where CAS academicians acquired their bachelor's degree, which we think is the most important learning phase that laid the foundations for their further research. Work places are where CAS academicians worked when they were elected

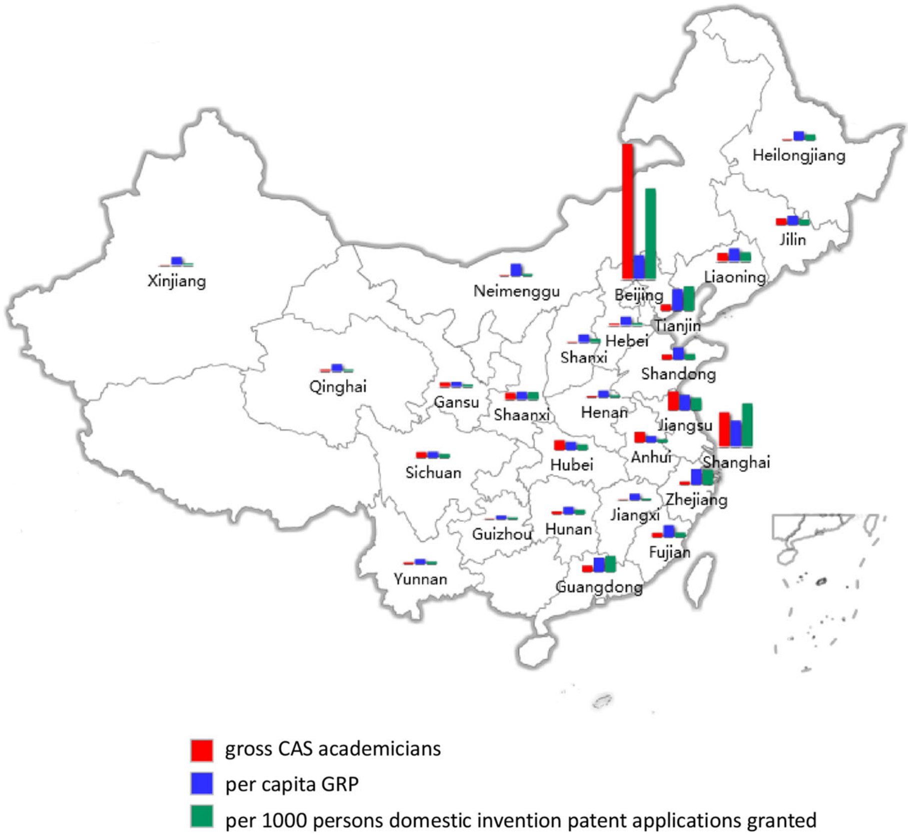


Fig. 8 The percentage in total amount of gross CAS academicians, the accumulated number of per capita GRP and domestic invention patent applications per 1,000 persons granted in each region since 1993 in China

Accordingly, the appearance of the Matthew effect in China's science is attributed to the uneven distribution of scientific resources and sustained by scientific research achievements.

Moreover, to investigate whether the Matthew effect also exists among different academic divisions in the CAS and its evolution, we present the distribution of CAS academicians elected from 1993 to 2013 in Fig. 11. The CV is used to measure the dispersion of the frequency distribution of CAS academicians among academic divisions. Using the biennial number of CAS academicians from six academic divisions as the sample data, the CV results are shown in Table 4 and display a decrease from 24.50 % in 1993 to 10.16 % in 2013. This, combined with all six declining lines displayed in Fig. 11, indicates that the uneven distribution of CAS academicians among different disciplines has weakened in the last 20 years.

Discussion and conclusions

Since Merton introduced the "Matthew effect" in science, this phenomenon has been widely studied across different areas. Evidence has been accumulated in support of the Matthew effect in terms of paper citations, information systems, cohorts of economists, and R&D public subsidies. In this paper, we examined the Matthew effect in China's science using the data of newly elected CAS academicians from 1993 to 2013. Our analysis of the data indicates that the Matthew effect exists in China's science, as reflected in the uneven selection of CAS academicians among different regions and academic divisions. However, from the perspective of regions and disciplines, this effect has weakened since 1993.

On the regional level, by the end of 2013, 564 CAS academicians were unevenly distributed among 27 different provincial level administrative divisions. Taking provincial populations into account, five regions including Beijing, Shanghai, Jiangsu, Anhui and Hong Kong account for approximately 70 % of CAS academicians while having only 15 % of the total population. When measured by concentration index using the number of CAS academicians per million capita, the values of *I* fluctuates around 0.9 with a declining trend. This, combined with a rising trend of positive MI, suggests that nationwide, the uneven distribution of CAS academicians among different regions caused by the Matthew effect in China's science has become less concentrated in the years of the studied period.

An interesting phenomenon appeared when comparing Beijing to other regions. With the highest MI in 2013, Beijing shows a slightly increasing trend of the Matthew effect since 1993. On the contrary, other regions with constant positive MI experienced a

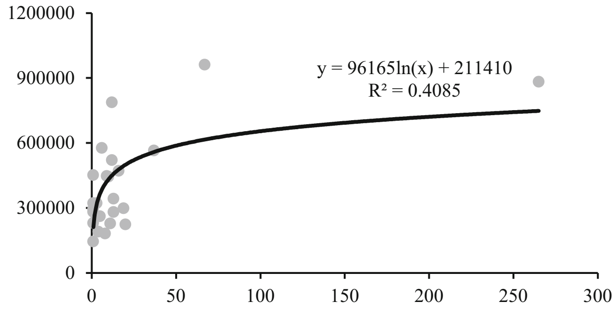


Fig. 9 The relationship between gross CAS academicians and the accumulated per capita GRP since 1993

Fig. 10 The relationship between gross CAS academicians and the accumulated number of per 1,000 persons domestic invention patent applications granted since 1993

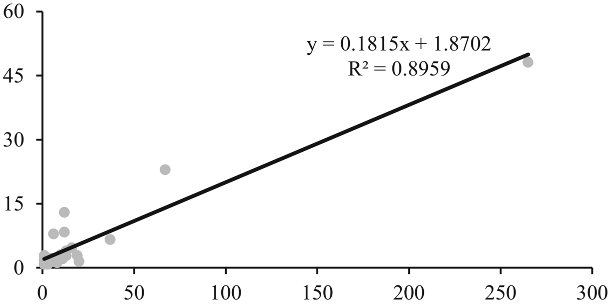


Table 3 The output of regression using a stepwise method

Variable	Model 1	Model 2
Intercept	−7.065 (−1.829)***	21.498 (3.639)***
Per 1,000 persons domestic invention patent applications granted	4.937 (14.376)***	6.605 (17.059)***
Per capita GRP		−9.652E-5 (−5.395)***
R^2	0.896	0.954
F-statistic	206.657***	238.873***

In this regression, the dependent variable is the gross CAS academicians in each region

*** Significant at 1 % level

Fig. 11 Yearly distribution of CAS academicians by six academic divisions, 1993–2013

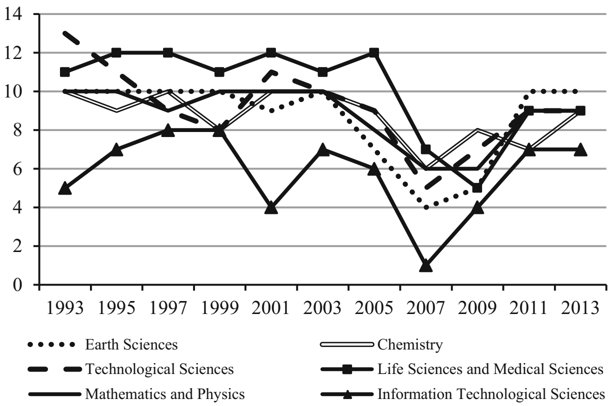


Table 4 The CV of CAS academicians among six academic divisions, 1993–2013

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013
CV (%)	24.50	15.99	12.90	13.24	27.43	12.90	22.27	40.36	23.04	13.15	10.16

decrease in the last 20 years. As the capital of China, Beijing is home to the largest number of high quality universities, which attract scientists to study and work there—over half of the CAS academicians have been studying or working in Beijing. In addition, the per capita GRP of Beijing and the granted domestic inventions per 1,000 persons are higher than the other regions in China. These factors increase the probability of the election of new CAS academicians in the following period. Consequently, opposite to the trend nationwide, the Matthew effect has been substantially strengthened in Beijing.

We also found evidence that the Matthew effect also exists among different academic divisions within CAS, but the changing value of CV illustrates that the uneven distribution of CAS academicians among different disciplines has loosened from 1993 till now.

This study has policy implications. First, the weakening trajectory of the Matthew effect at both the regional and the discipline level, may reflect, to some extent, that the political correcting mechanism is playing a role. As Cao (1998) suggested, the factors affecting the elections, such as disciplinary characteristics and the role of personal relationships in the 1990s, have been changed by the implementation of related policy. Second, we testified that the appearance of the Matthew effect in China’s science, especially in Beijing, is attributed to the uneven distribution of scientific resources and sustained by scientific research achievements. On the one hand, this polarization between Beijing and other regions has promoted granted invention patents in the capital of China. The cumulative advantage and the symbolism of intellectual property of the Matthew effect (Merton 1988) has further accelerated China’s scientific development. On the other hand, for sustainable development, these “poor” regions have to seek to eliminate the negative influence from the Matthew effect. We suggest that the Chinese central government should take effective countermeasure to balance regional development by alleviating the Matthew effect in the election of CAS academicians, while the local governments seek to take advantage of the Matthew effect by supporting the development of “rich” areas (growth pole) and the stimulation of “poor” areas inside the region. Last but not least, considering the promoted relationship between CAS academicians and regional scientific development together with economic development, the mobility of CAS academicians between “rich” and “poor” regions should be highly encouraged by policymakers.

Eventually, we have to acknowledge some limitations of this study, which deserve further exploration. First, the data for analysis is restricted to the CAS academicians elected over the last two decades. It would be interesting to extend the data sample back to 1955 with a total sample number of 1,245. In this way, we can have a broader time frame for discovering the dynamics of the Matthew effect in China’s science. Second, the migration of CAS academicians can be better grasped if both graduate and post-graduate learning experiences, which also have impacts on CAS academicians’ research, can be integrated into the analysis. Moreover, it would be an interesting topic if the career path for CAS academicians can be investigated and the patterns can be revealed. Although broadening the scope of the Matthew effect with economic factors in this study may be complicated, it will undoubtedly lead to a deeper understanding of the Matthew effect in China’s science. Last but not least, we did not investigate the “poor” regions with negative MI. We believe that additional consideration in future research will further enhance a collective understanding of the Matthew effect in science.

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Appendix

See Table 5.

Table 5 The illustration case of calculating Concentration Index *I*

Region	Density of CAS academicians	Density percentage in descending numerical order	Density percentage with equal distribution	Density percentage with concentrated distribution
1	12.53	63.59 %* (63.59 %)*	20 % (20 %)	100 % (100 %)
2	3.06	15.55 % (79.15 %)	20 % (40 %)	0 % (100 %)
3	2.77	14.08 % (93.23 %)	20 % (60 %)	0 % (100 %)
4	0.82	4.14 % (97.37 %)	20 % (80 %)	0 % (100 %)
5	0.52	2.63 % (100 %)	20 % (100 %)	0 % (100 %)
Sum	19.702	(433.33 %)	(300 %)	(500 %)

"()" is accumulated percentage

* (12.53/19.702)*100 % = 63.59 % $I = \frac{A-R}{M-R} = \frac{433.33\,\% - 300\,\%}{500\,\% - 300\,\%} = 0.67$

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