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A comparative overview of STEM discipline-based public research funding in China and the United States

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A comparative overview of STEM discipline-based public research funding in China and the United States

Patricia Akamp

This paper aims to expose a narrow, yet relevant aspect of funding changes in higher education in China, through a discipline-based overview of the country's public research funding. It makes specific comparisons with the United States (U.S.) in order to explore how research funding has changed in the first decade of the century in light of the worldwide trend of investment growth in the fields of science, technology, engineering and math (STEM), considering China's centralized approach to service provision. Through documentary analysis, findings indicate that China did follow the trend of prioritizing STEM subjects for research funding, opposed to those in the social sciences, humanities and arts (SSHA), while aligning them to set economic goals (as seen in the last three Five-Year plans). Even though China and the U.S. have had separate drivers at different times to justify increased investment earmarked for STEM subject areas, both countries hold the common aspiration of being the scientific leading reference in the world, and their policies draw from the assumption that this can only be achieved through further development in science and technology, even if in detriment of funds for SSHA. However, from a discipline-based perspective, by following U.S.' research funding policies, China may be creating dependency paths for SSHA, as already seen in the U.S.

Key words: research funding, China, U.S., SSHA, STEM, resource dependence theory.

Introduction

Worldwide economic and political changes in the past decades have led to reforms in public administration, characterized by a more managerial take on public service provision in various sectors, such as security, health and education. In higher education (HE), the allocation of public funds for research has witnessed a drastic shift towards science, technology, engineering and math disciplines (STEM) as countries prepare their labour market for the demands of a knowledge economy. In most developed countries, and indeed now even some highly industrialized developing countries, the concept of knowledge economy is not a trend, but the stage that best describes their current economic base. In this context, governments tend to steer the direction of knowledge production and the intellectual culture of the country through funding allocations. Innovation then becomes as important as teaching and research. While this approach to education, research and innovation supports further disciplinary collaboration, and legitimizes the decreasing role of the state in HE (as the role of the industry grows), this is not the case for every country. With each country being in different stages of HE development and having diverse histories and industry bases, the manners in which they engage in global trends are also unique. Considering the importance of China in the world of HE, this paper aims to explore how public research funding has changed in the period between 2000 – 2015 in light of the worldwide trend of increased investment in STEM subjects, making specific comparisons to the United States (U.S.) as a reference. That is, considering the centralized approach to service provision in China (quasi-market, as opposed to market led), how have such changes in research funding among distinct subject areas taken place? In particular, what are the effects of such changes on the interdisciplinary relationships between STEM and social science, humanities and arts (SSHA)? The topic is relevant for it is known that research in STEM subjects may indeed lead to scientific breakthroughs and ignite new cycles of innovation (Walker & Zhu, 2013). Nonetheless, SSHA also provide valuable insights, by clarifying the relationships of individuals in light of such phenomena, as well as how science and innovation work in general – leading to grand theories, and at times new schools of thought (Mills, 1959). It also follows that its provision is less costly than STEM. Hence, this study proposes that the financial need caused by the unequal distribution of funds may be one of the contributing factors leading faculties to cooperate across disciplines in recent years, and to a certain extent, it may also be fostering a relationship of resource dependence between STEM and SSHA.

The next sections will introduce the theoretical framework and methodology applied, followed by a brief review of literature, and a short historical overview of public funding among distinct subject areas in the U.S. and China. Later, the paper presents the policy development of research funding from 2001 to 2015 (10th to 12th Five-Year Plan) in China. This is followed by analysis (with resource dependency theory (RDT) as a framework), limitations and conclusion.

Theoretical framework

It has been almost four decades since Pfeffer and Salancik wrote their seminal work on RDT (Pfeffer & Salancik, The external control of organizations, 1978). The theory departs from the premise that "internal behaviours of organizational members are understood through the actions of external agents" (Pfeffer & Salancik, The external control of organizations, 1978, p. 2). Key to organisations are their capacity for strategic decision-making and their adaptiveness in order to ensure sufficient resources (Pfeffer & Salancik, The external control of organizations, 1978). Primarily, the theory outlines three main concepts: "social context matters; organizations have strategies to enhance their autonomy and pursue interests; and power […] is important for understanding internal and external actions of organizations" (Davis & Cobb, 2010, p. 5). Hence, the focus is on power and (inter)dependence. The theory identifies a catalogue of organisational tactics, as response to the environmental interdependence. "Interdependence exists whenever one actor does not entirely control all of the conditions necessary for the achievement of an action or for obtaining the outcomes desired from the action" (Pfeffer & Salancik, The external control of organizations, 1978, p. 40). While analysing the proposed tactics in a continuum from least to most constraining, it considers size as cardinal, since bigger organisations hold more influence; joining associations and business groups; building alliances or joint ventures; and co-opting, which means exchanging autonomy for support (Davis & Cobb, 2010).

More importantly, RDT was primarily created to offer an alternative perspective to the one proposed by economic theories of "mergers and board interlocks, and to understand precisely the type of inter-organizational relations that have played such a large role in recent 'market failures''' (Pfeffer & Salancik, The External Control of Organizations: A Resource Dependence Perspective, 2003, S. 25). In the case of HE, the premise differs though. The current circumstances do not necessarily represent a market failure, but rather a transition where the steady growth of HE provision combined with technological advances and new societal challenges have brought about new demands that the public sector is more often than not, incapable of fulfilling on its own. The promotion of institutional autonomy for HEIs midst cuts in public funds are the two main traits that define this transition. However, funding for HEIs in some parts of the world (i.e.: Europe, China) still to a large extent dependent on the government. China more specifically has a quite distinct government model of developmental state. In this context, HEIs are encouraged to engage with the private sector in order to foster innovation and receive more notorious roles in national plans (leading the path from 'knowledge consumers to producers' - as it will be seen in China's Five-Year Plans). In its rationale, RDT considers organisations as flexible and in constant interaction with the environment. However, "[t]he contest of control within the organization intervenes to affect the enactment of organizational environments. Since coping with critical contingencies is an important determinant of influence, sub-units will seek to enact environments to favour their position" (Pfeffer & Salancik, The external control of organizations, 1978, p. 261). In this study, the focus is on inter-organizational relations between STEM and SSHA, where both discipline blocks will be operationalised as sub-units within HEIs - under the light posed by Pfeffer and Salancik (ibid.). A more thorough translation of RDT from the organisational level to the sub-unit level under investigation (i.e. STEM and SSHA) is prohibitive at this occasion due to scope and time. Thus, suffice to explain that RDT will frame the focus in the collection of data and analysis.

Methodology

By employing qualitative modes of enquiry this descriptive study will investigate the questions posed in the introduction. Through documentary analysis of primary and secondary resources (government documents, academic articles, and reports), it will introduce a historical overview of the past decades as well as the state of affairs of research funding in the context of STEM and SSHA in China (with specific comparisons to the U.S.). The theoretical framework will assist in the analysis by providing a new interpretation to the hybridization of subjects, commonly called interdisciplinarity – here, interdependence. It uses the main concepts of RDT (i.e. context, strategy and interdependence) to guide the data collection and to analyse information (i.e. capacity for strategic decision making, adaptiveness and the level of constrain on the tactics adopted). While this paper will focus on government funding, it will not cover the full economic spectrum of research funding, such as the private sector and others. The analysis must be evaluated as a partial assessment of public research funding to certain subject areas in China, while using the U.S. as a reference case. The choice to include the U.S. is due to the fact that the country is China's top scientific partner, in addition to having the highest research and development (R&D) investment per GDP in the world (OECD, 2014). Therefore, exploring the case of the U.S. may help to contextualize the situation in China.

Literature review

The shift of public research funding to STEM in the last decades is often embedded in the context of interdisciplinarity. Proponents of such shift claim that not only are STEM subjects essential to ignite innovation, there is also a need for further collaboration between the distinct disciplines to enhance the creative process. The first seminal work that proposes this new interpretation of knowledge production (from Mode 1 to Mode 2) was written by Gibbons et al. in 1994 (Gibbons, et al., 1994). There the authors point out that earlier science was characterized by its relative isolation from wider society, which then saw an increase in knowledge production in cooperation with various societal stakeholders, such as industry and government. Based on that observation the authors argue that knowledge production is entering a new phase, "from disciplinary, university-based or large government laboratory-based, investigator-driven type of science, to one which is multidisciplinary, based on networks of distributed knowledge, and oriented towards problem solving and societal challenges" (as cited in Bonaccorsi, 2008, p. 286).

Scholars have also explored other factors influencing the relationship between disciplines, such as funding and the role of funding agencies in the cognitive development of science. As Braun (1998) argues, "[s]cience policy is mostly effected by the funding of research projects or research institutes" (p. 807). His research points out that the provision of financial resources also affects the actions and thoughts of scientists. According to the author the scientific system provides a setting where seeking power in the research process is the main drive for scientists. In this environment, a researcher can earn social, economic and cultural capital. Social capital, being the respect and recognition from fellow scientists, is a result of a scientist's performance in his/her field; cultural capital being his/her faculties and individual cognitive capacity/resources acquired throughout his/her educational/ research journey; and lastly, economic capital being the financial means and resources that researchers need to perform their research of interest. Notably:

> the quantity and quality of economic capital available may very well decide who is privileged within a discipline or which kind of discipline has a higher standing in the social world of science. It contributes, therefore, to the intra - as well as - interdisciplinary distribution of power (Braun, 1998, p. 809).

The sum of the three capitals, is what Braun (1998) calls "scientific capital" (p. 809), and scientists and disciplines well equipped with such, have a comparative advantage against others (ibid.). Furthermore, the author proposes three types of funding agencies: 1) science-based funding agency (supports all disciplines of sciences, an example is the NSF); 2) strategic-funding agencies (promotes research in a particular area in public service, such as health, an example would be the Research Councils in the UK); and 3) political-funding agencies (project agencies attending the needs of Ministries, examples of such are common in Germany and China – with the various project agencies under the Ministry of Education and Research) (Braun, 1998).

In the interim, Gulbrandsen (2005) focuses instead on the environment where fund is dispersed and identify some existing tensions in the research council and research community relationship. These tensions: basic vs. applied; steering vs. aggregation; disciplinary vs. cross-disciplinary; researchers vs. users/stakeholders; review and monitoring dilemmas - are described as strategic choices of the research council (also referred as the principal) (Gulbrandsen, 2005). Whilst referring to a survey conducted by the Norwegian Research Council (NRC), the author points out to evidence that social scientists and researchers from the humanities give the highest priority to cross-disciplinary work. He then adds that further tensions may arise from collaborations with the 'hard' sciences since social scientists often report funding from several NRC divisions. This raises an interesting question that aligns with RDT, how does dependence on external resources shape the capacity of one to make autonomous decisions? In which case, one of the interpretations could be that SSHA scientists and researchers prioritize cross-disciplinary work with hard science researchers as a way to have access to more funds and projects.

Another incentive that significantly influences the capacity for strategic decision making of HEIs, is the race for prestige often acquired through ranking position. Turner (2017) points out that although the most well-known rankings apply unique methodologies for selection, more often than not they present similar results. He further alludes to the fact that specialization in STEM subjects is a contributor to performance, while liberal arts less so (Turner, 2017). The author imparts that the use of STEM research as a standard for performance evaluation across disciplines has become the norm. In particular, he scrutinizes the institutionalization of such standards and the lack of attention given to the connection between the rise of international rankings and national policies aiming to concentrate research funding in a few institutions, within certain subject areas (specially STEM subjects), largely in detriment of the needs and particularities of SSHA subjects (ibid.). Meanwhile, Bonacorsi tries to identify common areas of analysis among distinct disciplines, which are closer to analytical frameworks of social sciences and economics such as rate of growth, degree of diversity, and type of complementarity. He concludes that new sciences (information science, materials science, life science) are growing faster, more diverse and making use of new forms of complementarity (Bonaccorsi, 2008).

In a non-exhaustive review of its more recent applications in first tear journals of HE between 2011-2016, RDT has been sparsely applied. In addition to theoretical studies, RDT has been applied at regional, national and institutional levels. Examples at regional level: to examine how universities in Kenya and South Africa have used diversification of revenue sources to mitigate dependence difficulties (Ouma, 2011). At national level: to explain the influence of evaluation results on resource allocation among institutions (Liu S. , 2015); as a tool to analyse and predict institutional responses in quasi-market contexts related to fair access and fee setting (Bowl & Hughes, 2016); to analyse the failure of performance-based funding policy in the U.S. (Nisar, 2015); to describe how new funding may misalign the steering capacity of faculty and administrators from the direction posed by the institutional mission (Fowles, 2014). At the institutional level: to explain why some campuses focus on the state and community engagement to survive and why self-sufficient HEIs are not tended to bolster state appropriations (Weerts, 2014); to assess interactions between pro-vice chancellors in a network of universities as the means to achieve financial stability (Pilbeam, 2012); to evaluate how HEIs respond to change in funding and steering attempts in different disciplines in the Italian context (Reale & Seeber, 2011).

Overall, all scholars seem to address similar concerns: the drivers, challenges, limitations, and opportunities within the changing nature of research production. They have the common understanding that STEM and SSHA differ in nature, in their relationship with society and are treated differently. In order to contextualize such understandings, the paper will present a brief overview of the research funding models in China and the U.S. as they pertain to STEM/SSHA.

A discipline-based overview of public research funding in China and the U.S.

Early references to research policies

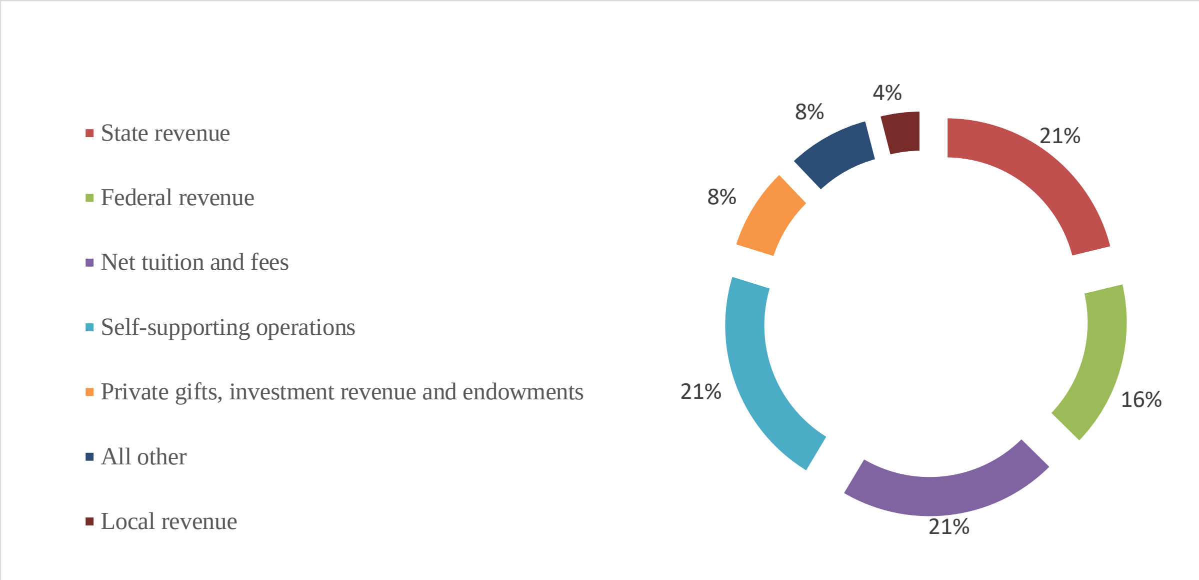
At the time of the People's Republic of China's (PRC) foundation (mid-20th century), the country had approximately 50,000 science and technology researchers and less than 500 natural science researchers (Liu, Duan, Xiao, & and Tang, 2011). STEM subject areas were not well positioned and the scientific research sector was rather weak. The PRC, having close ties with Union of Soviet Socialist Republic (USSR), followed Soviet models for strategizing, organizing, managing, and developing the education sector. A new planning structure for Chinese HE was completed in 1957, and included new management systems, disciplines, curriculum, teaching and textbook systems. This approach presented some negative side effects such as narrow specializations and the separation between teaching and scientific research. However, in a short period of time the numbers of researchers grew to more than 9,000. The number of research institutions also increased from 40 in 1949 to more than 380 and a variety of disciplines began emerging (ibid.). As research became more prominent, various foundations and funding agencies were created in China. Similar to the National Science Foundation (NSF) in the U.S., the National Natural Science Foundation of China (NSFC) was established in 1986, ten years after the end of the Cultural Revolution, and has grown consistently over the years (i.e.: from 80 million Yuan in 1986 to 3,400 million Yuan in 2006), and still supports basic and applied research today. Additionally, NSFC promotes a balanced and harmonious development of disciplines as well as interdisciplinary research and the development of new disciplines (ibid.).

In the case of the U.S., research was mainly subsidized by the private sector before world war II. National defence was the anchor that legitimized the growing relationship between the government and science (and the heavy increase in investment on basic and applied research). The report Science: The Endless Frontier (which laid the foundation for post-war research and science) was issued during President's Roosevelt's office and led to several federal research funding agencies, including the NSF in 1950. In the early stages, between 1957 to 1967 the federal government's R&D investment quadrupled, with funding for the NSF rising from U.S. $ 40 million in 1957 to U.S. $ 465 million in 1967 (National Science Foundation, 2014). Although it would be a far stretch to assume that STEM subjects in the U.S. have been more politically and economically aligned than in China due to U.S.' leading role in both world wars (WWs), it is known in politics that the status of urgency gained in contexts of conflict, allows for extraordinary measures (and expenditures) that common politics cannot achieve – and it may have indeed created windows of opportunity for a strong start to science in the U.S. An example of this insight was the query placed in the U.S. Congress in 1963 to the National Academy of Sciences for the level of support required to keep the U.S. in "a position of leadership through basic research in the advancement of science and technology and their economic, cultural, and military applications" (The National Academy of Sciences, 1965, p. 1 as cited in Olsen, 2007). The federal research funding agencies created in the 1950's still comprise the modern science and technology funding and management system in the U.S.

Sources of funding for higher education in the United States

The U.S. remains one of the leading government spenders on public HEIs at $3.5 trillion or 2 per cent of the federal budget in 2013. HE is also the third largest category of expenditures at the state level at $65 billion that same year. Figure 1 presents the share of U.S. federal and state funding budgeted in 2013 for HE, which amounted to 37 per cent of the total received by public colleges and universities.

Figure 1. Composition of Public Higher Education Institutional Revenue, fiscal year 2013 (The Pew Charitable Trusts, 2015)

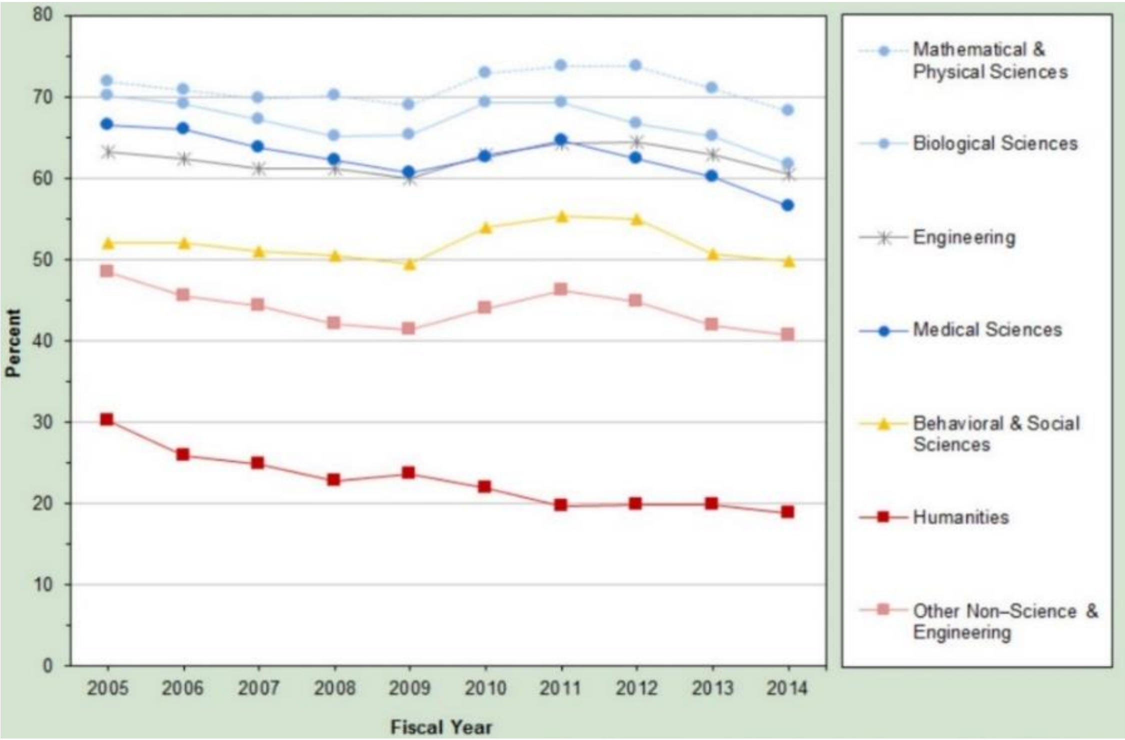


Tuition fees, self-supporting operations, fundraising, local revenue, and other sources covered the other 62-63per cent. Despite only 1/5 of public funding for HE being state funds, and federal allocations representing an even lower fraction, these levels of government financial support are still vital sources of income due to its flexibility to compensate for sharp cuts by the private sector.

a) Investment in STEM and SSHA in the U.S.

Figure 2. shows that funding by the federal level has differed among subject areas between 2005 and 2014, with Humanities consistently receiving the lowest share of funding, followed by other non-science & engineering subjects, behavioural & social sciences. While other STEM subjects have also suffered a decrease of funding, they have maintained a higher share of funding throughout the period.

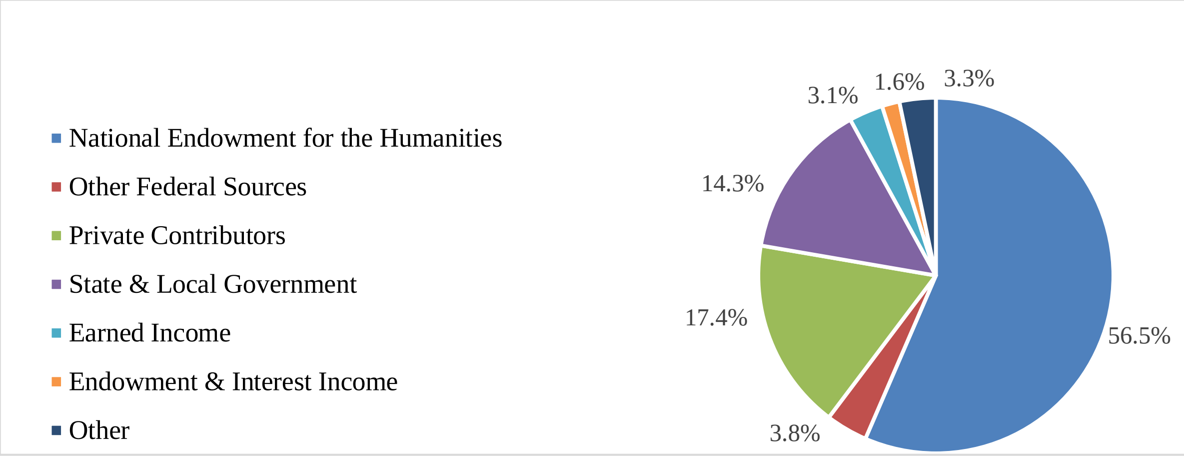
Figure 2. Federally Funded Share of Expenditure for Academic Research and Development in the Humanities and Other Selected Fields, Years 2005 – 2014 (Humanities Indicators, 2014)



In the U.S. investments in STEM have increased as a result of government incentives. For example, at least 13 states in the U.S. that have HE performance-based funding mechanisms clearly indicate incentives for funding STEM disciplines (National Conference of State Legislature, 2015). On the other hand, the NSF as one of the agencies that provide significant funding for basic research, did not include spending on SSHA until 2008 (National Science Foundation, 2014). Still, specialists in the field believe that SSHA play a crucial role along with STEM. For example, in an interview with Thomas Jørgensen at the European Higher Education News, he argued that even though SSHA are seen as auxiliary sciences, the understanding of the relationship between science, technological innovation and society is embedded in concepts only found within SSHA (Jørgensen, 2015). In addition, that the lack of data has made it difficult to run comparative studies (and build a case for SSHA).

Sources of funding for the State Humanities Council (Figure 3) indicate that in 2014 only 14.3 per cent of funding came from state and local government, with national endowment for the humanities and other federal sources accounting for more than 60 per cent of its funds.

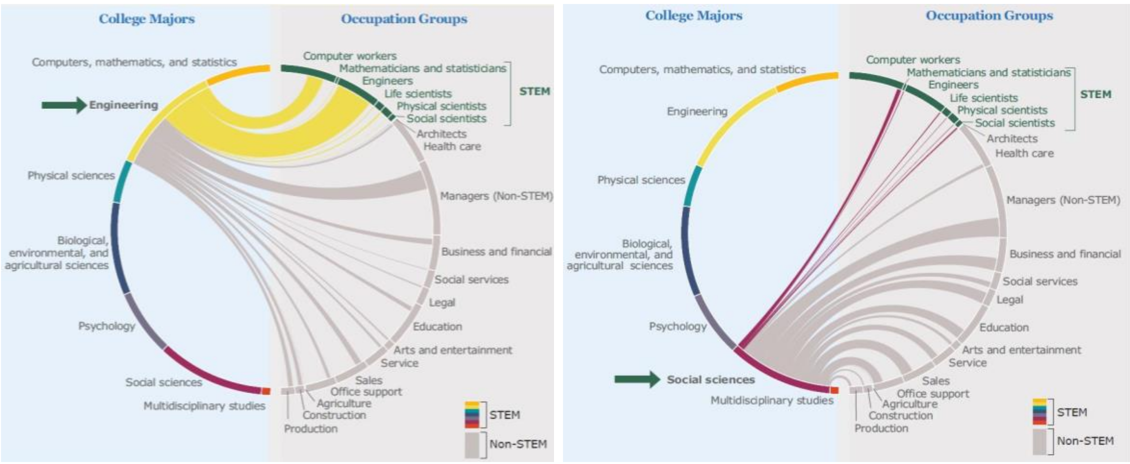
Figure 3. Sources of State Humanities Council Funding, Fiscal Year 2014 (Humanities Indicators, 2014)



b) College Majors and Occupation Groups in the U.S.

In the U.S. the rationale of many policymakers for the importance of STEM subjects, and their priority in public funding, seem to be closely related to employment prospect. The association of college majors and occupations in Figure 4 has been prepared by the National Science Board (NSB) and illustrates pathways from education to the labour market.

Figure 4. The relation between colleges majors and occupation groups in the United States (National Science Board, 2015)

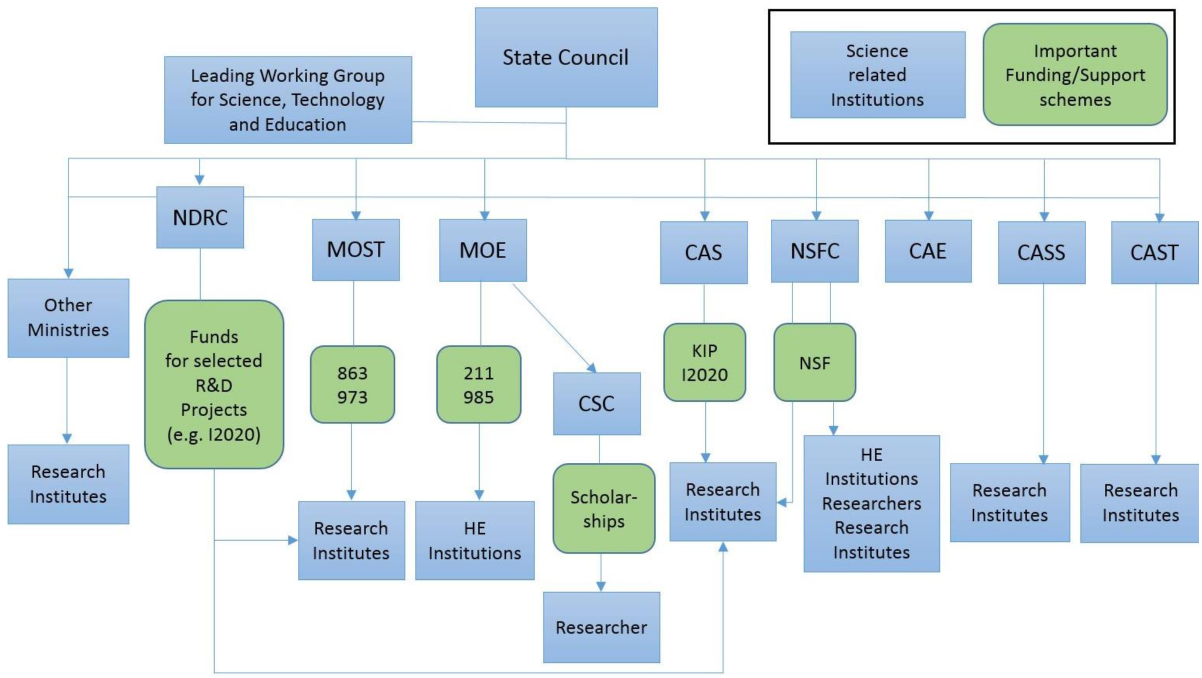


According to the NSB, engineers can secure jobs in both (STEM and non-STEM fields), while graduates from social sciences can secure mostly jobs in the non-STEM fields. However, looking closely, one can see that as SSHA can secure most jobs in non-STEM fields, so do STEM fields to the reverse, that is, STEM graduates can secure most jobs in STEM fields. More importantly, considering such similarity in range of employment between STEM and SSHA graduates, and the fact that it is cheaper to train SSHA graduates, should there not be further research to really evaluate the claim presented by NSB (that more investment in STEM meets the needs of the economy)?

Sources of funding for higher education in China

In China, the State Council is the agency responsible for education, science and innovation in China. The Ministry of Education (MoE) is responsible for all aspects and levels of education. The financial jurisdiction of each HEI falls under the designated level of government: central government (including special government departments), province, municipality and autonomous regions (PRC, 2014). In terms of size, in 2014 China had 2542 HEIs consisting of 2246 regular colleges and universities (of which 444 private) and 296 colleges and universities for adults (1 private). As indicated in Organogram 1, China's education and scientific research funding system is coordinated mostly through research funding agencies. Agencies can be divided into governmental and non-governmental channels, natural science and social science have separate agencies but they may overlap in some cases. The major funding agencies in China are MoST, NSFC, and the CSC affiliated to the MoE (Hong, et al., 2011). Funding/supporting schemes such as "Project 211" (1995) aims to raise the education and research standards of 100 key universities and project 985 (1988) has selected a number of HEIs to become world-class institutions (PRC, 2014).

Organogram 1. Govt. and Govt. Affiliated Institutions in the fields of Education and Research (DAAD, 2015)



NDRC: National Development Reform Commission

MoST: Ministry of Science and Technology

CAS: Chinese Academy of Science

CSC: China Scholarship Council

NSFC: National Natural Science Foundation

CASS: Chinese Academy of Social Sciences

CAST: China Assoc. for Science and Technology

KIP: Knowledge Innovation Progaramme

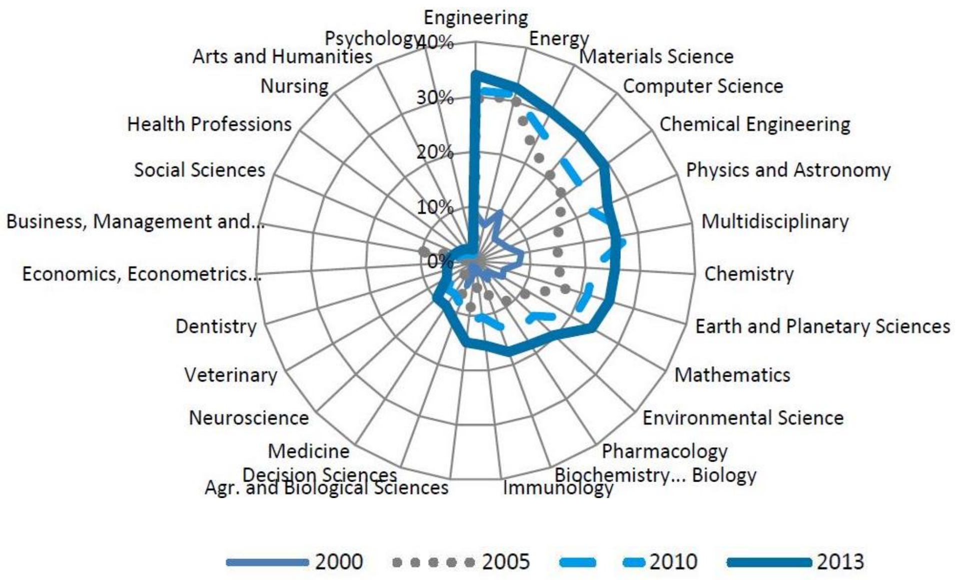
I2020: Innovation 2020

NSF: National Science Fund

a) China's performance in STEM and SSHA subject areas

A report on Science, Technology and Innovation Performance of China prepared in 2014 indicated that while assessing general trends in twelve fields and identifying the strength of research output in China, the results differed from the global results, with Engineering, Physics and Astronomy, Material science, and Chemistry as the best performers. Meanwhile, research in SSHA has not progressed to the same extent as per the Figure 5 (AIT, UNU-Merit, SPI, 2014).

Figure 5. Subject fields of Chinese publications as percentage of worldwide total (AIT, UNU-Merit, SPI, 2014)



b) History of research: the tradition of STEM as main subject areas in China

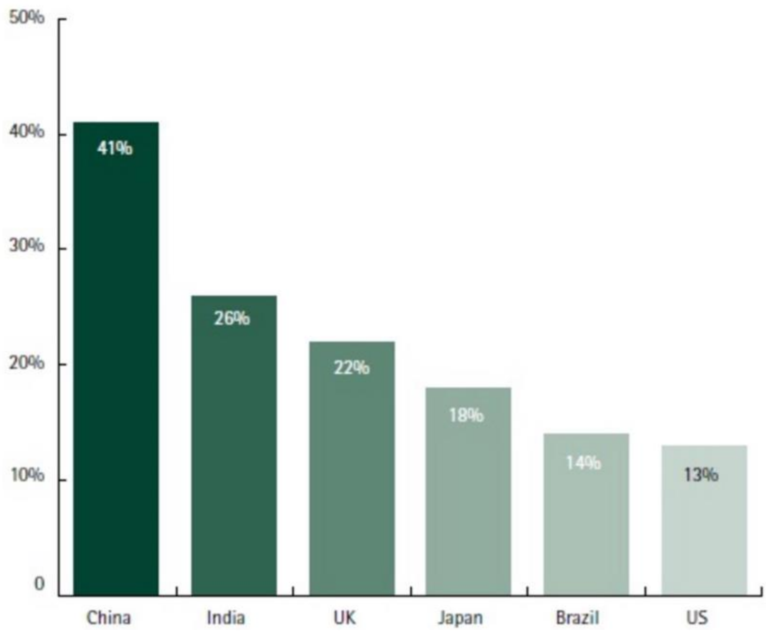
China's strong performance in STEM is not new. According to the Chinese Academy of Sciences, China's investment in R&D stood at 861 billion yuan ($137.9 billion) in 2011, making it the 2nd highest such investment in the world. As a result of such investment, China's Science Citation Index rose to the 7th place in the world that year, and the number of Patent Cooperation Treaty applications ranked 4th globally (China Daily, 2012). However, not much has changed. Table 1 presents China's main scientific foci and collaboration countries between 1997 and 2012. The country has historically focused on STEM subjects (engineering, physics and materials sciences). In 2008 computer science replaced material sciences in the top three disciplines.

Table 1. Main research disciplinary specialisation and collaboration partners, 1997-2012 (UNESCO, 2014)

Country or territory	Compound annual growth rate of publications (%)	Main scientific foci			Main international collaboration countries		
		1997-2001	2002-2007	2008-2012	1997-2001	2002-2007	2008-2012
CHINA	17.8	Engineering	Engineering	Engineering	United States	United States	United States
		Physics and Astronomy	Physics and Astronomy	Computer Science	Japan	China, Hong Kong	Japan
		Materials Sciences	Materials Sciences	Physics and Astronomy	China, Hong Kong	Japan	China, Hong Kong

In terms of partnerships, as previously mentioned, the U.S. is China's top scientific partner, followed by Hong Kong and Japan. With regards to publication output, China's performance has doubled since 1997 with a 17.8per cent compound annual growth rate of publications (UNESCO, 2014). Even though China's interest in STEM is not novel, the decision to increase research fund on STEM subjects in China was also the result of a shift in the economy. Following the crisis in 2008, Chinese leaders put forward (as will be noted in the 5-year plan session that follows) the restructuring of the economy from export to domestically oriented, requiring substantial diversification and innovation. Figure 6. shows that the results from such change in investment were prompt, with 41 per cent of all degrees issued in 2011 in China from a STEM subject.

Figure 6. STEM degrees as a percentage of all degrees in 2011 (Katsomitros, 2013)



Nonetheless, a study ran by the UK's Royal Society science academy pointed out that China must catch up with more developed countries in terms of job-creating quality research (Katsomitros, 2013). Next, the Five-Year Plans between 2000-15 in China.

Research & Development Policy Orientation in China: 10th, 11th and 12th Five-Year Plans

China follows a five-year plan, which "aims to arrange national key construction projects, manage the distribution of productive forces and individual sector's contributions to the national economy, map the direction of future development, and set targets" (China Organization, 2016, pp. 1).

10th Five-Year Plan (2001-2005)

The 10th Five-Year Plan increased R&D by 1.5per cent of GDP, improving the scientific and technological base, and innovation and technological development (China Organization, 2000). In addition, the Plan:

- Set up venture capital to encourage companies to increase investment in R&D. Encouraged cooperation among universities, research institutions and enterprises to enhance the capability to innovate and develop new products;
- Improved the structure of products, organization and the internal market to open up the international market, increased exports and gradually increased the proportion of home-grown brands and products with locally developed technology in exports;
- Formulated technical standards for different technologies, strived to participate in the development of international technology standards (United Nations Public Administration, 2001, p. 22)

11th Five-Year Plan (2006-2010)

The 11th Five-Year plan focused mainly on two strategies, the scientific concept of development and the building of a harmonious socialist society. The plan also:

- […] transform[ed] economic growth from being driven by investment and export to being driven by consumption, investment, domestic and foreign demand combined in a balanced manner;
- […] transformed economic growth from being driven by industry and quantitative expansion to being driven by the balanced development of the primary, secondary and tertiary industries and by structural optimization and upgrading;
- […] shift[ed] economic growth from relying on the input of capital and substance factor to relying on science and technology advancement and human resources by rejuvenating the country through science, education, technology

advancement and innovation as major driving forces of economic and social development;

- […] shift[ed] economic growth from relying on administrative intervention largely in some areas to giving more play to the fundamental role of the market in allocating resources under guidance of macro regulation and control (PRC, 2006, pp. 12-15).

12th Five-Year Plan (2011-2015)

The 12th Five-Year plan focused mainly on three policies, "first - a focus on scientific development, second - government support for seven strategic emerging industries, and third - construction of transportation and energy infrastructure" (U.S., 2011). The plan also:

- […] promote[d] scientific development to upgrade China's manufacturing sector;
- […] boost local R&D, and;
- […] increase[d] the global competitiveness of Chinese firms (U.S., 2011, p. 5).

Key indicators include raising R&D spending from 1.75 percent to 2.2 percent of GDP (by contrast, the U.S. spent 2.7 percent of GDP on R&D in 2007, ranking eighth globally); increasing the number of patents per 10,000 people (3.3 patents per 10,000 people in 2015 nearly doubled the number approved in 2010); and boosting educational attainment, all under the rubric of "scientific education" (U.S., 2011).

Analysis

When assessing such changes through the lens of RDT, the findings indicated that the contexts where these changes took place in China and the U.S. had very distinct history and rationale. In its origins, China's public research funding drew from its historic relationship with URSS, whilst the U.S. from its international leadership role in the WWs, closely aligning science and innovation to defence. As of 2013, government participation in research funding in the U.S. was relatively low at 37 per cent of the total received by HEIs. Concomitantly, China's increase in research funding became substantial especially since 2008.

In the U.S., science policy strategy has privileged STEM subjects over the years. Some of the contributing factors include: performance-based funding at state level (incentives favouring STEM); omission of SSHA from NSF's reports until 2008 (making comparison and monitoring difficult); and finally, a higher private financial involvement in STEM rather than SSHA (with almost 75 per cent of the total sources of funding for SSHA coming from public funds, at state or national levels – hence, decreasing SSHA's leverage within HEIs). In terms of employment, previous studies have argued that STEM is more beneficial as a public investment for society. However, while looking at Table 4 more carefully, one can see that the distribution of employment access for both (STEM and non-STEM) indicates similar results, with SSHA's cost for training being lower than STEM. Such findings bring to question the established dependence paths between the two subject groups in the U.S., with preference for STEM in detriment of SSHA.

Meanwhile, in China, the core of the research policy strategy includes focused funding/supporting schemes with the aim to raise standards and facilitate the advancement of selected national institutions to world-class HEIs. Overall, research performance in STEM has been higher than in SSHA, according to a report prepared in 2014 by AIT, UNU-Merit. Such results were a response to the policy shift that followed the 2008 crisis, where leaders chose to focus on domestic consumption rather than export, with STEM serving as the basis for the required substantial diversification and innovation. As a result, in 2011 41 per cent of the degrees awarded in China were in one of the STEM subjects, a percentage ahead of India, the UK, Japan, Brazil and the U.S. In the same year China became the second largest investor in STEM subjects in the world, raising China's performance in the Science Citation Index to the 7th place, and 4th in the Patent Cooperation Treaty. In terms of employment, according to a study prepared for the UK's Royal Society, the increase in graduates in the STEM field in China has not necessarily translated into more jobs in quality research fields. This may represent a window of opportunity for further collaboration and interdisciplinarity with SSHA.

Assessments of China's Five-Year Plan from 2001 to 2015 suggest that: funds allocated to R&D increased consistently during this period; from 2001 to 2005 China mainly increased the funds to STEM, laying the foundation for accelerated progress; from 2006 to 2010 the government shifted the focus to the domestic market; and finally, from 2011 to 2015, China further invested on scientific development, while supporting strategic industries and infrastructure development. China’s capacity for strategic decision making has become more complex over the years, as China customize western notions of economic progress. Public policies for research funding have been embedded in many of supporting schemes, which confirms China’s capacity for strategic decision making. China has selected certain aspects that can ensure performance while keeping relevant local characteristics of its developmental state, confirming its high level of adaptiveness. Lastly, the tactics adopted by China to achieve such results indicate that the government has historically favoured STEM over SSHA. While being cognisant of Turner’s (2017) research on prestige and Gulbrandsen’s (2005) previous findings on humanities’ tendency to give priority to cross-disciplinary work, this paper concludes that, from a discipline-based perspective, SSHA - as HE subunits - are left in a position where trading autonomy for support may become the modus operandi of interdisciplinarity/interdependence between STEM and SSHA. The risk here lies in prioritizing solemnly economics for funding allocation, and subsidizing or encouraging certain types of knowledge over others, through direct funding or incentive systems. By doing so, China may be risking to create resource dependency between distinct areas of knowledge production, rather than the development of genuine interdisciplinarity. More importantly, as new fields of study emerge, such disciplinary stratification may risk China’s capacity to innovate, creating dependency paths in the local knowledge culture and innovation systems.

Limitation

Since updated information related to subject areas in China are mostly in Mandarin, much of the information provided in the paper makes reference to secondary sources. Information related to research funding for SSHA and STEM in both countries are scattered in individual websites, without a simple overall point of information to guide the collection of data. Updated information and definitions of variables was not consistent, making comparison between the U.S. and China difficult.

Conclusion

This study proposed to identify and elaborate the context, strategy and interdependence (as proposed in RDT) between STEM and SSHA in China from 2000 to 2015, using the

U.S. as a reference, to understand how research funding has changed due to the worldwide trend of increased investment in STEM. Both contexts allowed for policy coherence and funding opportunities. RDT was adopted to frame data collection and guide the analysis. Through a very brief historical review of research policy from the mid-20th century onwards in China and the U.S., notions of power and interdependence emerged. Findings suggest that as China engages in new ways to develop economically, it prioritizes certain institutions and industry areas - with HEIs as important actors in this process (enablers of knowledge production, rather than knowledge consumption). Overall, an increasing focus on STEM subjects as a response to changes in the international economic environment in 2008 took place through growing funding for HE, and inward focus on specific industries and fields of study (affecting the perception of what is commonly known as interdisciplinarity, to interdependence between the distinct subjects). A more centralized approach to research funding in China, with a stronger focus on STEM, may duplicate the existing STEM-SSHA dependency paths already found in the U.S. The long-term consequences of such policies are yet to be analysed.

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