Education and Computing Science in China: an institutional perspective

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This paper provides a general perspective of the institutional arrangements that have influenced the quality of education in higher education (HE) institutions in China. It provides a general perspective of how the participation between the Party and the State sets the conditions for the provision of the public good: education. Afterwards, it is synthesized how these general conditions affect higher education in computing science. The limitations of getting specific data about the relationship between the institutional arrangements and the education in computing science were the main reason to analyze the quality of this public good under the lens of technological innovation. This was done under the assumption that a high-quality education in computing science enables innovation.

Education in China is a state-run affair with minimal involvement of private actors within the education system. The Education Law of the People's Republic of China enacted in 1995 during the eighth National People's Congress provided the main attributes of this public good. In Articles 3 and 6, the main purpose of education in China was identified as developing a socialist education in “Marxist-Lenism, Mao Zedong Thought” through the state solely [1]. Article 14 further consolidated the hierarchy of control, saying that higher education “shall be managed by the State Council and the People's government of province, autonomous region or municipality directly under the central government”. This public good involves the national and the provincial authority in the management of the education system.

1. What is this public good: computing science in China

The case of higher education in China, particularly in computing science, defies the paradigm of university autonomy and quality education commonly granted to the Western hemisphere universities. China can afford to have universities of high quality of education without conceding a high level of autonomy to its universities. Alternatively, the case of Tsinghua University shows that the university can influence the state’s power to gain more autonomy and improve the quality of research through academic exchange with foreign universities [5]. Therefore, this public good is a service provided by the state and heavily influenced by the state, but, at the same time, a somewhat-autonomous body that is influenced partially by the demand from the global scientific community. This public good has a standard curriculum that competes with other top universities in the world (see Table No.1 below). This curriculum is coherent with the technological research priorities of the industry and the international demand for a specific field of knowledge. For example, an admitted student in Tsinghua University is expected to develop enough knowledge to continue their academic life in research or working in the following key areas, which can also be found in top, competing schools in the U.S. and worldwide:

1. *Computers systems*: this area is related to artificial intelligence. It offers the possibility to develop better computers to solve real world problems through algorithms and novel hardware development (processors, RAMs, among other).
2. *Computer networks*: for example, this is linked to research in blockchain. This is research concentrated in connecting in an optimal way millions of people, companies through a better internet (faster and safer transactions).
3. *Information processing*: this helps to understand information that comes from nature. For example, analyzing the black holes in the universe through the magnetic waves captured in the earth. This type of non-traditional data requires it to be captured and analyzed in a distinctive manner than the typical data of a data science work.

2. Who is receiving this public good

University education in China is a public good in the sense that it is non-excludable and quasi-non-rivalrous for the fact that the majority of the computer science programs in China -- even those that rank within the top 15 in the world -- are public. However, accessing computing science as a public good in China is a process of exclusion.

The main requirement to be admitted in a HE institution is the National College Entrance Examination commonly known as “GaoKao”. Scoring high in this examination gives access with a certain grade of confidence to top universities like Peking or Tsinghua University. Almost 9.5 million students present a three day exam every year. An exam that represents access to the Chinese society development opportunities [8].

The requirements for international students are less demanding considering that they are not obliged to present the “GaoKao” test. It is estimated that 28% of the international students who apply are admitted [7]. The acceptance rate for a university like Tsinghua University is 2%. This means that only "...200 out of the 300 students who ranked within the top 10 from 30 provinces end up choosing Tsinghua University as their preferred university" [7].

3. A Successful Transformation

Since 2003, Chinese universities have improved their international standings in the most popular academic rankings due to a targeted state intervention. Computing science studies reflect the extent to which several Chinese universities are competitive *vis a vis* with traditional top universities.

The Table No. 1 summarizes the Chinese universities appearing in the top of the QS, Times Higher, and Shanghai rankings. The case of Tsinghua University shows an outstanding academic level by being ranked in the top 20 for computing science in all three rankings.

Table No.1

QS	Times Higher	Academic Ranking of World Universities (ARWU)/Shanghai
(13th) Tsinghua University	(15th) Tsinghua University	(7th) Tsinghua University
(19th) Peking University	(17th) The Hong Kong University of Science and Technology	(19th) Shanghai Jiao Tong University
(34th) Shanghai Jiao Tong University	(27th) Peking University	(20th) Zhejiang University

Sources: Own elaboration from data retrieved from QS World University Rankings, Times Higher, Academic Ranking of World Universities

The ARWU ranking grants more importance to the scientific production created by the universities than their reputation among employers. Using the data from ARWU, these universities have improved their international standing from 2003 to 2020 in the following order:

- Tsinghua University: 90% of improvement--from being ranked as No. 300 (2003) to No. 29 (2020).
- Shanghai Jiao Tong University: 84% of improvement--from being ranked as No. 500 (2003) to No. 63 (2020).
- Peking University: 84% of improvement--from being ranked as No. 300 (2003) to No. 49 (2020).
- The Hong Kong University of Science and Technology: 62% of improvement--from being ranked as No. 400 (2003) to No. 150 (2020).

The State intervention during the period 1985 and 2003 was successful and had an important impact on the quality of the public education system by making China more competitive internationally.

3.1. Who was responsible for this success?

The People's Republic of China runs a decentralized education system. This decentralization was done through the "Decision on the Reform of the Educational Structure" in 1985 [4]. This reform was done by the Central Committee of the Communist Party. The decentralization granted a certain level of autonomy to the county-level, provincial, and national level in order to manage the most populous education system in the world with efficiency[1]. Each level has a specific responsibility. The county level is responsible for the primary education, while the provincial level manages higher education institutions. At the national level, the Ministry of Education (MOE) has been involved with: "macro-level monitoring of the education system. It steers education reform via laws, plans, budget allocation, information services, policy guidance and administrative means" [3]. The provincial level has the highest level of authority in relation to education affairs.

3.2. Reform and Organs of the higher education system

After the decentralization in 1985, the projects 985 and 211 were particularly remarkable to improve the Higher Education system (HE). These efforts were a consequence of a priority defined by President Jiang Zemin in 1998 of having a number of first-rate universities to compete internationally in particular in STEM fields [2].

Based on this presidential request, project 985 and 211 were launched as a way to prioritize a pool of flagship universities that will open a space for China in the international scientific community. The Image No.1 shows Universities "985" and "211"as the national priority for the central government and the MOE. This means that 111 universities (5% of the total) receive 60% of the research funding, while the remaining (ordinary universities) receive less than 40%.

3.2. (A) The Ministry of Education (MOE)

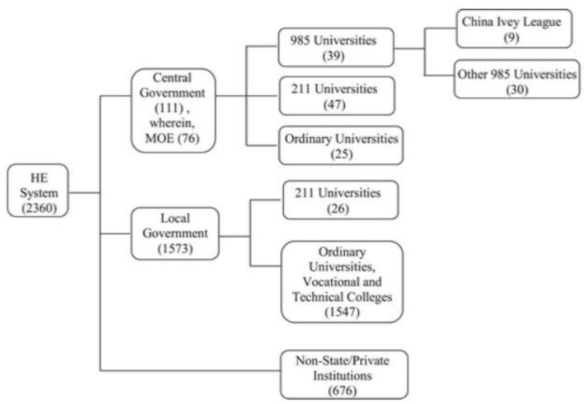
The Ministry of Education is under the authority of the CPC Central Committee. The Ministry of Education plays a central role in defining the strategy to be implemented at the provincial level or in each university. Amidst the provincial level organs obtained financial and administrative autonomy during the 1985 reform, projects 985 and 211 granted more control to State over the participant

[1] Based on the OECD data, China has: 260 million students, 15 million teachers in about 514,000 schools. No country has such dimensions in the world.

universities that were receiving funds from the central level of the government. Both projects were formulated by the CPC central committee and the State Council.

The Ministry of Education designs the national educational guidelines, but it is required the approval of the National People's Congress. Once a determined policy has obtained Congress' approval it is effectively implemented in the provincial and the county level.

Image No.1



Source: [6]

3.2. (B) The Universities

According to [9, pg.61], there are two main offices inside the Chinese universities: The Office of the Party Committee and The Office of the President. The Party Secretary and the President have the same administrative level; however, the Party Secretary has a greater power of decision than the latter. Aside from having more authority, the Party Secretary is the political power representative [9]. The HE institution depends on its ability to obtain funding and representation in higher political instances. This representation is relevant because it is the way by which the University obtains access to projects of collaboration that represent funding. On the other hand, the President represents the academic administration of the HE institution. His main responsibility is to ensure the quality of education through the administration of the teachers and research projects.

According to Gu J., Li X., and Wang L., the Higher Education Law adopted in 1998, the greater instance of decision making is the University CPC Primary Committee where the two main roles the President and Party Secretary take decisions in coordination in the following aspects:

- “To draw up development plans, formulate specific rules and regulations and annual work plans, and arrange for their implementation...
- To arrange for teaching, research, and ideological and moral education.
- To draw up plans for internal structure, nominate candidates for vice-presidents, and appoint or remove directors of the departments of the institution.” [9]

Traditionally, the Party Secretary in these top universities (“985 universities” or “211 universities”) is somebody with extensive academic background in engineering or basic science research in the university where they are being appointed as Party Secretary. Table No.2 shows a sample of who were the party secretaries from these top universities and their last succession in 2020 by party members involved with security and ideology indoctrination with lower academic background than their predecessors [10]. This factor might reduce the strategic capacity of these universities considering that the Secretary Party coordinates the academic production of HE institution with the objectives set in broader plans like the 14th 5-year plan.

Table No.2

University	Party Secretary	Profile	Succeeded by
Tsinghua	‘ Dr. Chen Xu	“Dr. Chen Xu is a professor of electronic engineering Doctorate (Ph.D) from Tsinghua Professor in the Department of Electronic Engineering” [13]	Not identified
Pekin	Hao Ping	“He gained his undergraduate degree in history at Peking University in 1982 and went on to complete a Masters in history at the University of Hawaii (1995) and later a PhD in international relations at Peking University in 1999.” [14]	“Qiu Shuiping (2020) Former party secretary of the Beijing bureau of the Ministry of State Security. This appointment shows the importance of The Peking University in China's political life.” [11]
Jiao Tong	Ma Dexiu	“Ph.D graduated from the Department of Automatic Control. She joined the National Development and Reform Commission, where she left in 2003 as Director-General of its Hi-Tech Industry Division”. [15]	“Yang Zhenbin (2020) Former Deputy Secretary of the Party Committee of Tsinghua University and Director of the Department of Ideological and Political Work of the Ministry of Education” [12]
Hong Kong	N/A	N/A	N/A

3.2. (C) China's education system and the National Science and Technology Leading Group

Traditionally, the main connection between the CPC and the MOE is defined through the role of China's Premier Li Keqiang. The direct interaction between the national priorities in terms of innovation and scientific development originated in 2018 as a new institutional arrangement to integrate the development objectives and the scientific production. The National Science and Technology Leading Group created by The General Office of the State Council of China brings together the MOE and The Ministry of Science and Technology, The Ministry of Industry and Technology, The Chinese Academy of Sciences, Engineering, and finally the National Natural Science Foundation. This implies a more direct horizontal coordination between the universities directed by the MOE, the planning economic institutions like the National Development and Reform Commission, and the Ministries coordinating the industrial sector in China.

According to [9, p. 35] The model of higher education in China has fluctuated between a centralized leadership model to a decentralized local administration. With the creation of The National Science and Technology Leading Group, the Party centralized the decision making by enabling China's Premier to have a direct surveillance of the whole system of innovation and industrial production. In particular for "985 universities" and "211 universities", this new framework implies a reduction of their level of autonomy.

3.2. (D) Studies in computing science in the era of Xi

The Xi era has brought a wave of leadership centralization on the education affairs, but also a wave of public investments. In particular, the investment from two decades (1996-2016) grew on average by 20% every year [16]. Today, most of these public investments are aimed to achieve what Xi has delineated to bring innovation to the R&D agenda: pushing the limits of research in basic sciences. It is clear that these billionaire investments have yielded some remarkable results: the fastest supercomputer, launching the first quantum communication satellite, and competing in the highest stakes of the 5G networks.

The main implication for the universities like Jiao Tong or Tsinghua is a direct expansion of their budget research for areas considered as a priority to provide technological independence like computing science. However, the efficiency of these investments has not been proportional to the amount of the invested resources.

One of the main problems is the level of oversight of the funding granted to the different research projects in patent production. Part of this problem of oversight is related to the transition from university research to commercialization of products. Research done by Liu, Serger, Tagscherer and Chang (2017), proves that much of China's technological innovation is not transferring to sustainable economic development on a larger scale, despite policy changes that sought to increase the amount of reward for creating patents that commercialize as such [17]. Evidence that "most of the patents in universities are inactive" and have not been commercialized speaks to the extent of public investment not being supervised. China is producing applicable solutions in the field of computing science and the industry, but there are still weaknesses at connecting the innovation system in order that producers and users can exchange effectively.

Furthermore, punitive policies, such as evaluating researchers by their number of patents instead of by their efficacy in the market, have "hindered the transfer of innovative ideas and technology from research into the market" [17]. This proves that scientific innovation in China, especially in computer science, may appear to be increasing rapidly, but does not necessarily solve the challenges that it was trying to solve originally. The ways by which we measure this surge of technological innovation in China should consider the quality of this innovation, especially when university researchers are pressured by punitive quotas for scientific production.

Additionally, academic research in China has been found to have plagiarism and inexact data. According to Kennedy (2019), "The number of retractions by Chinese scientists has risen dramatically in recent decades, due mainly to plagiarism, fraud, and faked peer review" [18]. Some studies have found that China's rate of retracted published articles is twice that of the United States. Since researchers in China have less ownership over their innovations and their profits, it appears that they are more motivated to publish at rapid rates from the fear of retaliation, rather than by the benefit of reward from more income or licensing [19]. Despite the high level of innovation led by the computing science departments in China and the rapid expansion of government-funded research, the innovation system is incentivized less by economic benefits and more through coercion to “publish or perish” [19].

4. Improving computing science as a public good that creates innovation

Part of bringing up the new generation of computer scientists is the possibility of reducing the amount of wasted talent from the gap of educational opportunities for rural communities. Computing science as a public good serves the Chinese youth as an opportunity to get access to the advantages of a stable labor market with a good salary. In this sense, an admission system based solely in the GaoKao test might be discarding talent by using a unidimensional measure of academic success: the ability to respond to standardized tests. China must move forward from a system that prizes standardization over creativity because this is the only way to propose new technological paradigms. In this sense, China’s innovation goals in computing science depend on being successful at investigating the basis behind disruptive technologies like AI or quantum computing. This basis is the investment in basic sciences. Based on the case of the US, a large investment in basic sciences like mathematics or physics, would offer China a long-term competitive advantage.

However, just increasing public investment is not enough. The current incentives to innovate are not compatible with these long-term goals. It is required to improve by setting a coordination environment between the provincial level and the national level. Researchers in this State-led model of innovation, for example, are more incentivized to produce for not being punished rather than by the opportunities offered in the meritocratic competition. Furthermore, the expansion of the Party influence/control by appointing Party Secretaries in top universities with lack of specific knowledge of the HE institution (as is happening is Xi’s era) and without a holistic academic background sends the wrong message to the academic community about the real goal of being transparent at detecting challenges in the research process: to correct effectively all those factors preventing that the investing public funds become in an improvement to the productivity (patents, commercialization, and innovation). Setting these cooperation systems starts by guaranteeing an environment where the improvement opportunities are open to be discussed, rather than just reinforcing Mao's old system of competing quotas during the Great Leap Forward.

Finally, promoting international cooperation agreements where other strategic countries can trust China as a reliable ally, it represents an opportunity to improve computing science at the provincial level. As it was explained, China was able to compete technologically, but still uses the basic science created by other countries. As for example, the career for artificial intelligence supremacy between the U.S and China depends on the country's ability to attract talent through strategic alliances. The U.S is still the largest hub of talent concentration measured by the number of researchers [16] but also is the largest hub in attracting private investment to AI projects. China requires to be perceived as a global agent of innovation to enrich its institutional capabilities with public research done by other countries.

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