The particular case of China's private sector and the funding of Science, Technology and Innovation - A hybrid counter model and its challenges

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A hybrid counter model and its challenges

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Abstract

After three decades of socialist restructuring, before China could create a contemporary innovation system, it needed first and foremost to rebuild a market-oriented economic system with enterprises which would invest in domestic science.
The Chinese corporate sector, after its reconstruction, also had a crucial role to play in the development of China's innovation capacities. Like China's economic system, however, creating a Western-style innovation system from scratch had its challenges: the government installed numerous measures between the business and science sectors to employ companies in research funding. However, Chinese strategies and institutions borrowed from the West were built on very specific frameworks shaped by traditional and socialist China. Therefore, strategy implementation appeared to repeatedly encounter the same obstacles. While progress is visible, it still lags behind the high expectations and targeted pressure from the Chinese State.
Growing economic challenges also drove China's efforts to become even more innovative. Since the turn of the millennium, financial incentives have been pushed specifically for the promotion of STI by (private) enterprises. There are thus opposing power structures that China's central government attempts to keep under control. This contradictory situation raises basic questions on market forces and innovation systems in authoritarian frameworks. This paper discusses the question of whether the case of this hybrid status quo of private public relationship in Chinese STI is doomed to fail because of its fundamental contradictions to the conventional, hitherto dominant concepts of functioning innovation systems? Or whether it is precisely these previous approaches that are being called into question because of the empirically effective persistence of other approaches? This question will be explored on the basis of the Triple Helix model, as will the discussion whether the hybrid nature of the private and political sectors in China, due to their now dominant international role also calls into question other regional systems that have functioned according to previous patterns of private science funding.

1. Introduction

The relationship between public research and private knowledge in the contemporary People's Republic of China is a unique one. In this respect, a great deal has happened in China since the beginning of the reform era around 1980. The Chinese concepts of science, technology and innovation (STI) policies in the Reform era developed gradually according to the global trends and models. Statistical figures show a clear success of the commitment of Chinese (private) business to science and research & development (R&D) promotion.
This is indicated, for example, by the development of the proportional share of Chinese companies in the financing of R&D in China. In the early 1990s this share was still only about 23 percent (1993) (Keji Zhibiao 1994: 40), whereas the industrial share of R&D funding in China increased to 77 percent by 2020 (NBS 2021). This development was explicitly targeted by Chinese policy makers and in accordance with international standards. Although this is a great success of China's reform measures to date, the situation is more complex than it appears at first glance.

The reason why the overall condition between private funding and public knowledge in China is so hybrid and difficult to grasp, is closely related to its genesis. First, the model of the socialist market economy with Chinese characteristics took 40 years to build. Until today, this specific historic background as well as the current result of restructuring led to blurred boundaries between the public and private spheres in general and especially in the context of research and innovation.
Since the beginning of the reform era after 1978, science in China has officially served national economic development. Since then, the direct functional relationship between both sectors has been legitimized and is regarded as uncontroversial in China. According to this aspired symbiosis, Chinese companies were bound to play a decisive role in research funding. Moreover, the plan was to unfold the role of business in technological development and innovation in China, analogously to Western market economies/modern industrialized states (Christmann-Budian 2013). Against this background, the artificial fusion of state-funded science and the private sector advanced intensively. But at the early reform stage, for the targeted fast-track replication of Western science and innovation systems, the private sector had first to arise.
The Chinese relationship between public knowledge and private research and funding is of particular interest in this context, because it had to find its way through the special conditions. The Chinese ideological setting is pseudo-socialist und capitalist at the same time. This is accompanied by a hybrid structure of institutions, which evolved in different epochs and have Western, modern Asian, Soviet and Confucian roots (Weggel 1985). Their development was accompanied by several waves of policy measures, programs and plans to reach the strategic goals of a science-based economy.

2. Theoretical and methodological approach

Since the end of the 20th century, the traditional differentiations between basic and applied research and development seemed to blur. With the concepts of the knowledge economy and science for development (Drori et al. 2003), in the age of neoliberalism, globalism and pragmatism, science was viewed linear under the objective to lead to innovation, economic growth and competitiveness. China, similar to other developing countries, replicated the trajectory of developed countries and focused on connecting the science sector (including public universities and research institutes), industry and government as it is described in the influential approach of the Triple Helix Model

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A wide range of diverse societies formulated and followed innovation strategies designed to shape science-industry relations through reflexive science, technology and innovation policies. The objective was to increase innovation and thus competitive potential in an era of expanding globalization.
The position of science in society also has an impact on scientific work, e.g., the production of knowledge is also influenced by the increased creation of new application contexts. (Innovation) competition between nation states is accompanied by strengthened roles and networking of regional and supranational institutions that drive development via policy and funding recommendations. Modified time horizons, evaluation scales and criteria for scientific activity also impact research activity and interactions between actors, including academia and industry.

In turn, the network formation among the primary actors of the Triple Helix, from government, business and academia/universities, also causes a change in the distribution of roles within the sciences. Universities and companies now each perform tasks that previously belonged only to the other side. The boundaries between private and public actors, outlined in the model of a developed industrialized country, are also blurring in this new matrix of interaction. But what does this mean with regard to a political system such as that of the People's Republic of China, in which the previous characteristics of all the institutional forms of science, business and politics involved, have already been shaped differently beforehand? And what does this teach us in comparison with parallel developments in relation to conventional systems that used to be the model systems of the Knowledge Economy or Triple Helix?

Finally, it is also not sufficient to equate the divergent patterns in China's development with the evidence on other (partly former) developing countries and their performance in the context of the Triple Helix. As will be described below, China's case is less about the weaker structural conditions (or at most at the starting point) as it is stated for developing countries according to the standards of the Triple Helix constellation: : "the widespread fragmentation and rigidity (...) leave little or no room for interconnectedness between institutions in terms of jurisdictions; consequently (...) a low volume of interaction between institutional actors." (Saad / Zawdie 2011) Instead, as will become clear below, the lack of innovation effects observed in developing countries is contrasted by strong improvements in performance in China's development. This points to an innovation approach that tends to be stable and increasingly effective, even if it contradicts familiar (primarily "Western") patterns.
However, the Chinese approach, which over a very long period of time since the 1980s has been characterized primarily by the formative role of the government, and which calls into question the independent scope of science and business, does not stop at the country's borders. Rather, China is striving for pioneering roles even globally, and not least because of its economic and technological expansion, this different approach also affects other science systems and actually challenges previous habits in terms of governance internationally.
Last but not least, the special role of Chinese science policy drawn here in the context of Triple Helix and the subject of private funding for public research, has been extended in recent years by at least one additional aspect: this is that the private character of Chinese leading enterprises champions became even more complex through international ownership mergers and acquisitions

which again might play an additional role in the steering of their engagement in science and innovation.

3. Combining contradictions: The (Re)organization of China's innovation system

Why is the Chinese innovation system and the connection between academia and the private sector hybrid, different of others, contradictory? As explained in the introductory two chapters, models like the Knowledge Economy, the National Innovation System, including even the theory of the Triple Helix model itself, have been received and reflected upon in China, too. But - as the hypothesis put forward in this paper - the orientation and adopting of some leading parts of these global concepts mentioned above were combined with a persisting, deep mixture of former, traditional and systemic elements of the Chinese systems of politics and science. The result of the simultaneous effort to renew and preserve different elements leads to a continuous compromise or a balancing act between different influences and models. These could represent a fundamental contradiction, so that none of the mentioned efforts works in the end. But the empirical evidence to date on China's innovation system, and also on the interaction between the private and public sectors to promote research, demonstrates barriers but not dysfunctionality.

In order to understand this in terms of its causes and effects, it is necessary to go back in time and trace the genesis of the contemporary Chinese innovation system in more detail, with a focus on networking in the sense of the Triple Helix model:
At the beginning of the Opening Up reforms (Gaige Kaifang) since the 1980s, China's exclusively state-run structures did not offer any opportunities for private-sector support of research and development. This developed gradually, but slowly, as the privatization of the corporate landscape progressed in parallel. For a long time, however, research was still tied to the original structures with sector administration, departmental state enterprises and collaborative research. The Chinese enterprises, which emerged experimentally on a private level, had to maintain public appearances and linkages in order to survive. The private Chinese enterprises of the early years of Opening Up policy usually had to wear the “red hat," which meant to be disguised as a state enterprise (affiliated mostly to the regional/local government levels), in order to move forward smoothly. Afterwards, the gradual institutional change did not alter the tradition of closely intertwined relationships between private enterprises and the party-state that have existed ever since (Ten Brink 2012).

At the earliest stages of restructuring, China possessed only SOEs and town village enterprises (TVEs). After that, China gradually successfully attracted more and more multinational corporations (MNC). After a slow start with a focus on Chinese labour capacities, multinationals have also been increasingly involved in China's corporate R&D development strategies. (Wilsdon, Keeley 2007: 41).
In addition, newer domestic corporate forms emerged from the science and technology reforms and restructurings. These companies were based particularly in the area of new and high technologies and emerged, for example, in the state-supported, increasingly numerous industrial and high-tech development zones or so-called science parks. There, many enterprises were created as spin-offs in part from universities or state research institutions such as the Chinese Academy of Sciences (Sigurdson 2004).

With successful spin-offs and similar high-tech companies gradually expanding, China's corporate landscape changed gradually, but significantly. Since the late 1990s an increasing number of large companies with partial or full private ownership were among the domestic companies. As the size of these young private companies grew, they also gained political influence and government institutions began to consider and to adapt practically to this new player. This affected the private enterprises' general political involvement in the party and the state as well as their role in innovation policy measures (Hsiung 2002, p. 38).

The Chinese private companies were increasingly able to apply for funding from current government programs in competition with research institutions. In this, they also increasingly succeeded compared to the large SOEs. By the turn of the millennium, the sector had already expanded considerably (APEC 2007).

At the other side of the Triple Helix, the Chinese government began soon to focus on the enterprises with various measures which were often inspired by international counterparts and recommendations. The political sector set up various funding programs and intermediary institutions that functioned at the interface between public research and private-sector development: These included a large collection of programs to promote application-oriented research at state research institutes. In state programs and policies, promising key technologies for markets were defined, then dictated top down in more or less transparent processes und funded with generous financial means (IDRC 1997).

In the first decades of the reform era before the 2000s, these policy measures functioned best in direct spin-offs from research institutions (in the positive case that these were also blessed with management capabilities). The government - with the help of scientific stakeholders -regularly defined key funding fields and strategies. Those focus areas were adjusted periodically with the new publication of every Five-Year Plan of the Chinese government and the related sub-plans on institutional and regional levels. Outside of these official research and technology fields, there was little room for new thematic R&D activities with bottom-up approaches, especially in the application-related area.

There were several, popular examples of those funding instruments at the state level such as the Key Technologies R&D Program (from 1982 onward) or the 863 Program (since 1986) which ran over several decades. These long-term initiatives were accompanied by various other programs issued by different sector ministries and their regional counterparts. Another category of programs at the intersection of private and public research were the infrastructure grants, which, as mentioned previously, produced spin-offs, start-ups and incubators e.g., within the S&T and high-tech development zones all over China. The Torch Program for instance was one of the most effective sources among the government initiatives for founding private companies. The program specifically promoted high-tech industrialization in China and drove product development and commercialization forward with structure-building measures. Beginning in 1988, the program launched a wave of newly founded high-tech zones that lasted until after year 2000 (Cui 2002: 117).

During the following period, the Chinese government issued more comprehensive programs for the development of R&D in the private sector. One of the relevant programs, launched in 1999 which ran throughout the 2000s was the Innovation Fund for Technology Based Firms. Within this Innofund Program, small and medium-sized high-tech enterprises were primarily supported by providing seed capital of CNY 1-2 million respectively. In addition, the state also funded tech-heavy product developments or pilot production phases via subsidies, in some cases through advantageous bank loans or equity investment (Christmann-Budian 2013: 265).

In addition to priority-oriented support measures and subsidies for technological modernization at companies and new company start-ups, the state increasingly appealed to the country's established companies to increase direct activities and investments in corporate R&D.

According to Chinese statistics, private sector investment in R&D in China increased to over 50 percent of all spending by the turn of the millennium. In the early 2000s, the Chinese corporate sector had already taken over a considerable share of R&D activities in China, but most of the companies active in this sector remained SOEs or at least had close ties to the state. Accordingly, a large share of the increased investment shifts to the business sector resulted from the restructuring of a large part of the state-owned technology-related research institutes into private institutions (Kong 2004). Thus, the state's share in financing as well as in shaping R&D in China continued to dominate despite the official numbers for business R&D.

During the first two decades of the reform era almost all of the SOEs, around 20,000 at that time, had carried out technical renewal measures with the support of the Chinese government (Jiang 1997: 145). State institutions modernized various SOEs, some of which did not specialize in science or technology, for example the central Economic and Trade Commissions. Even at this early stage, this led to criticism that China's STI system was fragmented and inefficient—a criticism, which was voiced repeatedly hereafter (IDRC 1997). Altogether, the activities of the well-established and larger SOEs continued to be reluctant to directly promote and implement their own R&D activities in the 1990s. This was mainly due to a lack of training and market experience of decision-makers in the SOEs, who rarely saw the need for their own initiative to generate more technological autonomy or innovation.

In the first decade after the turn of the millennium, China's STI system was therefore viewed as being heavily dominated by politics, as initiatives mostly originated directly or indirectly from political authorities. In contrast, the Chinese economy was hardly prepared to take financial risks at this time, for example, to build its own laboratories and research facilities on a larger scale. Rather, Chinese tech enterprises took advantage of the tax loopholes and other financial aid. But all these incentives did not lead to the broader outcomes desired by the political authorities. Instead, even the increasing number of private (or partially private) companies continued for a long time to invest primarily in the Key Laboratories, which were initiated and supported by the state and the numerous research facilities in the high-tech parks. In its efforts to mobilize R&D activities in companies after 2000, the Chinese State also focused on the companies in the high-tech parks, which mostly originated from the state's research institutions. Another funding focus was the small and medium-sized high-tech companies that were supported within the Innofund program (Stiller 2006).

As a result, by the early 2000s the Chinese corporate sector had already taken over a considerable share of R&D activities in China. This was finally achieved even though most of the companies active in this sector were still state-owned or at least had close ties to the state.

4. The players of the Chinese business-research interface and their state-made interactions

The central government's major funding programs served not only as instruments to enhance China's scientific and technological performance, but at the same time as important contributors to the development of various sectors of the Chinese economy.

The continued investment in expensive, mostly imported technologies for SOEs, in the 1990s and 2000s, remained futile because of the persistent lack of skills and equipment for the subsequent adaptation and efficient use of these modernizations. This constellation led to a high inefficiency of measures in China in the area of business R&D in relation to their financial inputs (IDRC 1997; Cao et al. 2018).

In addition, the companies assigned to the departmental ministries, which were privatized in large numbers during the 1990s, were still used to receive assistance from the state research institutes for free. Therefore, enterprises were rather reluctant in spending money for R&D on their own. Although competitive pressure increased and company-specific interests were added to the state guidance, a major cultural change was needed to sustainably establish market orientation in company management and also to proactively and purposefully pursue R&D activities (China Daily 2003).

As a result of these developments, in the following years the Chinese governments made efforts to convert the SOEs into stock corporations, although the companies were initially to remain in state control (Xinhua 2003). The overall situation also delayed the establishment of research facilities run by the SOEs. The state leadership then explicitly encouraged SOEs to establish and run research facilities from 1990 onwards. Chinese policy makers soon came to the conclusion that the gap between the (increasingly application-oriented) public research institutes and most SOEs could not be closed (IDRC 1997: 103-108).

In addition, political S&T measures had barely any effect on China's small to medium-sized private enterprises in the 1980s and early 1990s as technological development projects were still very limited during this period. The hundreds of thousands of non-state small and medium-sized enterprises (SME) lacked appropriate government funding for R&D activities. In addition, non-governmental companies did not have any experience in accessing government technology programs (Jiang 1997: 146).

However, this lack of funding ultimately had a positive effect in that the new technology companies became proactively market-oriented and took the initiative for R&D activities themselves. Although this did not have a very significant impact in this earlier reform phase due to their relatively small size, it did train habits over time in dealing with R&D and innovation. Thereby it strengthens their impact in the long run. With the highly competitive pressure on SMEs, compared to that on SOEs, companies professionalized more rapidly, so they recorded more significant progress in terms of R&D, especially during the 1990s and 2000s.

Among technology companies, several categories had emerged in the meantime, first being spin-off companies created by government research institutes as a result of cuts in direct funding. They served to directly implement the commercialization of the technologies they had developed on their own. The spin-offs were also a hybrid group: many of these companies officially belonged to the private sector, but they often remained closely tied to their state parent organizations (also in terms of ownership). For the successful ones among them ownership diversified from their entry into the equity markets. An apt example is Lenovo, formerly Legend, which emerged from the Chinese Academy of Sciences (CAS) (FT 2012). CAS had the role of a relevant player among the research institutions which created numerous spin-off companies. Soon after CAS started with its start-up

activities, Chinese universities also became engaged in establishing enterprise spin-offs. The number of CAS' companies from the 1990s are estimated in various sources at between 200-450, some of which were very successful (Christmann-Budian 2013: 313). The side-effect of CAS' intensive focus on horizontal incomes and entrepreneurial endeavors was the negligence of its former main duty of basic research. For the Chinese universities this was even more true. The engagement of Chinese public research as an economic player therefore went out of balance. It exceeded what was recommended by the model of the Triple Helix: As universities were supposed to develop new linkages with industry in order to make research, teaching and economic development compatible, it should still preserve a certain degree of independency (Etzkowitz, Leydesdorff 1998),
This general overemphasis on development and commercialization of Chinese STI at all levels was acknowledged already as early as the mid-1990. However, as until now it is one of the main challenges of the Chinese innovation system mentioned repeatedly in the respective literature as well as in the policies to overcome this issue (Sun, Cao 2021).

However, the Chinese government subsequently attempted—in line with international recommendations—to strengthen the role of private companies in national R&D accordingly.
Some smaller non-state enterprises, especially those in new technologies (NTEs), had already outperformed their larger competitors in the 1990s, for example, in the creation of new products, (Jiang 1997: 147-149). These innovative companies were, however, still too small to provide input in R&D comparable to the SOEs (Hsiung 2002: 40). The Chinese government's extensive establishment of Science and Technology Industrial (Development) Parks (STIP) was aimed at promoting the transfer of technology from research to industry. In the process, newly founded companies in the high-tech sector or start-ups acted as incubators in close proximity to research institutes (Walcott 2003: 170). This marked a clear shift in strategy away from the disproportionate concentration on the large SOEs in the previous reform period of the 1980s and 1990s (Dahlman, Aubert 2001: 61). High-tech enterprises, since around early 2000, were encouraged by various policy measures to become active on the international stage (Takahashi 2004: 5). A famous example of this is the company Huawei, which expanded during its early stages and broadly in Europe with onsite R&D activities.

Since the turn of the millennium, the Chinese state also pushed financial incentives specifically for the promotion of STI by (private) enterprises. In 1999, a new strategy document initially targeted financial support policy instruments that provided loan collateral for R&D activities of the SMEs (CCP 1999). Since then, the construction of a capital market also progressed, which, among other things, was conducive to the development of the national high-tech industry in China. For this purpose, the Chinese government created a system for venture capital investment with corresponding specialized companies as well as promotion funds to be built up step by step. High-tech companies that were already mature for this purpose were to be placed on the national and international capital market to attract investment. At this time, the Shanghai and Shenzhen stock exchanges were also included in the strategy to provide specific market segments for hi-tech companies (Keji Falü 2003: 24).

SMEs were also a permanent fixture in Chinese innovation strategies for several years, in line with global innovation strategies and activities, which repeatedly referred to the potential of SMEs. However, SOEs remain the dominant players in the Chinese system, which are supported by the political system and also absorbed most of the funding for STI activities (OECD 2018).

With respect to the activities of the multinational corporations (MNCs) in China, the 1980s and most of the 1990s were still characterized by the predominant use of China's low-cost, low-skilled labor. From the late 1990s, the use of China's R&D in MNCs gained momentum. Since then, the Chinese State made targeted efforts through various measures to attract the MNCs to high-tech R&D sites in addition to setting up production facilities in China. Not only did the Chinese government push strategies and regulations to activate international private economic actors in this direction, but the MNCs and JVs themselves also became increasingly interested. This interest was partly due to possible cost savings by using the increased number of scientists in China for local research activities (Wilsdon, Keeley 2007). Some of the international enterprises also felt political pressure to formally operate scientific laboratories and other research facilities. The situation was similar to the one of bilateral joint ventures (JVs) in China, which had to include research activities in contract negotiations in the respective sectors (Jiang et al. 2018).

However, multinational companies increasingly recognized the added value of research activities within China, which, for example, made it much easier to adapt products to the local market. For this reason, these international companies were intrinsically motivated to undertake or promote effective R&D activities locally. These activities included the operation of their own research laboratories, specific R&D departments or activities within a Chinese branch or joint venture company with Chinese partners, and cooperation with a Chinese university or research institution (Schwaag-Serger 2006: 243-245).

As a result, the MNCs (as well as the relevant joint ventures) also played a growing role alongside Chinese private companies in promoting R&D in China. This also drove the increased interaction of these private, international players with public research in China. As an outcome of the measures and strategy adjustments, in 2005, for example, between 600-750 R&D facilities of multinational companies were documented (Normile 2005, Schwaag-Serger 2006: 244-245).

Altogether, there have been clear increases in private sector R&D activities, including those of the MNCs, especially since 2000. The quality of their implementation has, however, been questioned in the research community (Kroll et al. 2008: 187). With regards to the Triple Helix model, the Chinese approach demonstrated a strong imbalance on the incentive-giving side of the state, whereas the politic sector pulled academia and enterprises excessively in the intended direction. The mentioned excessive pushing of the government—lacking deeper conviction and structural adjustment within the institutions - delayed a more efficient impact of the political efforts.

5. Progress with persistent challenges

Over the last two decades, science policy in China has continued to use China's private and international companies to promote public as well as its own research in China. This trend was supplemented by Chinese companies which increasingly financed and ran research projects abroad. However, the increased activity of international stakeholders in R&D was subsequently placed under additional scrutiny. This followed controversial debates in the early 2000s and was fueled by the fact that China was still not sufficiently benefiting from many of its STI funding measures. In the eyes of critics in the Chinese government, the innovation performance of Chinese companies was still not competitive. An indicator of this trend was the number of invention patents. Many more private sector researchers became driven to apply for this most valuable patent which helped to increase this number in time. Invention patents represent novelty in innovation (Frietsch, Wang 2007) and for the paths towards real outstanding innovative and thus competitive products. The prestigious "capital" in private research sector was an outstanding innovative product that would lead new markets in the future. This can be compared to a Nobel Prize in the basic sciences, for which China is longing and providing incentives for more than a decade already. Therefore, the Chinese government focused increasingly on this tangible value regarding private research which also served to count the progress of their science policy measures, i.e., the subsidies provided for the patent application processes (Lei, Sun, Wright 2013).

At the same time, the pressure on the Chinese innovation system continued to increase throughout the mid-2000s: in addition to the ongoing dependence on foreign technologies, price competition also increased, and cooperation between companies was more difficult with enhanced IPR protection.
What's more, the government's innovation policy still supported large corporations instead of specifically promoting SMEs, which are considered crucial for the development of innovations (e.g., Deloitte 2017). Even the 2002 "Law of the People's Republic of China on the Promotion of Small- and Medium-sized Enterprises" was unable to change this situation in the short term, although it highlighted once again the political importance of the issue. Technology transfer institutions and the venture capital market were also not yet ready to make the necessary impact (Jessberger 2019: 67-68).

Afterwards, during the drafting period of the "National Medium- and Long-Term Plan for Science and Technology Development 2006-2020" (MLP), the Chinese and overseas research community fiercely debated the issues around the sustained dissatisfaction with the outcomes of S&T reform measures. At the same time, the Chinese government introduced the new slogan "indigenous innovation" policy (Schwaag-Serger, Breidne 2007: 136). The protectionist facets implied here (and subsequently also hotly discussed internationally) were already seen as the "emergence of techno-nationalism" at the time of the publication of the MLP. These connotations pushed the practical side of the adapted strategies into the background. The orientation of these strategies placed an even stronger focus on the goal of increasing innovation and exploiting domestic markets, but also on the targeted promotion of new technologies in all of the areas with potential for catch-up and even leapfrogging. In order to achieve the latter, internationalization of the own national champions as well as M&A were other explicit goals.

At the same time, China's central government's "Go Global" strategy encouraged local companies to invest abroad from the early 2000s, laying the groundwork for a second approach to techno-nationalism made in China. This new approach was outward oriented: Private Chinese enterprises had to follow the ambivalent strategy to act protectionist and globalist at the same time. This approach was not only a response to globalization activities around the world, but a reversal of the strategy to collaborate with foreign partners in China (Bellabona, Spigarelli: 2007). Instead of this approach, Chinese companies were given opportunities (including again generous financial incentives) to acquire advanced foreign technologies and management know-how abroad (Di Minin et al. 2012). This paradigm of supposedly contentious strategies is continued recently under the strategy "Dual circulation," where again the focus in the inner markets and actors (including privileges and protectionism) is combined with explicit continuity of tech-based entrepreneurial activities on the international level (Lin, Wang 2021).

Chinese companies have had access to funding since the 2000s to set up R&D centers abroad, to buy up foreign technology companies to improve their competitiveness and technological capabilities, and to carry out production and infrastructure projects in an international context (Fu, Xiong 2011: 4-9). After the introduction of the “Go Global” strategy and especially after the global financial crisis in 2008, Chinese direct investment abroad increased significantly (Jessberger 2019: 71) and a substantial part of it was earmarked for R&D activities.

The “National Medium- and Long-Term Plan for Science and Technology Development 2006-2020” (MLP), the epoch-making 15-year plan, contained numerous measures to promote innovation and, in particular, to activate the business sector for this purpose. This included tax incentives for investment in S&T and innovation, a government procurement policy to stimulate innovation, as well as the promotion of innovation by introducing advanced technologies from abroad and through new financial measures (Mu 2015).

Ongoing subjects among Chinese scientists include, for example, the enormous amount of funding provided to the mega project schemes by the Chinese government. Clearly, the realization of these de facto “big science” projects and many other aspects of the MLP were not always as positive as policymakers had expected confirming the waste and imbalanced concentration of funding that many scientists had predicted (Rao et al. 2004).

The definition and promotion of key technologies and high-tech industrial areas through the corresponding funding instruments remained another important feature of Chinese STI policy. In the West, such goal orientation has been pushed recently to be perceived as a strategic achievement of China (e.g., Speakman, C., 2021) but ultimately this selection of strategic fields also bears traditional traits of the former planned economy. It implies a rigorous adherence to proclaimed goals, often narrowly defined in detail, and a strict demarcation from other fields. Regardless of this background, intensive promotion of such narrow fields can lead to significant successes in the output area and the Chinese leadership was aware of this. Of course, Chinese technology companies, including spin-offs in particular, played a crucial strategic role in applied research and development of these defined key technologies. These goals were differentiated in the central government's further planning and later even quantified with market share targets and similar indicators (Seifert et al. 2018: 47).
With this in mind, the Chinese government decided in 2009 to intensively promote a number of technologies, known as the “seven strategic future industries,” as part of the “National Twelfth Five-Year Plan.” These industries or technology fields were: energy saving and environmental protection industry, new generation information technology (including photonics), bio-industry, advanced manufacturing industry, new energy industry, new materials (including nanotechnology), and new energy vehicles (Tagscherer, Christmann-Budian 2013).

By the end of the 2000s, despite the explicit goal of a National Innovation System, it still could be stated for China: most of the state's innovation policy measures continued to come from state organizations (public research institutes, universities, and state-owned enterprises) and not from private Chinese enterprises. However, even though the performance of the private sector with regards to innovation and research funding sill lacked behind, the government began to treat the private enterprises as key factors for development (Sun, Liu 2014).

Before, the private sector was not established enough to reach a sustainable way to self-finance nor did it initiate research projects. There appeared to be a lack of in-house research facilities—i.e., primarily laboratories within companies, and insufficient scientifically trained personnel. Despite the awareness of these problems and corresponding recommendations, the overall situation had not changed comprehensively until the first decade of the 2000s. But even though R&D activities by the business sector had grown rapidly in the meantime, the share of R&D spending in value added remained low. As recently as 2004, R&D spending in China's manufacturing sector accounted for 1.9 percent of total value added, compared with 7-11 percent in France, Germany, Japan, Korea, the United Kingdom and the United States (Schwaag-Serger, Breidne 2007: 142). Evidence of the persistently weak innovativeness of most Chinese companies is found in the fact that 99 percent of all Chinese companies had, in 2005, never registered a patent (Wilsdon, Keeley 2007: 20).

In the first years of the 12th Five Year Plan (FYP) starting from 2011, additional questions arose in the Chinese STI community regarding the output of the various reform and funding activities. These debates discussed scientific misconduct in general and the abuse of funding and wasting public money (Rao, Shi 2010). China-related scientists in and outside the country as well as the China Association of Science and Technology (CAST), the national umbrella organization of the Chinese professional science associations, took an important role by launching studies around these debates. A study by CAST caused a particular stir, as it showed that only about 40 percent of government funding for STI actually went directly to STI projects, the whereabouts of the remaining substantial funds, remained unclear or strongly indicated waste, abuse, and corruption (ZQB 2013).
This also significantly affected the funding at the interface between science and industry. In addition, it gives an idea of how large the number of unreported expenditures made directly via companies might have been, most of which also did not flow effectively into research and innovation.

In recent years, because of such analyses and related debates, the Chinese science policy sector had once again come to consider the most appropriate instruments to improve science and technology achievements.

In fact, the pressure has even increased during the last decade. This was partly because the Chinese government did not take the opportunity of the global financial crisis of 2008 for more radical reforms, but once again relied on traditional and short-term economic injections. The Chinese government introduced recovery packages to help the business sector bounce back, but the reform of the S&T system did not receive any innovations. Instead, Chinese politics continued to stick to the already established 15-year planning of the 2006 MLP. At the same time, China's economic growth initially slowed in an obvious way. This meant an average growth of nine percent between 2008 and 2013, only to be followed by even having to announce a “new normal” of 6.7 and 7.3 percent between 2014 and 2017. On the other hand, the growing economic challenges also drove China's efforts to become even more innovative. But it was still not clear how this was to be achieved in practice and which measures were needed in both science and industry to have a satisfactory effect (Cao et al. 2018).

An important policy document from the precedent decade, the “Opinions on Deepening the Reform of the Science and Technology System and Accelerating the Construction of a National Innovation System” (2012), explicitly listed the challenges that the system must overcome in the future. Its content highlighted that despite all the quantitative output, China's innovation capability has not yet met science policy expectations. Stakeholders in the Chinese science system critized again the lack interactions between companies, universities and research institutions, the still insufficient independent innovation (also as a result of this) and China's continued over-dependence on (imported) key technologies. The commercialization rate of R&D was also apparently still insufficient from the government's point of view.

In the fall of 2014, another policy paper from the State Council was published detailing the planned restructuring of China's funding system “Notice of the State Council on Issuing the Program for Deepening the Reform of the Administration of Central Finance Science and Technology Plans” (Document no. 64) (gov.cn 2014). This plan called for the establishment of several specialized funding organizations in addition to the NSFC (National Natural Science Foundation of China) to promote the other STI fields. These organizations were supposed to replace former direct funding by the ministries (esp. the MOST) and to operate according to uniform quality criteria in order to overcome former imbalances. As for the relationship between the state and the market in STI, the 2014 decisions aimed at a clearer relationship for the future: the Chinese government intended to focus on supporting public science and technology activities such as basic research for the common good and important key technologies for which the market could not provide effective resources. Once again, it proclaimed to actively create an innovation-friendly environment to solve the problem of “overstepping” (exceeding authority) and “lack of function” (the absence of government functions where something should be managed). The government would substitute the crucial role of the market by allocating resources and supporting the technological innovation of enterprises and the implementation of scientific and technological achievements through tax incentives, government procurement, and other universal policies and guidance. The proposed measures regarding the business sector of the government are similar to previous reform approaches. One remarkable feature was the rhetoric in the policy documents which proposed that government support should consist of (even more) openness, transparency, and social control.
Following this, in 2014, the government continued to postulate that it would reintroduce or improve its indirect measures, such as tax incentives and public procurement, to promote technological innovation. A highlight was the “Made in China 2025” strategy, published by the government shortly after in 2015. This initiative ultimately represented the Chinese response to the German and US strategies, “Industry 4.0” and “Industrial Internet”. At this time, China was less successful than usual in seeking international cooperation with economic and scientific actors in precisely these fields, so “Made in China 2025“ meant a change in strategy. This new STI strategy has been advertised offensively abroad to raise the attention of observers, competitors and potential partners (at least in the beginning) (Chen, E. 2019). In its content it brought together many of the existing policies in areas related to automation and AI, including “strategic emerging industries” initiatives and focus technologies in automation, IT, robotics, AI, etc. The “Made in China” strategy also attracted a lot of international attention and positioned China even more visibly as a competitor in the high-tech sector as well. “Made in China 2025” marked a milestone in the external impact of China's ambitions and capacities in STI by re-emphasizing the leap-frogging ambitions as well as reaching another level of self-marketing as a potential player in STI and AI. In addition to once again providing generous, multi-stranded funding (Sutter 2020), the Chinese government strengthened domestic companies by explicitly promoting the program and its players at home and abroad for technology cooperation. What’s more, some of the efforts in the Belt and Road Initiative context also provided a variety of strong support opportunities for STI activities by Chinese enterprises (Normile 2017).
Overall, a further culmination of the focus on science, technology and especially innovation can be observed for the period of government under Xi Jinping. This is supported by raising the issue to

top-level priority with the installation of new leadership bodies, in line with a policy concept of a "top-level design" (dingceng sheji) (Cao 2018).

The recent decade from 2012 to 2021 represents on the one hand—despite the state of emergency as well as standstill since the outbreak of the Corona pandemic in the winter of 2019/20—a phase of renewed, even more ambitious and intensive efforts of the promotion of public and private STI in China. On the other hand, another leitmotif of Chinese STI policy became more and more obvious during this period: this is the phenomenon of parallel political tendencies and measures that involuntary counteract the own policy goals. As an example, over for the past decade the anti-corruption campaign under Xi Jinping has paralyzed China's entire institutional system, including the innovation system, and delayed implementations of a wide range of measures.

These contradictions characterized Chinese STI policy throughout the reform era since 1978 and is actually a symptom of ambiguous political strategies and the systemic framework on the whole. Overall, this repeatedly involved the balancing act between the freedom of science and business to develop innovation potential versus the ongoing, and recently even intensified attempts at control to maintain central political power.

An exemplary detail in this context—with the framework conditions of advancing digitalization and competitive potential in the global innovation race—is the "Law on the National Intelligence Service" of 2017 (Law 2017). According to this law, China's citizens and institutions were officially obliged to comply with every order to fulfill the "work of the national intelligence service." On the one hand, this clearly manifested China's view of the balance of power and of state digital sovereignty. On the other hand, it also clearly showed foreign countries that there is precisely no institutional independence in the realm of the CCP, not even for the formally private companies. Such measures were used by skeptics in the United States, for example, in their arguments against Chinese providers such as Huawei for security-relevant technology equipment such as 5G (Hamilton, Ohlberg 2020: 80).

Dual use also plays an important role in the state's support of private technology companies (Nouwens, Legarda 2018). This feature should be considered for Chinese players when discussing international cooperation in STI, at least as a politically clearly intended possibility under the power relations described. Regarding the dual use of Chinese tech enterprises and their competitiveness, the empirics are, as expected, elusive.

In the civilian sector, however, the figures concerning enterprises for the period are telling: for China's latest five-year plan period of 2016-2020, evidence shows that Chinese companies account for the largest share of national R&D spending, both in funding and execution. In 2018, for example, this meant that expenditures totaled USD 429 billion. Naturally, the main focus was on R&D in industrial manufacturing (87 percent in 2016), including computers, electronics and optics at the forefront, followed by motor vehicle manufacturing (Kooperation International – KI).

However, even during this period, and despite the large amounts funded by China's companies for R&D, so far only two companies headquartered in China have been able to rank among the world's top 50 R&D investors: the electronics company and hardware producer Huawei and software producer/service provider Alibaba (ranked US: 22, DE: 8). China's "catching up" is unmistakable when looking at the R&D ranking of the world top 2500 companies. According to the 2019 EU

Industrial R&D Investment Scoreboard, 507 companies among 2500 internationally leading R&D companies are already headquartered in China, after 769 US companies (Scoreboard 2019). In 2020, there were already 3 companies under 50 headquartered in China as well as 536 enterprises among the top 2500 companies worldwide (Scoreboard 2020).

If, in turn, it is said that the share of direct financing through government grants in China is below the OECD average (KI), this also applies to tax incentives. This continues to be reflected in the OECD data for 2018, where China remained below the average in direct and fiscal support for business R&D (BERD) (OECD 2019). What is difficult to prove in quantitative data, however, is the presumed continued support of China's companies strategically active in R&D by the Chinese State, which is as opaque as state/party relations with the business or military sector. The close entanglement of politics and economics, however, is qualitatively evident, as shown above. Such is the focus of the predominant support programs on companies (whose detailed amount of funding, however, are also hardly known), so that the data presented here are of limited significance. It can be assumed that public input into formal private R&D activities by far exceeds the figures mentioned here, precisely because the boundaries between the public and the private sector are so blurred.

6. Chinese “Public Private Partnerships“

Once these diverse incentives e.g. tax subsidies, venture capital, business oriented funding schemes began to finally take effect and the high-tech enterprises were able to expand nationally and internationally, the relationship between the government and the private sector intensified and quickly improved. The successes of private enterprises also gave them further freedoms. Since the 16th Party Congress of the Chinese Communist Party (CCP) in 2002, the leading managers of the relevant private conglomerates were able to become members of the CCP (Heilmann 2004: 93). This was a decisive step in the linking of measures and interests between business and the state.

Since the early 2000s, the CCP has pursued a policy of bringing Chinese capitalists and companies into the party apparatus and revived the direct exchange of favors. The particularly successful billionaires or CEOs among them received appointments to the Chinese People's Political Consultative Conference as a reward (Hamilton, Ohlberg 2020: 80). Party membership increased by an average of 2.4 percent per year under Hu Jintao, the CCP's general secretary from 2002 to 2012. (It then slowed down again to an average of 1 percent per year.) A side effect during this active period of party expansion was also the expansion of the intra-institutional party cells that permeated every part of Chinese society, including private enterprises and institutes. The focus of the admissions effort had shifted, and — instead of the previously focused three revolutionary classes-workers, peasants, and soldiers — intellectuals, professionals, and entrepreneurs increasingly joined the party. For example, from 2007 to 2019, the percentage of managers and professionals increased from 22.4 percent to 26.7 percent.

In the private sector, companies such as internet giants Baidu and Didi Chuxing made high-paying jobs conditional on Communist Party membership. These were supposed to take over “party-building” activities because, in lieu of nonexistent market-supporting institutions, ties to the Communist Party served to provide companies with advantageous terms. These included favorable regulatory or tax conditions or access to resources such as bank loans. Among the ranks of prominent party members business leaders were and are to this day: Lenovo founder Liu Chuanzhi, Xu Jiayin of China Evergrande, Jack Ma Yun, founder of e-commerce giant Alibaba Group, and Ren Zhengfei, founder of telecommunications equipment maker Huawei Technologies Co. These connections have been cited by the US government and other Western countries as some of the reasons for security concerns about Huawei in the context of 5G. According to the South China Morning Post, not everyone goes through the standard process to become a party member: special candidates, such as representatives of influential elites, can be admitted directly "under special circumstances" i.e., fast-tracking. Members of such circles usually maintain contact only with high-ranking cadres, and their identities are sometimes even concealed within the party to disguise their activities on behalf of the party (Cai, Chen 2021). This makes it clear that the links to politics, especially in the area of the new elites, are diverse and not very transparent, and that there is a particularly slight demarcation between the private sector and the state or the all-powerful CCP in China.

However, the changed framework conditions resulted in a shift in power from the state to the business sector in China, at least as far as the influence of business strategies on the behavior of local political administrations is concerned. This leads to opposing power structures on the regional / business level which still exist today and that China's central government would like to have under better control (Ten Brink 2012: 15).

In the course of the genesis of public and private support for STI in China, it becomes clear that the opening of the Chinese economy was never accompanied by a retreat of the Chinese leadership. In both the economic and the scientific system reform of the PRC, the government and it related stakeholders imported and implement structural elements of the successful industrial nations. At the same time, however, other pre-existing components of previous systems (especially the Leninist-influenced phase, but also earlier structures) were retained and connected with the new institutions (albeit in an improvised way). This hybrid mixture remains symptomatic of the inconsistency of the modernization of Chinese economy and science. From the current perspective and how it is presented, it appears that the relatively free operation of market forces did not weaken the power of the one-party state (Hamilton, Ohlberg 2020). The dominance of the Party and state in R&D is a symptomatic part in the interactions with businesses.

The top managers of SOEs continued to be appointed by the Communist Party's Organization Department. President Xi Jinping in 2016 reaffirmed the role of SOEs, as well as the expectation that board members would not make any major decisions without consulting the company's internal Party committee. Other types of companies with a certain size also were obliged to have a Party committee member, including private tech companies, foreign companies, among others. The party secretary is often 2nd in the hierarchy in the official structure of Chinese institutions, yet nothing is expected to happen without their consent. The power structures have also been extended to private companies and any kind of supposedly independent institutions within China, and in foreign countries, too (see The Economist 2021 and the original government document: gov.cn 2019).

The linkages between the Party and the corporate sector have political and personal aspects e.g., senior officials or their families in China often also have stakes in companies. Since the anti-corruption campaign, these stakes are often kept discreetly, more so than before (abroad, via letterbox companies, etc.)(Garnaut 2012).

Such networked companies, in turn, have access to various systemic privileges, for example, access to regional land and other capacities, in procurement procedures, etc. (Pei 2016: 116 ff.).

As a result of strategies such as “Go Global”, Chinese companies uphold the CCP's interests abroad. Similarly, the framework of action of economic actors at home can be described as a balancing act, between central and regional policy levels or between benefits and constraints. Chinese companies benefit commercially, but at the same time they are ultimately obliged to comply with the requirements (Hamilton, Ohlberg 2020: 78). This also applies to activities in the context of promoting R&D, where the balancing act for growth-oriented, innovative companies is all the more difficult. Even such successful companies like Alibaba, after decades of cooperation with the political system, can apparently reach their limits if they dare to engage in a power struggle with the Chinese government in their corporate interest. This case like several others accounts for leading innovative enterprises in China which act too self-confidently or independently in the eyes of the ruling party in China (Calhoun 2021). Of course, such examples, which specifically involve disagreement between the state and representatives of the private sector regarding ownership rights to innovations and—symptomatic in today's digital age—also to data, slow down other ambitious and STI-active companies in China. The constraints on achieving innovation goals and simultaneously following the rules in the realm of the CCP is correspondingly complex.

Although the constellation has changed due to the multiplication and enlargement of formally private companies in the course of the reform decades in China, the close ties to the political leadership continue almost as they once existed only for SOEs. Private companies now however must simultaneously keep an eye on global competition and their potential for innovation, and usually have a deeper understanding of this than the politicians who continue to try to dominate them. This also affects the priorities in the planning of STI activities of the Chinese private sector, which can also collide strategically in terms of their timeline with the continuing medium and long-term planning of the Chinese political system.

This balancing act is another aspect of the overall situation in which China repeatedly comes up against its own systemic limits in its institutional adaptation to global, market-based and scientific structures. Moreover, the various areas of China's innovation system continues to be characterized by a lack of networking and fierce competition in the public sector, even below the level of actors and initiatives of the central state, which also influenced actions toward the private sector. Duplication of measures, wasting funds, little oversight or checks and balances (esp. against corruption) were to be specifically addressed during the period of the 13th Five-Year Plan. However, until now there is no clear evidence of successful policy measures yet.

Altogether, these factors brought about to the current state, that independent or “indigenous” progress in science and innovation in China still remained insufficient in the eyes of the ruling elites. This also applies, even though China now has visible global champions such as Huawei, Tencent, and Baidu, and Shenzhen as China's Silicon Valley or its advances in AI were the “talk of the town.” Additionally, China’s government still complains about too much dependence on imported key technologies and even in 2021, Xi Jinping called once again for the “creation of a first-class innovation ecology” (Xi 2021). But the transformation is still not complete or rather: the effects are not yet considered satisfactory. This may never be the case in China in dynamic times like the current ones, but the efforts that the Chinese state has made so far for reform and structural design in favor of the development of an innovative (private) economy is nevertheless internationally unparalleled.

The quantitative output figures and, first and foremost, the more than successful leapfrogging in the context of AI (Li, Tong, Xiao 2021) prove that the efforts of Chinese STI policy making in support of innovation-promoting measures were not in vain. The achievements in telecommunications/ICT and other market-shaping high technologies were also developed in a targeted manner in China's advantageous environment and are perceived internationally as competition for the traditionally dominant players.

Interestingly, China's success in these technology areas has been discussed in Western countries more recently in conjunction with other aspects (Lewis 2019), at least as an alternative systemic model worthy of consideration. As a side effect, even the habit of political five or fifteen-year plans and long-term goals, which actually originated in the socialist planned economy, are now being discussed by some Western observers as an alternative path to success. This development is complex and cannot be explained alone, but certainly also with the ideological vacuum next to capitalist growth striving in the "old" industrial nations, and the changed global power structure of the times. China's outward success story is convincing, coupled with its overall respectable, multifaceted market dominance and its geopolitical aspirations via campaigns such as the Belt and Road Initiative.

The current state of China's innovation system and its private actors is too multifarious to be presented here in its entirety. One central question, that also causes the continued dissatisfaction of the Chinese leadership with the effect of its STI reforms, is the structural imbalance and the roles of the actors of the Triple Helix model. These reforms aimed at the integration of the private sector in the STI activities, but the input of funding and general support did not lead to an equivalent output of measurable success, such as a real innovation leader or leading new products on a global level. It dawned on the Chinese policy makers that the solution was more likely to be found by considering the qualitative levels of scientific progress and the less focused disciplines or regions instead of the purely quantitative output data at the macro level. But the Chinese system lacked alternative approaches since also all global models were oriented towards measurable growth. In this context, it should not be forgotten that the Chinese government already tried to discreetly account for reduced growth in the 12th and 13th annual plans compared with the previous period. This was labeled positively as a "new normal" (NESTA 2020). It can be assumed that, analogous to earlier tendencies to whitewash Chinese national statistics (Schueller 2002; Christmann-Budian 2013), the real growth was (though still comparatively high) lower than the around seven percent which were announced.

In any case, the economic and political pressure forced Chinese companies to compete and expand increasingly. At the same time, the government placed even more emphasis on innovation issues in state ideology. After the "Scientific development concept" from President Hu Jintao's era and Xi Jinping's first slogan "Science and technology innovation concept," the so-called "Innovation-driven Development Strategy," followed 2016 and defined innovation as overall dogma and alternative ideology.

7. Paradigm shift made in China?

The current period of the 14th Five Year Plan (FYP, 2021-2025) will again focus on technology and innovation, now on the basis of the Dual Circulation strategy which brings STI under a new ideological roof (gov.cn 2021.a). The strategy strongly addresses the Chinese private sector, global aspirations, and the strengthening of the domestic market. While “indigenous innovation” aroused indignation abroad 15 years ago, protectionist approaches have become acceptable in the post-Donald Trump era. Therefore, when Chinese strategists recently tried to reconcile the international component of free trade and global production chains with the newly simultaneous combination of an emphasis on the domestic market, the time seemed ripe for this two-pronged strategy. Xi Jinping's appearance in Davos in 2017 (Xi 2017) remains unforgotten, when he called to maintain global open markets. Xi’s positive announcements have been welcomed by the other countries at that time, especially because it stood in contrast to President Trump’s “America First” and other related policies from back then. Meanwhile, it is not only the US that complicates cooperation with China, but other countries such as Australia, the UK and even the EU are increasingly critical and cautious, as well as mindful of their own interests (Kelly 2020).

The dual circulation approach to new innovation strategies is described as strengthening internal circuits (for example, by shielding against risks arising from integration into global value chains) in order to develop greater economic resilience. Dual Circulation is a strategy made up of both “great internal circulation,” as a basis for the country's development and “international circulation,” i.e., the global economy, as a means to prioritize of the domestic economy (Gruenberg/Brussee, 2021). In contrast to its predecessors, e.g., “Reviving the Nation with Science” (Kejiao Xingguo, 1995) or “Indigenous Innovation” (Zizhu Chuangxin, 1999/2006 MLP) (Christmann-Budian 2013), the term “Dual Circulation” seems to be more suitable as it does not imply direct nationalist implications like its predecessors.

Simultaneously, “Dual Circulation” attempts to positively resolve the contradiction between global openness and protectionist inland development. If the plan was to represent an approach to “decoupling” on the Chinese side at all, as in some Western interpretations, it would rather be a continuation of earlier Chinese protectionist initiatives such as “Indigenous Innovation” than a reaction to recent Western trends. It is likely that the Chinese government is fully aware that total decoupling would not be at all possible or desirable, if China still pursues the objective of increasing its innovation capacities. The latter remains a high incentive for international cooperation from the Chinese government's point of view, as well as to foreign markets. This is also evident from the original text of the 14th Five-Year Plan, where “international” is predominantly mentioned in the context of enterprises, innovation, and related cooperation (FYP). The FYP also repeatedly refers to the complex international situation that must be addressed with the current strategies of the plan. Here, reference is made both directly to the effects of the COVID-19 pandemic, and also to global economic challenges, energy supply issues, and overall turbulent times of change, including unilateralism, protectionism, and hegemonism.

The goal of becoming a leader in new key technologies has still not been achieved in the eyes of the Chinese government. Therefore, this topic was also taken up again in the new FYP period. China’s enterprises are essential in this context, but the question remains how to control the economic sector under the current circumstances to fulfill this purpose.

Most of the challenges existed before the pandemic broke out. According to a recent study by the World Bank, the decline in productivity growth is seen as a major cause of China's declining economic growth (Brandt et al. 2020). China's leadership is attempting to counter this by once again intensifying its focus on the country's innovation potential. According to globally common parameters and related rankings of innovation measurement, China had been steadily improving, but on average it is still quite far from the global technology frontiers (e.g., BDI 2020). The catch-up process needed to advance, which gave way to an increase in the adoption of more advanced technologies and management skills from established industrialized countries, a drive that previously proved effective in the 2010s. To some extent, this was even more true at the time of the COVID-19 pandemic, especially for the acquisition of companies weakened by lockdowns. Prior to that, the mood in Europe and other Western regions grew increasingly suspicious of Chinese acquisitions of technology assets abroad. Even prior to the pandemic the acquisition of such assets abroad was under threat. Now, however, despite increased pronouncements in Western countries for stricter control, for instance on corporate acquisitions from China, the current focus of international politics is on the health crisis rather than on China's global business activities, which also serve to promote innovation in the private sector (WZ 2021). (The renewed increase in corporate acquisitions by Chinese players since 2019, for example in Europe, can be viewed in the statistics from Federal Statistical Office of Germany [Statista 2021]).

The current 14th FYP names major S&T projects (now, under the name "Innovation 2030"), most of which signal to continuations as well as some innovations in strategically important areas. Specifically, these are the pioneering areas of artificial intelligence, quantum information, integrated circuits, public health, brain research, breeding biotechnology, deep-sea research, and space technology. For these, there are both ample development potential (including in the entrepreneurial arena), as well as new or optimized facilities and mechanisms planned that are supposed to facilitate the sharing of sources.

An important feature in the current FYP related to the country's enterprises can be summarized by the term "opening up". It is striking, even compared to international trends, that the digital sector in China has been prioritized in the context of innovation cooperation. This applies especially at the supra-regional and international level and is propagated under diverse slogans referring to "openness." As part of this feature, enterprises are gaining access to national research platforms, science and technology reports, and research data. The current 14th FYP promotes innovation in transfer mechanisms, for example, through the development of specialized market-oriented technology transfer institutions and technology managers.

In addition to the expansion of supportive financial instruments for private companies and STI, however, it is precisely this "opening up" in the digital context that is the strongest incentive in these latest developments. Of course, the construction of digital China will also be pushed forward with the help of the country's relevant enterprises in the 14th FYP period. Apart from this, the 14th FYP only provides a few new approaches regarding economic development and private promotion of innovation. This also includes the continued strengthening of national innovation demonstration zones, high-tech industry development zones, where, as previously described, hybrid forms of Chinese-style public-private partnerships have emerged (Poo, 2021).

The diverse approaches around open innovation (based mainly on Chesbrough 2003, 2006), and similar ideas for the diverse application areas (open source, open science, open access, etc.) have increasingly found their way into China in the past two decades (Fu, Xiong 2001). Since then, open innovation trials have taken place with businesses. Companies could use both external and internal ideas, as well as inner and outer routes to markets, to further develop their technologies. This was supposed to be done in particular with the support of digitalization, so that cloud-based collaboration platforms could also open up ways in the area of private companies to enable exchanges with external partners without much effort.

During this period, the Chinese government intends to accelerate the construction of a digital economy, a digital society, and a digital government, as well as digitally transform production lines, the government and citizen’s way of life. The economy will be further digitalized, in particular by ensuring full use of the benefits that big data and potential applications bring with them. In the current FYP, there are references to numerous public and private databases in China, which were also regulated by formal regulations for their role in the service of the Chinese State (Meltzer 2020). This current FYP focuses on the financing from the state to the business sector. But as the above shows, in most cases the nation’s funding measures are to be understood as a cycle and the role of enterprises is indispensable in China's reciprocal funding system, e.g., in the recent major trend of open innovation processes.

As expected, strengthening innovation capabilities in the area of key digital technologies will continue throughout the 14th FYP period. China will also continue to support catch-up or leapfrogging strategies in state funding for companies, and for the enterprises to fund other institutions in the research project and development or innovation sector. In these regards, the plan lists (like its predecessors) areas of technology and products to receive funding, such as high-end chips, (presumably new/proprietary) operating systems, key algorithms of artificial intelligence, sensors and many more. What’s more it aims to strengthen the integration of general-purpose processors, (continuing) cloud computing systems, quantum computing, quantum communications, neural chips, DNA memory, and more. These fields are also the areas in the ICT sector where support for and by Chinese companies can be expected in the current period. The situation is similar for other key areas in the STI-related companies mentioned above. As it is tradition in the system of the PRC, this FYP will be followed by more detailed plans for certain sectors, disciplines or regions.

The potential of such cooperation (in terms of saving money and time as well as for the political control of international scientific contacts, which both expanded since Xi Jinping came to power) had become increasingly attractive even before the outbreak of the COVID-19 pandemic. In China’s interpretation of a “new normal” since the pandemic, variations of open innovation are going to be further established and expanded over the next five-year plan period. This is also being done in the deepening realization that international exchange, travel, and cooperation will probably not return to pre-pandemic habits for quite some time. Therefore, open innovation is a welcome substitute in this respect. This is even more relevant under the given conditions of the COVID-19 pandemic, when (physical) international exchange has come to an almost total standstill in the corporate innovation sector. Even before that, international cooperation had long been a challenging task for policymakers due to the lack of controllability when interacting with other systems. Therefore, the virtual cooperation via platforms and other open innovation initiatives seems to be an appropriate and promising compensation in the view of the Chinese administration.

As an example of the trend to increasingly support open innovation and related infrastructure, the Chinese Ministry of Science and Technology (MOST) announced in May 2020, already in the midst of the pandemic, that the IT company SenseTime would be officially entrusted with the establishment of the "National Open Innovation Platform for Next-Generation Artificial Intelligence on Intelligent Vision." With this, SenseTime followed Alibaba Cloud, Baidu, Tencent and iFLYTEK as another company entrusted with building the National Open Innovation Platform for Next-Generation AI. SenseTime, based in Hong Kong, supplies facial recognition software to the PRC. This company is also expected to play a key role in further merging the regions of Guangdong and the two former colonial states of Hong Kong and Macau, making the Greater Bay Area a global center for innovation and technology (SenseTime 2021).

Another feature of the plan is to simplify the domestic listing and financing channels for technology-based enterprises, the criteria for "hard technology" characteristics of the Science and Technology Venture Board. Overall, various initiatives focus on improving funding for private STI and start-ups. In addition, the Chinese government encourages angel investment or venture capital advisory funds and private equity funds.

The last particular facet of China's recent development in terms of private research and innovation funding concerns basic research. In the current planning period of the 14th FYP, basic research in China will be additionally supported directly by the business sector, contrary to the general practice of the state sector providing the majority of funding for basic research.

In this paradigm shift, the dichotomy of basic research and the private sector is supposed to be overcome, and basic research is intended to move closer to the key innovation areas of modern Chinese industry. Obviously, this is a new approach with Chinese characteristics to counter the persistent lack of sensational breakthrough innovations. Such pioneering innovations have a similar significance for Chinese nationalist ideology on the path to innovation leadership. A breakthrough innovation can be considered the "Nobel Prize" for the Chinese science system, which would come with significant features for economic success and potential for market dominance in relevant technology fields. Similar to the pursuit of the Nobel Prize for the basic research community in China (Cao 2014), the Chinese government explicitly announced the pursuit of inventions and related patents as a goal for private research sectors and its actors.

For this overall objective, government institutions designed appropriate incentive instruments e.g., industrial investments in basic research are to receive tax breaks. At the same time, the state will implement credit facilities for invention activities which are supposed to function more effectively than before. By embedding innovations from basic research in industrial chains, the development of traditional Chinese industries is supposed to be driven forward not only in the direction of technology leadership, but also in terms of smart automation and green development (Poo, 2021).

As is so often the case with new reform attempts in the Chinese science system, the elite structure of the Chinese Academy of Sciences (CAS) will not be left out. Hou Jianguo, president of CAS since the end of 2020, describes the new approach of directly linking basic research with the needs and innovation efforts of the domestic, yet globally ambitious, economy:

> "We must ... get rid of the linear thinking model from basic research, applied research to experimental development, break the closure and separation in the organization of scientific and technological innovation activities, and build scientific and technological innovation on a more solid foundation of quality and efficiency." (gov.cn 2021.b)[1]

All this has to be done under the new slogan "Self-reliance and self-improvement in science," which ultimately means the same as its predecessors—national strengthening by increasing innovation potentials, nationalism and scientism. But the approach which targets a direct bridge between public basic research and the private sector in fact means officially breaking down former theoretic borders. It could be posited that China may for the first time leave the path of the global model for science and innovation development. This is especially true, if the announced transition would be put into practice. However, we have to wait and see in the current five-year period before we can make a valid assessment of whether China is for the first time breaking new, innovative ground in science funding outside the Western pattern.

8. Conclusion

Overall, it could be said that a leitmotif of the reform era was to further establish a proactive role of Chinese enterprises within the domestic innovation system. This feature is closely related to the specific combination in China of constantly reforming economic structures with not yet fully unleashed market forces and hybrid institutions with varying systemic origins and levels of development.

As this paper has shown, China is a special, hybrid case in regards to the development and status quo of its private sector as well as its involvement in the promotion of public research. Ultimately, as this paper has made clear, these areas were mainly set up in a "man-made" and controlled style by the Chinese one-party state (although strongly inspired by foreign/global players and models (IDRC 1997)). Even if we acknowledge that according to the Triple Helix or other approaches the networking and interaction between the political, industrial, and science sector have to exist so that innovation works. But China's system cannot be pressed into this mold. As Cai Yuzhuo puts it, "(…) although Chinese economic reforms have changed the policy environment in a direction that may facilitate the implementation of the Triple Helix model in China, some institutional logics at work may shape its development in a different way as seen in the West" (Cai, Y., 2014).
In this paper we assumed that the Tripe Helix model (even in case of a conscious support with funding) must be accompanied with a balance of intrinsic motivation at all three angles (Etzkowitz, Leydesdorff 1998). This does not seem to exist in China in the sense of the original Triple Helix model because of the Chinese government's dominant role in this network of relationships. They are steering rather than encouraging other actors, and therefore leaving little space for other stakeholders (namely the private sector and the public science sector). Nevertheless, it can be stated

[1] Author's translation; original quotation in Chinese see: „Hou Jianguo: Self-reliance and self-improvement in science and technology as a strategic support for national development" (侯建国：把科技自立自强作为国家发展的战略支撑), on: URL: http://www.gov.cn/xinwen/2021-03/17/content_5593521.htm.

that the constellation, which deviates from the original Western-style Triple Helix Model (Cai, Y., 2014), nevertheless leads to measurable success in China.

After the PRC experimented with a planned economy for thirty years from 1949, it took several decades to re-establish market-economy conditions, including an appropriate enterprise structure. It took even longer to establish efficient support structures between the young private sector and (public) research. However, this goal has been at the top of the Chinese policy agenda since the beginning of the reform era. Since then, China followed the Western-influenced model of science and innovation to rebuild its economy in a market-oriented way. At the same time, however, in China many structural elements and institutions of the socialist system remained in place, particularly the framework conditions.

Furthermore, until well into the 2000s, the vast majority of enterprises in China could not be considered private by conventional definition—the boundaries between private and public remained blurred for a long time. Even though ownership structures have now increased significantly in favor of private shares, and the companies appear to be private, the state still frequently holds shares in them, especially in former SOEs and spin-offs of former public institutions. And even in cases where it doesn't, the Chinese state retains various control elements by offering positive and negative incentives, with which it secures authority over all enterprises in the system.

The other systemic characteristics of the private sector in China, which also concerns its research promotion, lie in management practices. Chinese management culture is characterized by hierarchies and the habit of receiving top-down instructions, first of all from the state. All in all, it can be assumed that state influence on corporate decisions still exists in China. As discussed above, the Chinese government was also the main driver of certain strategies during the reform period to involve enterprises in the funding of public research and innovation. It's still a relatively new phenomenon however, that companies in and from China invest in research while considering the markets and their own interesting in a leading competitive position. In addition, all activities from the private sector are still characterized by the attempt of total control of the state and the Chinese Communist Party. Therefore, the Chinese private sector cannot yet be compared to industrialized countries in the West in its role as a promoter of R&D.

In its haste to unleash the impact of the corporate sector for knowledge creation in the service of economic development, China has used concrete models of foreign and global institutions. In doing so, it has, in part, dared to experiment early with ideas that, in some Western countries, were applied much later by business and science/innovation. Examples of this have been detailed in this article, such as early approaches of venture capital financing in the sector, tax benefits for private enterprises for the engagement in R&D etc. in the late 1990s. A whole infrastructure of intermediaries, financial institutions, etc. was built for these purposes in China since then. Before that, the infrastructure had to first be created by the system for these measures. This included comprehensive structural measures in the form of science and industrial parks, incubators, and specialized sub-institutions of the industry ministries. All of this happened during a relatively short period of about 15 years and largely by the initiative of the Chinese state.

In a relatively short time period, the Chinese government managed to create an entire innovation landscape and new processes and programs from scratch, keeping business, and science in China on their toes. The results so far are respectable, but as described, compared to the huge scale of investment, not yet to the satisfaction of the political leadership.

The sociological concepts around isomorphism of (Western) World Models (DiMaggio, Powell 1983, Meyer, J., et.al. 1997) and loose coupling (Weick, K., 1976) describe the processes which occur between global/Western models and their implementation in national-cultural basic structures. The differences between existing institutional logics, processes, and habits on the local level in China are a decisive reason why the proposed development of the corporate sector's science promotion in China did not have exactly the effect intended by the global models (including the Triple Helix approach). In short, this refers to imported, more recent measures, and institutions (of the Global Model of Science, Drori et al. 2003) that do not have the exact functions when combined with existing structures and practices and without the option to make the necessary adjustments. Therefore, although Chinese policy makers considered and adopted diverse global recommendations (e.g., also provided by global institutions such as the OECD, UN, World Bank), the global models were never fully implemented. Regarding the private sector and its engagement with public research in China this is for instance reflected by the lack of structural coherence when trying to bring businesses and research bodies together.

The ultimate causes for the different relationships and roles of the private sector combined with the government and academia in China, which differs from the original Triple Helix model, lie in the deeply rooted systemic characteristics of the Chinese innovation system. This also includes state dominance, different management habits, institutional competition, including practical barriers such as waste and fraud generated from this competition. Only a superficial reorientation and experimentation with new approaches, such as the recent plan to directly involve the private sector in basic research activities is unlikely to substantially overcome the challenges still identified by the Chinese leadership. Nevertheless, as the Chinese leadership claim in the global race continues in both the economic and innovative spheres, the current FYP period should be observed with particular interest.

This is all the more interesting because this Chinese claim to leadership is to be maintained despite the challenges and setbacks since the pandemic and–as also evidenced by the comments in the current FYP–complete self-reliance seems unrealistic for the Chinese private sector itself.

But what does this mean for the Chinese approach to innovation, when at the same time the positive achievements of its previous hybrid structure without complete coverage of the global models are undisputed overall? In many respects, China has taken the intended role among the leaders in innovation competition (Boeing 2016, Wang et al. 2020). The dominance of the Chinese government, also in the context of Triple Helix, is seen by more and more foreign actors as a recipe for success and could thus establish a new innovation model globally. This is the main reason why the Chinese case remains interesting in the present context, as it challenges traditional models beyond China's borders.

This main argument for this competition of innovation models is only likely to be weakened by the fact that Chinese policy makers are themselves still struggling with their approaches, as they are best able to understand the challenges of the system. However, systemic solutions in the sense of conventional Western models continue to be ruled out as long as the political status quo is preserved.

In the context of China’s private enterprises and their role in the innovation system, the most possible factors that can lead to change is rooted in the internal structures as well as their international linkages. Systemic autonomy for China, especially in economic terms, is a long way off, even in times of shutdowns and newly reinforced borders. Interconnections with global markets, investors–the “Wall Street” factor–and existing and emerging global crises and challenges will continue to influence the development of China's private enterprises and their role in the innovation system. The interactions on global innovation models such as the Triple Helix remain to be seen, depending on what global economic course the future holds.

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