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Peipei Yang, Xielin Liu, Richard P. Suttmeier, Si Zhang

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Does the techno-nationalism approach work for the nation's catch-up? The evaluation of MLP (2006–2020) in China

Peipei Yang

Fraunhofer Institute for Systems and Innovation Research ISI,
Breslauer Str. 48, 76139, Karlsruhe, Germany
Email: yangpeipei66@gmail.com

Xielin Liu*

School of Economics and Management,
University of Chinese Academy of Sciences,
No. 80, Zhongguancun East Road,
Haidian District, 100190, Beijing, China
Email: liuxielin@ucas.ac.cn

*Corresponding author

Richard P. Suttmeier

Department of Political Science,
University of Oregon,
Prince Lucien Campbell Hall, 1415 Kincaid St.,
Eugene, OR 97403, USA
Email: petesutt@uoregon.edu

Si Zhang

School of Economics and Management,
University of Chinese Academy of Sciences,
No. 80, Zhongguancun East Road,
Haidian District, 100190, Beijing, China
Email: zhangsi@ucas.ac.cn

Abstract: In 2006, China launched the ‘National Middle and Long-Term Plan for Science and Technology Development, 2006–2020’ (MLP), which proposed the indigenous innovation. It is among the most essential S&T policies during the past several decades in China, aiming to catch up with the leading countries. This plan marks a transition of China from the techno-globalism development paradigm to the techno-nationalism paradigm, along with changes in the views toward globalisation, the roles of the state, and the underlying logics. The paper examines this policy’s implementation, outcomes as well as the role of techno-nationalism in China’s catch-up by incorporating the institutional logics perspective. Our analysis demonstrates

that, although significant progress has been made in China's science and technology, and catch-up has been realised to some degree, improvements are still needed urgently for China's further development.

Keywords: techno-nationalism; MLP; indigenous innovation; catch-up; China.

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Biographical notes: Peipei Yang is a Postdoc Researcher in Fraunhofer Institute for Systems and Innovation Research ISI. She obtained her PhD degree in Innovation Management from University of Chinese Academy of Sciences, Beijing, China. Currently, she is pursuing her second PhD in International Business at Aalborg University. She has published several papers in peer-reviewed SSCI journals, like *Management and Organization Review* and *International Journal of Technology Management*. Her research interests include innovation strategy, public policy, and innovation ecosystem.

Xielin Liu is a Professor in Management Science at the School of Economics and Management, University of Chinese Academy of Sciences. His research interests include public policy, innovation ecosystem and innovation management. He obtained his PhD in Management from Tsinghua University. He has been directly participating in the national science and technology planning, innovation policy-making, and has made much contribution to the development of the national innovation system. He has published in international journals like *Research Policy*, *Technovation*, *Science and Public Policy* and *International Journal of Technology Management*, etc.

Richard P. Suttmeier is a Professor Emeritus at the Department of Political Science, University of Oregon. He has written widely on science and technology development issues in China. He has served as Senior Analyst, Office of Technology Assessment, Director of the Beijing Office, National Academy of Sciences/Committee on Scholarly Communication with the People's Republic of China. He also served as a Consultant to the World Bank, the UNDP, the Chinese Ministry of Science and Technology, and to the US Government.

Si Zhang is an Associate Professor in Management Science at the School of Economics and Management, University of Chinese Academy of Sciences where she practices teaching and research in technology economics, international development and international business. She obtained her PhD in Economics from the University of Reading, UK and worked as a post-doc researcher in Tsinghua University. She has published in the *Journal of Technological Forecasting and Social Change*, *IEEE Transactions on Engineering Management*, *R&D Management*, *Journal of Engineering and Technology Management* and other SSCI journals.

1 Introduction

Techno-nationalism, as Edgerton defines: “assumes that the key unit of analysis for the study of technology is the nation: nations are the units that innovate, that have R&D budgets and cultures of innovation, that diffuse and use technology. The success of

nations, it is believed by techno nationalists, depends on how well they do this” [Edgerton, (2007), p.1]. Many scholars have labelled Japan and China as representative countries in the techno-nationalism camp. Nevertheless, recently, more and more countries have joined the camp, including the USA in Trump’s era, despite it being regarded as a new tech-nationalism different from the traditional one mentioned above (Luo, 2022). The main difference between traditional and new techno-nationalisms is that the former embraces globalisation, a pivotal method to upgrade local economies, while the latter sets many restrictions on globalisation to weaken the competitiveness of rival countries’ industries (Luo, 2022). Besides, there is another paradigm, namely, techno-globalism, which holds that technology is turning the world into a ‘global village’ (Edgerton, 2007). For example, the new telecommunication technologies would make the boundary of countries disappear. The views towards globalisation, the roles of the state, and the underlying institutional logics vary among different paradigms (see Table 1).

Table 1 Comparison of different development paradigms

	<i>Traditional techno-nationalism</i>	<i>New techno-nationalism</i>	<i>Techno-globalism</i>
View toward globalisation	Embracing globalisation as a critical means to upgrade local economies	Denouncing globalisation, imposing restrictions against technology inflows and outflows of rival nations	Treating globalisation as the dominant means to upgrade the global value chain
Logic	Development logic	National security logic	International collaboration logic
Representative event in China	MLP (2006-2020)	China-US trade war	Reform and opening up
Role of the state	Improving the country’s innovation capability and competitiveness	Weakening target countries’ innovation capability and competitiveness	Improving national economic development and assimilating the world’s leading technologies

Note: Adapted from Luo (2022), with authors’ editing

In Chinese history, the ‘traditional’ (in Luo’s terms) techno-nationalism has played an essential role in the development of science and technology, along with long-time practice of the planned economy and strong government intervention in economic life. The whole-nation system was one of the fruits of the traditional techno-nationalism paradigm, which has gained huge success in several notable projects, like the ‘Two Bombs and One Satellite (*Liangdan Yixing*)’ in the 1950s and 1960s. The spirit of the *Liangdan Yixing* has been grounded in China until now to encourage the realisation of national goals. But the voice of the traditional techno-nationalism became weak after the 1980s following Deng Xiaoping’s taking power and proposal of China’s market reform and opening up, which demonstrated the coming of the techno-globalism. Under this paradigm, economic development was the primary task of the country, and assimilating the world’s leading technologies became the top agenda in national strategies. As a result, FDI has flooded into China and served as an economic engine for China since the 1990s. Around 2000, foreign-invested enterprises accounted for more than 85% of all high-tech exports¹.

As multinationals became increasingly important in economic life (Liu et al., 2017), many government officials and intellectuals worried that foreign enterprises might take over China's economy and threaten China's sovereignty. Against this context, the traditional techno-nationalism became a primary agenda again. This ideology shaped the germination of the MLP (2006–2020) and other essential policies, such as the Made in China 2025 proposed afterwards².

In this study, we mainly focus on the case of MLP (2006–2020) in China, which is regarded as China's most important and ambitious techno-industrial policy in the past several years, aiming to transform China into an indigenous innovative country by 2020 and realising catch-up. The government recurrently stresses that innovation is the determinant of future development and China should catch up with the world by resorting to indigenous innovation. There are mainly three categories of innovation underneath the concept of indigenous innovation: the original innovation that usually comes from basic research; the integrated innovation from the combination of different technologies; the re-innovation based on imported technologies. It demonstrates a broad layout of innovation rather than a flag to close China to the world. Thus, we hold that the MLP is also a milestone for China to transform from the techno-globalism to the traditional techno-nationalism (hereafter, called techno-nationalism), rather than the so-called new techno-nationalism.

The MLP (2006–2020) had come to its end by 2020, and the time is therefore appropriate for reviewing its implementation and the final outcomes, as well as the role of the techno-nationalism in China's catch-up. Though the MLP is vital for China, few studies have analysed it comprehensively. Extant studies about the MLP focus much on some narrow aspects, such as its background, contents, and impact on specific industries or sectors (e.g., Cao et al., 2013; Gu et al., 2009; Serger and Breidne, 2007). For example, Bichler and Schmidkonz (2012) have evaluated the indigenous innovation strategy's impact on foreign enterprises' survival and performances in China. Appelbaum et al. (2016) conclude that the strategic goals of indigenous innovation cannot be realised without a fundamental change in the MLP framework after interviewing stakeholders in the nanotechnology field in China. Another critical work related to the MLP is done by Chen and Naughton (2016), who demonstrate an essential change in China's innovation policymaking after 2003, from a market-oriented mode to government intervention, coinciding with our argument of China's transformation from the techno-globalism to the traditional techno-nationalism under the MLP. But in their paper, they have only analysed the megaprojects of MLP, and their work was done in 2016, far from its end, which cannot guarantee the comprehensiveness of the evaluation. As 2020 was the end year of MLP, it is a good opportunity to analyse the MLP from the whole period, including the key initiatives, the implementation process as well as its outcomes.

The innovative actors in the national innovation system are the main actors in the MLP, much related to this policy's implementation and outcomes. However, little research has been carried out regarding the main innovative actors. We hold that the institutional logic is a suitable perspective for our analysis since the logics that individuals or organisations obey would shape their behaviours as well as their performance (Alford and Friedland, 1985; Boxenbaum and Lounsbury, 2013; Friedland and Alford, 1991). Thus, we have the opportunity to look into actors' implementation of this policy and further evaluate its outcomes as well as the role of the techno-nationalism. It is noted that actors are usually exposed to different logics, which could trigger conflicts

due to logics' varied or even incompatible attributes, like the attention, norms, strategy, and source of authority, etc. (Thornton et al., 2012). It is also in line with our research context, where the innovative actors are following different logics, some of which may conflict with the development logic of the MLP, thus influencing actors' implementation behaviours as well as outcomes.

To address the gaps, we propose the following main questions:

- 1 What are the implementation mechanism and outcomes of the MLP, which has incorporated different innovative actors with different institutional logics in the national innovation system?
- 2 As China is still a developing country and has significantly benefited from globalisation from the 1970s to 2000s, does the techno-nationalism, represented by the MLP, make China realise catch-up?

Except for the logic conflicts, we also consider additional implementation costs that may significantly influence this policy's outcomes. Our findings show that China has made remarkable achievements and stepped into the innovative country list, indicating that China has realised catch-up to some degree under the traditional techno-nationalism paradigm. Yet, some deficiencies still impede China's S&T development due to logic conflicts and implementation costs.

This study contributes to theories and practice in the following ways. First, this paper comprehensively analyses the implementation and outcomes of the techno-nationalism policy (MLP), which supplements the previous evaluation work. Second, by incorporating the institutional logics perspective in the analysis of policies, our research supplements the extant policy analysis studies. Besides, this research also supplements extant techno-nationalism studies, which are located at the macro level and seldom focus on innovative actors. Finally, our work also sheds some light on policymaking and thus helps improve the effectiveness of future policies.

The paper is organised as follows. Section 2 briefly reviews the MLP and the institutional logics perspective. Section 3 presents the analysis of the implementation and outcomes of this policy. Section 4 and Section 5 discusses and concludes our main findings and implications separately.

2 The MLP (2006–2020) and the institutional logic

Since the economic reform and opening-up in the 1980s, China has entered a high-speed development period, especially after joining the WTO in 2001, which was intended to boost further liberalisation and attraction of FDI. For some Chinese analysts and policymakers, China seemed already on the fast track in terms of economic growth and modernisation. For example, the GDP increased from 9,593.3 billion RMB in 2001 to 20,940.7 billion RMB in 2006³.

However, despite the evidence that Chinese economic growth was highly related to export expansion led by foreign-invested firms and the introduction and application of foreign technologies, concerns were still increasing along with more and more FDI flowing into China. Some analysts expressed that attracting excessive foreign investment, which turned China into a 'world factory', was not a sustainable way to modernise the economy (Grimes and Du, 2013; Lu and Feng, 2005). Although China had introduced the

strategy of 'market for technology' to induce foreign investors to transfer advanced technologies, some terms, such as license agreements, were burdensome for domestic enterprises and were not suitable tactics for acquiring technologies (Bichler and Schmidkonz, 2012). In addition, it was argued that foreign enterprises were unwilling to transfer advanced technologies to China in reality. In a highly cited report from the State Council Development Center in 2006, foreign enterprises (FEs) dominated 21 out of 28 major industries in China⁴, and no Chinese enterprises were listed in the top five. It demonstrated that Chinese enterprises with weaker technologies could not compete with FEs and were in danger of being forced into a low value-added position in the supply chains dominated by FEs, who captured more profits from their technological leadership and controlled intellectual property and technical standards (Bichler and Schmidkonz, 2012; Grimes and Du, 2013).

Gradually, concerns stimulated a national discussion initiated by former Premier Wen Jiabao afterwards. It resulted in the introduction of the MLP (2006–2020), which puts great emphasis on 'indigenous innovation', a strategy of traditional techno-nationalism to protect China's economy and security by enhancing national technological sovereignty. China has launched several long-term science and technology plans in the past several decades, but only the '12-year plan' (1956–1967) was considered to be a success under which the 'Two Bombs and One Satellite' (*Liangdan Yixing*) project has gained great success and attracted the world's attention. Wen took much inspiration from it in formulating the MLP (2006–2020). While the policy was launched in 2006, the kickoff conference was held on 30 May 2003, and Wen was the chair. Subsequent meetings involving more than 2,000 experts from the country led to the formulation of the MLP, with the traditional techno-nationalism paradigm being emphasised. For Wen, the techno-nationalism could inspire China to become a global leader in certain technological areas and transform the country's development model from an investment-driven one to an innovation-driven one by improving its indigenous capabilities in science, technology, and innovation.

The MLP outlines the main strategies, policy instruments, and goals. The primary strategies of the MLP are to lead innovative actors to conduct indigenous innovative activities, reduce dependence on foreign technologies, move beyond technological imitation to indigenous innovation, and enhance China's global status and prestige (Senger and Breidne, 2007). The main goal of the MLP is to transform China into an innovative country by 2020, like the USA, Japan, and Germany, which can be measured by some international scoreboard books, indexes, or reports, such as the rankings from International Institute for Management Development (IMD), Global Innovation Index (GII) and the Global Competitive Index (GCI). Underneath the main goal, the following specific initiatives are delineated in the MLP⁵:

- 1 *Increasing R&D investment and reaching 2.5% GERD (Gross domestic expenditure on R&D) by 2020*: the 2.5% GERD is regarded as a necessary condition to become an innovative country. The realisation of this goal requires a significant increase in R&D input from the enterprise sector, as well as central and local governments. The usage of the R&D input is also with limitations, namely expenditures on technology imports to total R&D expenditures should be limited to 30% by 2020 in order to reduce dependence on foreign technologies. It is also a measure to gain greater technological sovereignty and achieve the indigenous innovation goal. Notably, this does not mean China would close the door to foreign technologies like the new

traditional techno-nationalism paradigm. The underlying fact is that Chinese enterprises rely too much on foreign technologies, and the government is trying to change the situation.

- 2 *Improving capability in IPR and standard-setting*: compared with leading countries, China was weaker in the IPR. Thus, the MLP provides exceptional support to relevant innovative activities by setting specific targets for publications, patents, and standard setting, aiming to make China be listed in the club of strong IPR countries by 2020. However, the central government did not clarify what should be done to reach the goal. Instead, the number of IPRs and standard-settings was claimed to be the main indicator, and regional governments began to allocate subsidies to relevant activities, such as patent application and standard-setting, with the aim of increasing the IPR and standard-setting number.
- 3 *16 megaprojects*: megaprojects are aimed to develop key technologies in strategic industries, including core electronic technologies, lunar exploration technologies, etc. These projects are governed by a high level of government bodies, with the Ministry of Science and Technology (MOST) as the key actor and the Ministry of Industry and Information and other ministries being involved at the meantime.

As a grand policy to change the development paradigm, some other instruments are required to supplement it. Thus, in 2007, the Ministry of Science and Technology (MOST) introduced a series of 99 additional policies to supplement the original MLP. These instruments manifest the government's considerations and protection towards some industries and megaprojects. The main initiatives of these policies are as following:

- 4 *Public procurement*: it is an initiative aiming to create new markets for indigenous innovative products. To encourage enterprises to allocate more resources to indigenous innovation, the government established the evaluation standards of new products, which were used to justify whether enterprises' products were eligible for preferential government procurement (Li and Wang, 2015).
- 5 *Special tax incentive policy for high-tech enterprises*: this was an old policy but was reinforced and strengthened in the MLP. It is aimed at encouraging high-tech enterprises in high-tech zones to improve their innovative capability and contribute more to the indigenous innovation.
- 6 *150% R&D tax deduction for enterprises' R&D expenditures*: with new and generous tax reduction initiatives, the government intends to incentivise enterprises to increase their R&D expenditures (Chen and Yang, 2019; Guan and Yam, 2015) and thus improve indigenous innovative capabilities. The policy was imported from western countries in the category of neutralised policy. Instead of picking up the winners, it is aimed to encourage all enterprises to invest more resources in R&D activities, and make enterprises the leading actor in the national innovation system.

The above specific evidence matches the characteristics of traditional techno-nationalism explained by Yadong Luo in the paper published in the *Journal of International Business* (Luo, 2022), rather than the new techno-nationalism paradigm. First, MLP does not mention that it would denounce globalisation. Instead, the MLP encourages re-innovation based on imported technologies. Second, the logic of the MLP is a development logic, aiming to realise catch-up and make China an innovative country. Third, the role of the

state is to improve national competitiveness and capabilities rather than weaken target countries' innovative capabilities.

Implementing this grand policy is a big challenge since it has incorporated many bodies, including many government ministries and departments, and different types of innovative actors in the national innovation system. All of them need to collaborate with each other in the implementation process, which may trigger conflicts since they are following different institutional logics. The institutional logic is defined as "the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality" [Thornton and Ocasio, (1999), p.804]. Thus, from this perspective, the willingness of actors to conduct relevant activities is usually shaped by the institutional logics they adhere to (Llopis and D'este, 2016; Pattit et al., 2012; Yousafzai et al., 2015).

Nowadays, actors are usually embedded in complex environments and thus exposed to different logics (Vedula et al., 2022; Yan et al., 2021; Berggren and Karabag, 2019; Greenwood et al., 2010), which may trigger many logic conflicts (Lounsbury, 2007; Gümüşay et al., 2020). The main innovative actors in the MLP include the universities and government research institutes (GRIs), state-owned enterprises (SOEs), and private enterprises (PEs). Foreign enterprises (FEs) operating in China are also involved in some initiatives under this policy, though with limited roles as a whole. They are following different logics, leading to different behaviours and performances under the development logic of the MLP. Specifically, SOEs are proactively advocating national development strategies following the state logic, which emphasises legitimacy, national capability, and security, etc. (Skelcher and Smith, 2015). PEs and FEs that mainly adhere to the market logic focus more on profit, efficiency, and competitiveness (Thomann et al., 2016). It indicates that under the techno-nationalism paradigm, they would care much more about the market or globalisation. The universities and GRIs, which mainly follow the science logic, put more emphasis on basic research and are eager for S&T outcomes, such as patents and papers (Llopis and D'este, 2016).

When the logic that these innovative actors are mainly following conflicts with the development logic of the MLP, the willingness of the actors to conduct what the governments planned would decrease and hereby influence the outcomes of this policy. Extant studies have verified that the logic conflicts would exert a negative influence on actors' behaviours and performance (Thornton, 2002; Pache and Santos, 2010, 2013; Gümüşay et al., 2020; Marquis and Lounsbury, 2007). For example, the employees may resist the changes when the new logic conflicts with the existing logic, although they value the changes personally (Malhotra et al., 2021). In the case of public service organisations, the logic conflicts arising from incompatible logics can also influence organisations' innovation performance (Vickers et al., 2017).

Thus, we hold that the perspective of institutional logics can provide us an opportunity to look into the implementation mechanisms of actors in the national innovation system and thereby evaluate the MLP's outcomes and the role of the techno-nationalism in China's catch-up. In addition, we also consider additional implementation costs, which may also influence the outcomes of this policy, hoping to analyse the policy more comprehensively.

3 Analysis of the implementation and outcomes of the MLP

In this section, by incorporating the institutional logics perspective, we analyse the implementation and outcomes of the MLP from its main initiatives, with both logic conflicts and implementation costs being considered. We collect data from various sources, including the National Bureau of Statistics, the United States Patent and Trademark Office, the Ministry of Education (MOE), incoPat Database, etc.

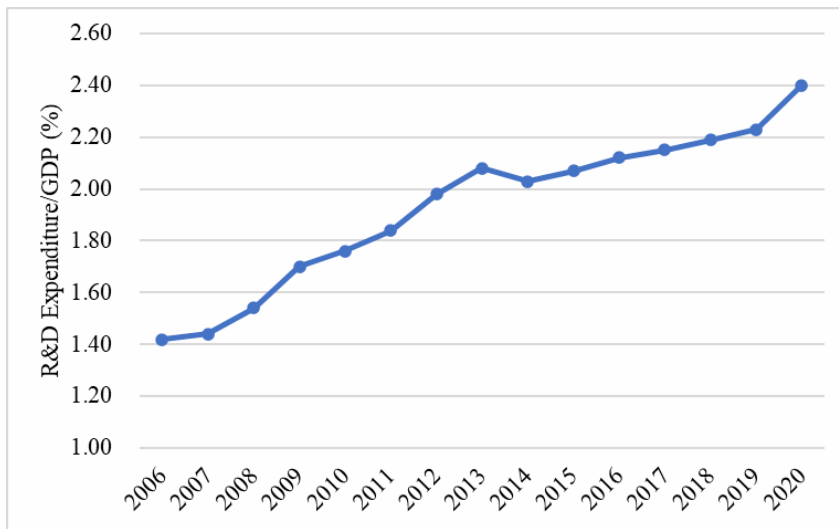
3.1 *Increasing R&D investment and reaching 2.5% GERD by 2020*

Edgerton once expressed, “an implicit techno-nationalism is found in an extreme and widespread form in the assumption that national economic and technological performance is determined by national rates of innovation” [Edgerton, (2007), p.5]. Thus, to catch up with leading countries by 2020, such as the US, China should speed up innovation, which requires much more investment in R&D activities than it used to. In addition, China realises that, compared with developed countries, China’s overall R&D expenditure is insufficient to reach the baseline of an innovative country. Thus, the MLP clearly set the goal for R&D expenditure to reach 2.5% of GDP by 2020. Since the enterprises, universities, and research institutes are all involved in this initiative, realising it requires all the commitment from these innovative actors.

From the institutional logics perspective, there are few logic conflicts. The willingness of enterprises, regardless of the type, to be involved in this initiative is high. For example, under the state logic, SOEs are willing to increase the R&D inputs to protect national sovereignty. For PEs, they can upgrade their innovative capabilities and improve their competitiveness in the increasingly fierce market environment by investing vastly in indigenous innovative activities, in line with the missions of the market logic. All enterprises, including the FEs, can also benefit a lot from relevant acts that are proposed to realise this goal, such as the 150% R&D tax deduction act (being raised to 175% afterwards), which we will discuss specifically in the final part of this section. In addition, domestic enterprises can reduce the costs to pay for the technologies bought from foreign rivals when their innovative capability is improved. The universities and research institutes also need to invest much recourse to increase R&D outcomes under the science logic, such as papers and patents, which are pivotal for their reputation and ranking. Researchers are also eager for more R&D outcomes to get promotions and apply for more projects (Fu et al., 2013; Liu et al., 2017).

Under the techno-nationalism paradigm, the whole ratio of R&D expenditure to GDP has kept rising since 2006 and has stabilised at over 2% since 2013, higher than the average level of EU countries (Figure 1). The proportion of the R&D expenditure to GDP reached 2.4% in 2020. The significant increase in R&D capital has ensured the success of many significant S&T programs that attract the world’s attention, such as the lunar exploration program.

There are few implementation costs for this initiative’s implementation since the R&D investment is decided and allocated directly by the government, an unshakable commitment. The logic conflicts and additional implementation costs under the 2.5 % GERD initiative are concluded in Table 2.

Figure 1 The proportion of R&D expenditure to GDP (see online version for colours)

Source: National Bureau of Statistic, accessed via
<http://www.stats.gov.cn/tjsj/ndsj/>

Table 2 Logic conflicts and additional implementation costs under the 2.5% GERD initiative

<i>Innovative actors</i>	<i>Logic conflicts degree</i>	<i>Additional implementation costs</i>
SOE	Low	Few
PE	Low	Few
FE	Low	Few
University and GRI	Low	Few

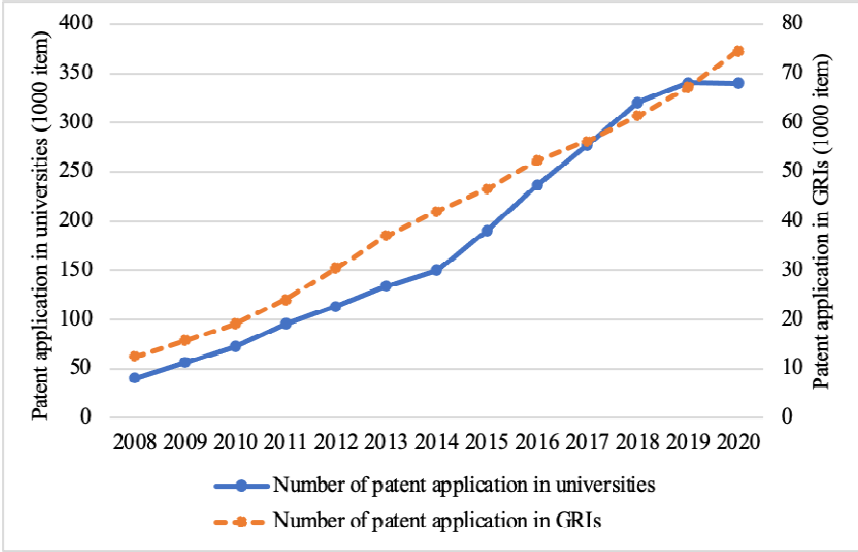
3.2 IPR and standard-setting

IPR used to be a tool to protect innovation. As developing countries usually imitate rather than innovate, strengthening the IPR could protect the interests of developed countries (Fu et al., 2011). Actually, at the beginning of the 21st century, China became quite sensitive to the importance of intellectual property and technical standards since they can enhance China's prestige and improve national competitiveness. In the MLP, under the techno-nationalism paradigm, this initiative aims more for indigenous patents and standards, which can indicate that the country has more technical resources to compete with rivals from developed countries (Peng et al., 2017). The MLP thus specified that the number of patents granted and the number of citations of international research papers should be among the world's top five countries by 2020. The main actors involved in this process are the ministries, local governments, and innovative actors, including enterprises, universities, and GRIs.

To realise this goal, the Ministry of Science and Technology (MOST) and Ministry of Education (MOE) issued several new documents, which expressed that patents and papers would be viewed as important indicators to evaluate R&D projects' performance, which was not modified until 2018⁶. Local governments are also important in realising

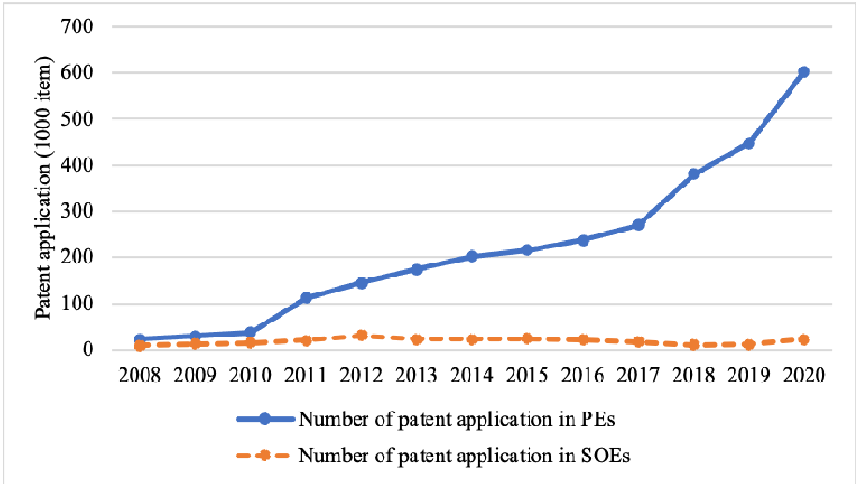
this goal since they need to provide incentives for innovative actors, such as subsidies (Li, 2012; Song et al., 2016). Following that, enterprises, universities, and GRIs were encouraged to increase IPR-related outputs.

Figure 2 Number of patent application in universities and GRIs (see online version for colours)



Source: National Bureau of Statistics, accessed via <http://www.stats.gov.cn/tjsj/ndsj/>

Figure 3 Number of patent application in PEs and SOEs (see online version for colours)



Source: National Bureau of Statistic, accessed at <http://www.stats.gov.cn/tjsj/ndsj/>

From the institutional logics perspective, the degree of logic conflicts triggered by this goal is low. Universities and GRIs have long been treating patents as one important type of

research outputs under the guidance of the science logic. In addition, professors and researchers prefer a measurable indicator to quantify their research work, which can help them apply for more funds and get promotions (Fu et al., 2013). Thus, a sharp increase in the patent number has emerged since 2008, as shown in Figure 2. For PEs, under the techno-nationalism paradigm and along with some preferential initiatives, such as subsidies and tax deduction, they began to take patenting seriously. Besides, in the increasingly competitive environment, they also prefer to apply patents to protect their R&D outcomes and increase competitiveness in both domestic and international markets, in line with the missions of the market logic. However, although the logic conflict is low for SOEs, they are not highly motivated to pay attention to patenting activities since they enjoy the privilege of monopoly in many industries. Thus, the number and the increasing rate of patent applications in SOEs have been disappointing (see Figure 3).

Table 3 Number of patents granted by the US Patent and Trademark Office (USPTO) to international corporate applicants

<i>Year</i>	<i>China</i>	<i>Brazil</i>	<i>India</i>	<i>Russia</i>	<i>South Africa</i>	<i>Germany</i>	<i>Japan</i>	<i>Korea</i>
1995	91	82	64	110	136	7,206	23,139	1,265
2000	274	136	184	273	138	11,592	33,387	3,560
2005	963	116	519	238	121	10,423	32,243	4,696
2010	4,495	277	1,617	436	169	15,171	47,759	12,738
2015	11,061	523	4,667	703	244	20,157	55,449	20,696
2019	25,831	658	7,462	877	304	22,776	57,042	24,140
<i>The annual growth rate in different periods (%)</i>								
1995–2000	24.66	10.65	23.52	19.94	0.29	9.97	7.61	22.99
2000–2005	28.58	–3.13	23.05	–2.71	–2.59	–2.10	–0.69	5.70
2005–2010	36.09	19.02	25.52	12.87	6.91	7.80	8.17	22.09
2010–2015	19.73	13.55	23.61	10.03	7.62	5.85	3.03	10.19
2015–2019	18.49	4.70	9.84	4.52	4.50	2.47	0.57	3.13
1995–2019	26.54	9.06	21.93	9.04	3.41	4.91	3.83	13.07

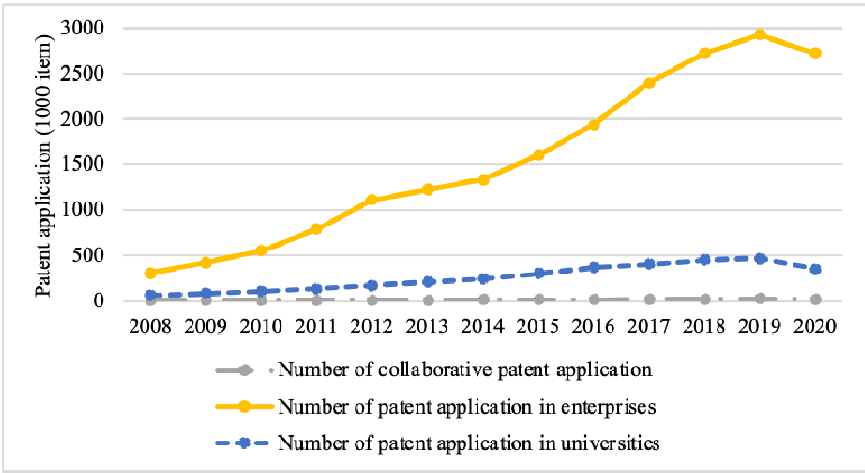
Source: Computed by authors, based on data from the United States Patent and Trademark Office (USPTO)

Overall, this goal has been well achieved (Table 3), and China has gained triumph under the techno-nationalism paradigm. For example, China has achieved great success in the TD-SCDMA standard for mobile telecommunications, which was recognised by the ITU in 2001 (Gao and Liu, 2012). Without MLP, it is impossible to put the TD-SCDMA into operation since there were already several mature standards for 3G at then, such as WCDMA and CDMA 2000. The calling for indigenous innovation, IPR and standard-setting, made the government determined to deploy domestic and new standards. Although TD-SCDMA failed to gain widespread commercialisation compared with widely accepted alternatives, the experience enhanced China's capability to participate in future international standard settings. By now, China has made great progress in the international standard-setting of 5G.

Although there are few logic conflicts, other implementation costs are high. First, costs are required to overcome the problem of weak collaboration between enterprises,

universities, and research institutes. As shown in Figure 4, there are few collaborative patents between enterprises and universities, compared with enterprises' or universities' own patents, which is not favourable for boosting national technology development and commercialisation, as well as improving China's innovative capability (Brannback et al., 2008; Saad et al., 2008; Sarpong et al., 2017). Second, many concerns also arise from the low-quality innovative outcomes (Boeing and Mueller, 2016; Dang and Motohashi, 2015), requiring additional implementation costs to tackle with this problem. Some scholars argued that the incentivising initiative of patenting has slowed down the pace for China to become a more innovative society since the low-quality patents with inferior technologies have got more protection, which may discourage the improvement of superior technologies.

Figure 4 The collaborative patent application between enterprises and universities (see online version for colours)



Source: incoPat Database, accessed via <https://www.incopat.com>

The logic conflicts and additional implementation costs under the IPR and standard-setting initiative are concluded in Table 4.

Table 4 Logic conflicts and additional implementation costs under the IPR and standard-setting initiative

<i>Innovative actors</i>	<i>Logic conflicts degree</i>	<i>Additional implementation costs</i>
SOE	Low	SOE: costs to overcoming inertia due to monopoly
PE	Low	
FE	Low	All participants:
University and GRI	Low	1 costs to coordinate them to carry out joint R&D activities
		2 costs to tackle with low-quality outcomes

3.3 Megaprojects

Under the techno-nationalism paradigm, the government has put much emphasis on the bottlenecks of strategic industries and applied the whole-nation power to tackle with them. Sixteen megaprojects are initiated as part of the MLP, with four major projects in basic research (Chen and Naughton, 2016). These megaprojects are aimed to break technological bottlenecks, safeguard China's technological sovereignty and national economy and defense. Megaprojects have been generously financed. From 2008 to 2012, for instance, about 266 billion RMB were allocated to 4,437 sub-projects under the ten civilian megaprojects, with 88.3 billion RMB from the central government, 29.8 billion RMB from local governments, and 147.7 billion RMB from enterprises.⁷

As can be seen in Table 5, except for ministries, the participants also include enterprises, universities, and research institutes. There are different degrees of logic conflicts among these innovative actors. The SOEs are mainly following the state logic and tasked with promoting technological development, especially in sensitive industries, and guaranteeing national security, in line with the missions of these projects. It indicates the logic conflicts degree within SOEs is low. Universities and research institutions mainly follow a science logic and focus more on basic research (Fu et al., 2013; Liu et al., 2017), also coinciding with the tasks of major megaprojects. Thus, the conflicts degree is also relatively low. PEs mainly obey the market logic, whose focuses usually conflict with the mission of these megaprojects. For example, most PEs are eager to gain short-term profits rather than invest considerable resources in basic and indigenous innovative research, which requires a long period of time to take effect and is full of risks. Therefore, the megaprojects were usually occupied by SOEs, GRIs, and universities. In comparison, PEs were assigned with limited roles despite their demonstrated capacity for market-driven innovation (see Appendix Table A1's examples of the ULSI Semiconductor Manufacturing and High-end Numerically Controlled Machine Tools).

Furthermore, the cost of coordinating actors involved in this initiative is high since the administration of the megaprojects is assigned to many government ministries and agencies, such as the MOST, NDRC, and MOF, and they need to cooperate with each other to realise the mission. In addition, different from other goals in the MLP, there are usually multiple participants in the megaprojects (with some involving hundreds of entities), thus requiring effective coordination among ministries, enterprises, and relevant research teams. But the cross-sector coordination has been a tough problem in the implementation of megaprojects. Despite various institutional reform efforts, the coordination problem was still difficult to be solved (Cao et al., 2013). As one policy analyst from the MOST noted, "... the multi-department joint leading group in promoting cross-sector of coordination in megaprojects is not ideal.... It still lacks supervision and accountability" (Zhang, 2014).

Overall, although several major breakthroughs have been made under the megaprojects, there are still some deficiencies due to the logic conflict as well as high coordination costs. These problems in the implementation process are still hampering industrial development nowadays. The logic conflicts and additional implementation costs under the megaprojects initiative are concluded in Table 6.

Table 5 16 megaprojects under the MLP

<i>Megaproject</i>	<i>Leading unit(s)</i>	<i>Major participants</i>
Core electronic devices, high-end general chip and basic software products	MIIT as the main sponsor	MOST and many agencies as co-organiser. Major actors: university, GRI and SOE
ULSI Semiconductor Manufacturing	Beijing and Shanghai municipal governments (the only major project under the leadership of local governments)	MIIT, MOE, CAS, etc. (Note: Jiangsu, Shenyang, Shenzhen, Wuhan, etc. also in the team)
Mobile broadband communications	MIIT	CAE, MOE, SASAC, CAS, etc.
High-end Numerically Controlled Machine Tools	MIIT	MOE, SASTIND, CAS, CAE etc.
Development of large oil and gas fields and coalbed methane	China National Petroleum Group	China Petroleum and Chemical Corporation, and many others such as MOE, CAS, CAE, China Offshore Oil, Ministry of Land and Resources
Large nuclear power plant project	National Energy Administration	SNPTC, Tsinghua University, CNNC
Water pollution control and treatment	MEE and MOHURD	MOE, MOA, MOHURD, MWR, CAS, CAE, etc.
The breeding of new genetically modified organisms	MOA and MEE	MOE, MOH, NHC, NFGA, SAMR, CAS, etc.
Major New Drug Initiative	NHC	More than 11 ministries in the team, including MOST, NATCM, MOF, etc.
Major Infectious Disease Initiative	NHC	Chinese Center for Disease Control and Prevention, Military Academy of Science

Notes: MIIT – Ministry of Industry and Information Technology; CAS – Chinese Academy of Sciences; CAE – Chinese Academy of Engineering; SASAC – State-owned Assets Supervision and Administration Commission of the State Council; MOA – Ministry of Agriculture and Rural Affairs; SNPTC – State Nuclear Power Technology Corporation Ltd.; CNNC – China National Nuclear Corporation ; MOHURD – Ministry of Housing and Urban-Rural Development; MWR – Ministry of Water Resources; MEE – Ministry of Ecology and Environment; SASTIND – State Administration of Science – Technology – and Industry for National Defense; NHC – National Health Commission; SAMR – State Administration for Market Regulation; NFGA – National Forestry and Grassland Administration; NATCM – National Administration of Traditional Chinese Medicine; MOF – Ministry of Finance; MND – Ministry of National Defense; NDRC – National Development and Reform Commission.

Source: Authors' editing

Table 5 16 megaprojects under the MLP

<i>Megaproject</i>	<i>Leading unit(s)</i>	<i>Major participants</i>
Large Passenger Aircraft	MIIT	Defense departments, regional government, SOE
High-Resolution Earth Observation System	SASTIND	China Centre for Resources Satellite Data and Application, CAS, etc.
Manned spaceflight and lunar exploration project	MIIT, defensive agency	SASAC, SASTIND, MND, etc.
BeiDou navigation system	NDRC	CAS, MIIT, etc.

Notes: MIIT – Ministry of Industry and Information Technology; CAS – Chinese Academy of Sciences; CAE – Chinese Academy of Engineering; SASAC – State-owned Assets Supervision and Administration Commission of the State Council; MOA – Ministry of Agriculture and Rural Affairs; SNPTC – State Nuclear Power Technology Corporation Ltd.; CNNC – China National Nuclear Corporation; MOHURD – Ministry of Housing and Urban-Rural Development; MWR – Ministry of Water Resources; MEE – Ministry of Ecology and Environment; SASTIND – State Administration of Science – Technology – and Industry for National Defense; NHC – National Health Commission; SAMR – State Administration for Market Regulation; NFGA – National Forestry and Grassland Administration; NATCM – National Administration of Traditional Chinese Medicine; MOF – Ministry of Finance; MND – Ministry of National Defense; NDRC – National Development and Reform Commission.

Source: Authors' editing

Table 6 Logic conflicts and additional implementation costs under the megaprojects initiative

<i>Innovative actors</i>	<i>Logic conflicts degree</i>	<i>Additional implementation costs</i>
SOE	Low	All participants: costs to promote cross-sector coordination
PE	High	
FE	--	
University and GRI	Low	

3.4 Public procurement

Following China's accession to WTO, foreign products dominated the domestic market in many industries rapidly, and even the governments have a partiality toward foreign brands, which triggered much concern and aroused widespread discussion. Afterwards, following the example of other countries, China introduced the public procurement policy as a techno-nationalism policy tool issued in the MLP (Georghiou et al., 2014), with the aim of promoting the development of indigenous innovative products (Bichler and Schmidkonz, 2012).

In 2006, the MOST, together with the National Development and Reform Commission (NDRC) and the Ministry of Finance (MOF), issued the Document No. 539, which was intended to clarify the scope of indigenous innovation products and pave the way for the implementation of this initiative. In 2007, the MOF issued three following documents requiring public agencies to purchase indigenous innovative products and services to improve domestic competitiveness⁸. The main actors involved in this initiative include the ministries, domestic enterprises, and foreign enterprises.

Under the techno-nationalism paradigm, this policy invokes many logic conflicts among enterprises, especially PEs and FEs. Due to the complexity of value chains and the main aim of PEs, namely, improving efficiency and gaining more profit under the market logic (Thomann et al., 2016), their products are usually based on many technologies with both foreign and domestic origins. Besides, it has also been proven difficult for the ministries to reach an agreement with enterprises about whether a product is ‘technologically indigenous’. For example, whether the Yaga, a sub-brand product under a leading Chinese computer manufacturer – Lenovo, is an indigenous or international product? It belongs to a domestic brand but is equipped with many imported technologies, such as Windows systems and Intel chips. The degree of logic conflicts in FEs is also high. Although the public procurement policy enjoyed an exemption from China’s WTO commitments since China did not sign the Government Procurement Agreement (GPA) at the time of accession (O’Brien, 2010), it triggered irritation from FEs who had heavily invested in China (Bichler and Schmidkonz, 2012), and aimed to gain more profits in the Chinese market under the market logic. Because it has directly kicked some multinationals out of the supply chain in China or caused much benefits loss to them. Thus, following the criticism from the USA and other western countries, the Chinese government terminated the public procurement policy in July 2011. It also means in the globalisation era, domestic policies need to consider the international stakeholders, which also coincides with the thoughts of the traditional techno-nationalism.

There are also additional implementation costs. Although the degree of logic conflicts in SOEs is low, many of them are not capable of producing complete indigenous products due to incompatibility or some agency problems in the Chinese context (Zhou et al., 2017). What’s more, many Chinese enterprises pretended to claim they were producing innovative indigenous products to get more government subsidies, which opened up the opportunity for corruption and thus diverted the government’s and enterprises’ attention from the real challenges of indigenous innovation.

Table 7 Logic conflicts and additional implementation costs under the public procurement initiative

<i>Innovative actors</i>	<i>Logic conflicts degree</i>	<i>Additional implementation costs</i>
SOE	Low	SOEs: costs to improve the capability to produce indigenous products
PE	High	
FE	High	All enterprises: costs to tackle with fraud information.
University and GRI	--	

The logic conflicts and additional implementation costs under the public procurement initiative are concluded in Table 7.

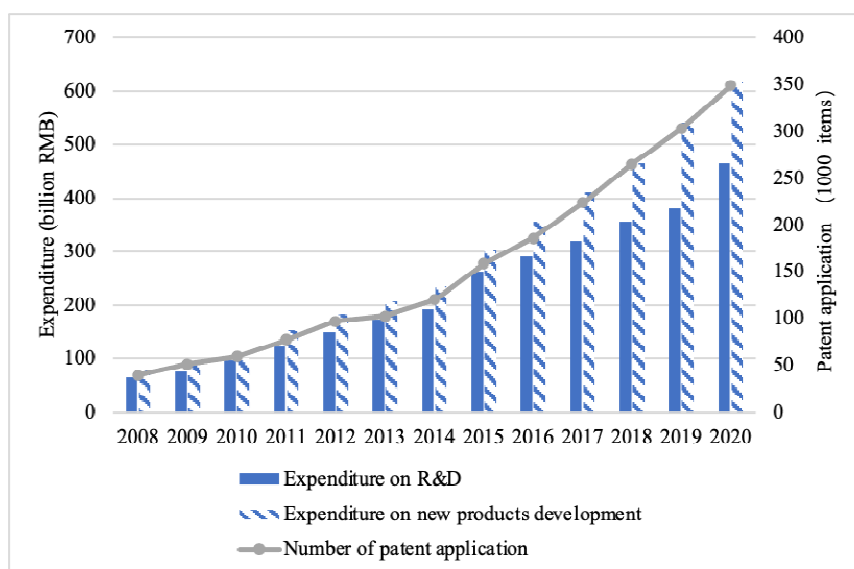
3.5 *Tax incentives for high-tech enterprises*

The Chinese government has long been trying to encourage the development of high-tech industries. The most important initiative for high-tech industries was to set up high-tech zones in 1986, aiming to create better institutional environments for relevant enterprises and promote the development of high-tech and advanced new technologies (Bai et al., 2015). Besides, tax incentives for high-tech enterprises are also essential measures that

have been established since the 1990s. Under the techno-nationalism paradigm, policymakers have put much emphasis on high-tech industries in the MLP, especially manufacturing ones. This is also reflected in the *Made in China 2025* proposed afterwards (Wübbeke et al., 2016).

Specifically, in 2006, the government issued the *Notification of the Ministry of Finance and State Taxation Administration on Preferential Policies for Enterprise Income Tax based on Enterprise Technological Innovation* to enhance the tax deduction of high-tech enterprises⁹, a pivotal instrument of the MLP. According to the *notification*, enterprises that qualify for high-tech zones' criteria could be exempt from income tax for two years after gaining profit. At the end of the exemption period, enterprise income tax would be levied at the reduced rate of 15% of profits.

Figure 5 R&D activities and outcomes of high-tech industries (see online version for colours)



Source: National Bureau of Statistics, accessed at <http://www.stats.gov.cn/tjsj/ndsj/>

Usually, this kind of policy instrument would trigger a low degree of logic conflicts since each type of high-tech enterprises can benefit from the policy, including the FEs. The tax deduction initiative has reduced the tax burden for relevant enterprises, which can also increase their willingness to carry out more innovative activities (Wan et al., 2022). In addition, tax deduction can help high-tech enterprises alleviate financing constraints and provide funds for their innovative activities, thus improving their competitiveness in the market (Bronzini and Iachini, 2014; Chen et al., 2020). The criteria for being a high-tech enterprise include the number of patents, R&D investment, and R&D workforce. As shown in Figure 5, high-tech enterprises have rapidly increased investment in R&D activities and new product development, with the increase of patent applications since the launch of the MLP.

Since the high-tech industries enjoy high priority in national development, this tax initiative has met few challenges, with few implementation costs. The logic conflicts and

implementation costs under the tax incentives for high-tech enterprises initiative are concluded in Table 8.

Table 8 Logic conflicts and additional implementation costs under the tax incentives for high-tech enterprises initiative

<i>Innovative actors</i>	<i>Logic conflicts degree</i>	<i>Additional implementation costs</i>
SOE	Low	Few
PE	Low	Few
FE	Low	Few
University and GRI	--	--

3.6 150% tax deduction for R&D expenditures

A more neutral initiative under the techno-nationalism paradigm is the 150% tax deduction for R&D expenditures of all enterprises. The aim is to encourage enterprises to invest more resources in indigenous R&D activities and take risks for innovation, thus remedying market failure. For many years, the innovative capabilities of most Chinese enterprises were relatively weak compared with universities and GRIs, with enterprises spending less than 1% of sales on R&D research. Most of the input was allocated for assimilating foreign technologies. This policy was intended to alter the behaviour of enterprises' innovative activities (Chen and Yang, 2019; Zhang and Guan, 2018). It also undertakes the special mission of promoting enterprises as the main actor in the innovation system of China.

From the perspective of institutional logics, there are few conflicts among enterprises since they can reduce the cost of R&D activities directly, and the risks arising from these activities can also be partly nullified (Xie et al., 2021). Besides, compared with other instruments, this initiative is more neutral and market-oriented, and thus enterprises can allocate R&D funds with more discretion and improve efficiency (Castellacci and Lie, 2015). It has contributed to the remarkable rise in GERD/GDP and the improvement of enterprises' innovative capabilities during the MLP (Chen and Yang, 2019).

However, there are high implementation costs. The main participants responsible for this initiative are the local governments. Although the central government in China enjoys the highest power to govern the whole society, the local governments are empowered with discretion to make rules for regional development (Chen et al., 2011; Chen et al., 2008). For this tax reduction initiative, while enterprises have enthusiastically embraced it, it also led to a huge loss of local governments' revenue, which used to benefit much from the taxes. Local governments, especially those in underdeveloped regions, worried that they would refund too much of their revenues under this initiative. As a result, the implementation of tax deduction for enterprises has been varied across regions, with the relatively wealthy ones more active, leading to the uncoordinated development of enterprises in different regions. Table 9 illustrates the implementation of this initiative in Hubei Province and Shanghai, with the latter being more developed. In a situation where the supply chains have already spread around every corner in the whole nation, the undercoordination of enterprises across regions would slow down the improvement of the national innovative capability significantly. Besides, additional implementation costs also arise from a situation in which some enterprises may relabel

and exaggerate their R&D expenditure to get more funds, increasing the implementation costs (Hall and van Reenen, 2000).

Table 9 150% additional tax reduction for R&D expenditure in Hubei Province

Year	Hubei			Shanghai		
	150% additional tax reduction (RMB)	R&D expenditure (RMB)	Share (%)	150% additional tax reduction (RMB)	R&D expenditure (RMB)	Share (%)
2010	4.99	26.0	19.20	17.15	47.7	35.95
2011	6.17	33.0	18.68	19.82	56.8	34.90
2012	7.29	37.8	19.29	22.88	63.5	36.02
2013	8.71	45.0	19.36	28.96	73.7	39.29

Note: Share (%) is the proportion of additional tax reduction to R&D investment.

Source: Lin and Zhao (2019); Xue (2015)

The logic conflicts and additional implementation costs under the 150% tax deduction initiative are concluded in Table 10.

Table 10 Logic conflicts and additional implementation costs under the 150% tax deduction initiative

Innovative actors	Logic conflicts degree	Additional implementation costs
SOE	Low	Enterprises: costs to coordinate the development rates due to the discretion of local governments;
PE	Low	
FE	Low	
University and GRI	--	Local governments and enterprises: costs to tackle with the fraud information of enterprises' R&D expenditure.

4 Discussion

At the 2022 National Science and Technology Conference, the MOST reported that progress in the MLP has contributed significantly to the improvement of China's innovation capabilities¹⁰, indicating that the traditional techno-nationalism paradigm can help China realise catch-up. There are also specific indicators to show that the implementation of the MLP (2006–2020) has helped China narrow down the gap with leading countries. For example, national R&D expenditures have grown steadily over the past 15 years, reaching a GERD/GDP of 2.4% in 2020 (Figure 1), which exceeds the 2% GERD/GDP threshold of becoming an innovative country.

Besides, the quantity and quality of scientific papers are also greatly improved, with Chinese SCI papers rising from 71,000 in 2006 to 495,900 in 2019 and highly cited papers rising from 5.9% to 23%, ranking second after the US. In addition, the number of patent applications and invention patent grants ranked first in 2019. It indicates that the universities and GRIs are the winners of the MLP, which faced a low degree of logic conflicts during the implementation of the MLP (see Tables 2, 4 and 6), and have quickly renewed the innovative capability in the past 15 years. In 2006, only two universities in

the Chinese mainland ranked in the top 100 university list according to the QS World University Rankings. But by 2020, this number has risen to six.

Moreover, the MLP has successfully changed the structure of the national innovation system by promoting enterprises as the main innovative actor. For example, lots of studies have provided evidence that the 150% R&D tax deduction initiative under the MLP (2006-2020) has triggered enterprises' enthusiasm to carry out more innovative activities (Chen and Yang, 2019; Guan and Yam, 2015; Xie et al., 2021). Tax incentives for high-tech enterprises also led to an increase in patent application and their excellent innovation performance. Currently, enterprises have contributed more than 70% of national R&D investment, which helps China improve the innovative capability significantly.

Despite significant achievements and progress, the MLP still creates a puzzle about top-down innovation strategies, especially for the PEs. The PEs' role in the MLP has been rather peripheral due to the logic conflicts. For example, they have been acting outside the main scope of the megaprojects. However, they have shown an entrepreneurial zeal for innovation, many of which have even become the world's leaders in some industries, such as Huawei in the ICT industry, Alibaba in the platform and online payment industry, and Tencent and Douyin (TikTok) in the social media area. As Figure 3 indicates, it was the PEs that made the critical contribution to national innovation, with their technologies being largely outside the MLP priorities but suiting the consumer economy. In contrast, SOEs have actively carried out indigenous innovative activities in strategic industries, such as the high-speed railway, but less in emerging industries (Liu et al., 2021).

In addition, under the traditional techno-nationalism paradigm, the degree of logic conflicts arising from some initiatives in the MLP is also high for FEs. For example, the public procurement for indigenous product policy has triggered boycotts from FEs, especially those from the US. What's more, this initiative has also aroused a high degree of logic conflicts among PEs. Thus, it was banned around 2011 due to the logic conflicts as well as implementation costs.

It is noted that although the gap between China and leading countries is narrowed, and the goal of becoming an innovative country seems to be realised, China still lacks the capacity to master 'core technologies' and remains heavily dependent on foreign technologies in some fields. At a conference on 'National Construction and Manufacturing Power' in 2019, the former president of the Chinese Academy of Engineering, Mr. Zhou, observed that "a recent assessment of the security of industrial chains at 26 manufacturing industries, carried out by the Chinese Academy of Engineering, shows that there are still bottlenecks in parts of Chinese industry chains, including lithography machines in the integrated circuit industry, high-end chips in the communications equipment industry, gas turbine thermal components power equipment industry, design and simulation software for the automotive industry, etc."¹¹. We hold that, except for the logic conflicts, additional implementation costs are also responsible for the deficiencies, like the coordination costs between all the innovative actors, costs to improve SOE's capability in indigenous innovation, etc., which should be addressed in future policymaking.

5 Conclusions

From the initiation of China's economic reform plan in 1978 to 2006, China adopted a techno-globalism paradigm and realised fast development. However, the development heavily depended on international technology transfers. Multinationals enjoyed a favourable policy environment and occupied a large market share in China's high-tech industries, triggering concerns among scholars and policymakers. Along with the initiation of the MLP in 2006, the most important S&T policy in the past several decades in China, the paradigm was changed to the traditional techno-nationalism, which prioritises national indigenous innovation and sovereignty. Nevertheless, globalisation also remains paramount, and China's significant progress in innovation is still based on embeddedness in the global innovation network. Although the China-US trade war broke out during the period of MLP, which pushes China focus more on indigenouness, especially on some strategic industries, like the ICT industry, the openness and globalisation are still emphasised by the Chinese government.

Despite great significance, few studies have explored the MLP's implementation as well as the outcomes comprehensively. Thus, in this paper, we analyse the implementation process and evaluate its outcomes by resorting to the perspective of institutional logics and considering the implementation costs. The results demonstrate that China has made great achievements under the MLP and is already on the list of innovative countries, with the realization of catch-up. However, due to the logic conflicts and additional implementation costs, deficiencies still impede China's further development. For example, compared with SOEs, many large PEs are more capable of carrying out indigenous innovative activities and undertaking some big projects. However, the role of PEs in megaprojects is peripheral due to the logic conflicts. In addition, due to the implementation costs to coordinate different kinds of innovative actors in some initiatives, the effectiveness of this policy is also weakened.

Our research contributes to the theory and practice in the following ways. First, although the MLP has been the most significant S&T policy in the past several decades in China, few studies have comprehensively explored the implementation of it as well as its' performance. Most of the relevant papers are focusing much on specific aspects (Cao et al., 2013; Gu et al., 2009), which cannot provide accurate findings. Since it has come to the end of the MLP (2006–2020), we can look into its implementation and outcomes in a more comprehensive manner, supplementing previous research.

Second, by incorporating the perspective of institutional logics in the policy analysis, we also supplement relevant studies in the political field. Since the outcomes and effectiveness of a policy heavily depend on the participants, understanding the logics the participants are following, and the logic conflicts arising from the logic can help us analyse the underlying implementation mechanisms of the policy more accurately.

Third, most of the extant studies about techno-nationalism focus on the macro level (Shim and Shin, 2019; Khan, 2023), and the assumption is that actors would obey the rules of this paradigm, which enjoys the highest priority. However, in reality, innovative actors are following different dominant institutional logics, some of which may conflict with the rules of the techno-nationalism, influencing their behaviours and performance. Our research provides a framework to analyse the logic conflicts under this paradigm and indicates that there would also be some variation in behaviours, extending previous studies.

This paper also sheds some insights into practice. The MLP case reinforces the view that the traditional techno-nationalism paradigm can help developing countries build innovation capability and narrow the gap with global S&T leaders. However, the experience also highlights the problems of nation-led innovation, which suggests that achievement of ‘beyond catch-up’ in China requires more autonomy for private enterprises and more market-friendly innovation policies for foreign enterprises. What’s more, it is necessary for policymakers to consider the logic conflicts and implementation costs to increase the effectiveness of policies. As China launches its 14th five-year plan and introduces a new 15-year MLP (2020–2035), these lessons from the now-completed MLP warrant critical policy attention. Finally, as more and more countries are involved in the techno-nationalism camp, Chinese practice and our evaluation can shed some light on how to design and implement this kind of policy more effectively.

The paper also has its limitation. We did not quantify the logic conflicts and the implementation costs of the MLP. Future research can try to collect more data or apply different research methods to quantify relevant indicators, thus providing more specific suggestions for policymaking. What is more, some influences of this grand policy may take a long time to be discerned. So, we hope that some years later, more work will be carried out to evaluate the MLP (2006–2020).

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Notes

- 1 Source: National Bureau of Statistics, http://www.stats.gov.cn/zt_18555/ztsj/kjndsj/kj2006/index_1.html.
- 2 Source: State Council, http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm.
- 3 Source: National Bureau of Statistics, <http://www.stats.gov.cn/search/s?tab=all&siteCode=bm36000002&q=GDP>.
- 4 Source: The Hexun News, <http://hexun.com/2008-10-25/110454987.html>.
- 5 Source: State Council, http://www.gov.cn/jrzq/2006-02/09/content_183787.htm.
- 6 Source: Ministry of Education, http://www.moe.gov.cn/srcsite/A16/s7062/201811/t20181113_354444.html.
- 7 Source: Ministry of Science and Technology, <http://www.most.cn/ndbg/2013ndbg/201404/P020140422513399067215.pdf>.
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- 10 Source: Ministry of Science and Technology, http://www.most.gov.cn/kjbgz/202201/t20220106_178939.html.
- 11 Source: China Industrial Economic Information, <http://www.cinic.org.cn/zgzz/xw/644065.html>.

Appendix

Table A1 Participants and fund sources of two mega-projects

<i>Mega-project</i>	<i>Main participants</i>	<i>Affiliation</i>	<i>Sub-project</i>	<i>Input and output</i>
High-end numerically controlled machine tools	Beijing Renda Kingbase	University spin-off	R&D and industrialisation of large general database management system and suite	Up to 2017, there are about 500 units (SOE, PE, university and GRI) and more than 50,000 R&D people, with an output of 8,900 patents and 700 standards. The fund for this mega-project from 2006–2020 is about 100 billion RMB, in which central government provides about 32.8 billion RMB.
	Shenyang Institute of Computing Technology Co., Ltd., CAS	GRI spin-off	Application and promotion of domestic software and hardware in CNC/industrial control device	
	Shandong SinoChip Semiconductors Co., Ltd. (SCS)	SOE	DDR3 Dynamic RAM product development and industrialisation	
	Institute of Computing Technology Chinese Academy of Sciences	GRI	Research on new architecture of ultra-high performance CPU	
	Dawning Information Industry Co., LTD.	GRI spin-off	The supporting project of E-level super-computing	
	Tsinghua Tongfang Co., Ltd.	University spin-off	Soc chips of digital television, chips of high-capacity SIM card and the development and promotion of Loongson safety general computer for interactive information	
	Sichuan Changhong Electric Co.,Ltd.	SOE	Research and development of high-quality TV image processing chip and its small batch application	
	Tencent	PE	New generation search engines and browsers	
	Baidu	PE	A new generation of search engine and browser based on 'box computing'	

Source: Authors' editing

Table A1 Participants and fund sources of two mega-projects (continued)

<i>Mega-project</i>	<i>Main participants</i>	<i>Affiliation</i>	<i>Sub-project</i>	<i>Input and output</i>
High-end numerically controlled machine tools	Nanjing University of Science and Technology	University	Research and development of common technology for rolling functional parts of high-grade CNC machine tools.	From 2009–2016, the central government provides about 9.1 billion RMB, with an output of 3,956 patent applications and 407 national and industrial standards. The number of new products and technologies is 2,951, and the added value is about 70.6 billion RMB.
	Beijing Research Institute of Automation for Machinery Industry	GIR	12 MeV standing wave electron linac for industrial non-destructive testing	
	Beijing Research Institute of Mechanical and Electrical Technology	GIR	Open-close heat treatment equipment	
	Baoji Machine Tool Group Co., Ltd.	SOE	High-speed CNC lathe and turning centre	
	Nanjing CNC Machine Tool Co., Ltd.	SOE	Research and application of serial products of large-size precision CNC lathe and turning centre	
	Jier Machine-Tool Group Co., Ltd.	SOE	High-speed gantry five-axis machining centre Double swing angle CNC universal milling head	
	Tianshui Spark machine tool Co., Ltd.	SOE	Research and development of Aviation Precision Machining CNC lathe	
	Shenyang Machine Tool Group	SOE	Five-axis precision horizontal machining centre and more.	
	Anyang Xinsheng Machine Tool Co., Ltd.	PE	ADG series high-speed CNC lathe and turning centre and more.	
	Qinchuan Machinery Development Co., Ltd.	SOE	High speed, precision and large CNC cylindrical gear grinding machine	

Source: Authors' editing