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Political Economy of STI in China: Analyzing Official Discourse on Science, Technology and Innovation-Driven Development in the Contemporary China

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Abstract

Science, technology, and Innovation (STI) have been the cornerstone of China's Reform and Opening-up processes. Employing a hybrid methodology, including textual analysis, this paper asserts that four decades of reform and opening-up have witnessed STI's pivotal role across sectors despite numerous challengesб such as economic slowdown, growing disparities, environmental issues, and a huge burden on the state-owned enterprises. China's substantial investments in the Fourth Industrial Revolution technologies, including Artificial Intelligence and New Energy Vehicles, exemplify its commitment to innovation, reflected in over 2.5% of GDP allocated for research and development in 2022. This robust investment has bolstered China's innovative capabilities and brought about its high ranking on the Global Innovation Index. In Chinese STI politics and policy-making, the programs like MLP-2006, SEI-2010 and Made in China 2025 have created a watershed moment. Three central research questions guide our exploration: the trajectory of policy framing on STI-Driven development, the theoretical underpinnings of Innovation-Driven Development and Green Development in Chinese STI politics, and the significance of these paradigms in China's context. This paper also hypothesizes the emergence of two distinct trajectories within China's STI politics through the adoption of Innovation-Driven Development and Green Development, positioning STI at the core of China's development paradigm. The study thoroughly dissects China's official discourse, framing these paradigms within the Sustainable Development context and highlighting their crucial roles in China's journey toward technological advancement and sustainability. The

analysis of the evolution of China's STI policy as portrayed in official discourse offers insights into the strategic role played by science, technology, and Innovation in moulding China's socio-economic trajectory alongside global implications stemming from its transformative development agenda.

Keywords
4rth IR, Innovation-Driven Development (IDD), Green Development, Science, Technology and Innovation (STI), STS Politics

JEL: O38.

Аннотация
Наука, технологии и инновации (НТИ) являются краеугольным камнем процесса реформ и открытости Китая. Используя гибридную методологию, включая текстовый анализ, автор утверждает, что четыре десятилетия реформ и открытости стали свидетелями ключевой роли НТИ во всех секторах, несмотря на многочисленные проблемы, такие как экономический спад, растущее неравенство, экологические проблемы и огромное бремя для предприятий, находящихся в государственной собственности. Значительные инвестиции Китая в технологии Четвертой промышленной революции, включая искусственный интеллект и транспортные средства на новой энергии, служат примером его приверженности инновациям: более 2,5% ВВП выделено на исследования и разработки в 2022 году. Эти крупные инвестиции укрепили инновационный потенциал Китая, о чем свидетельствует его высокий рейтинг в Глобальном инновационном индексе. В китайской политике в области НТИ такие программы, как MLP-2006, SEI-2010 и «Сделано в Китае 2025», стали переломным моментом. Три центральных исследовательских вопроса направляют наше исследование: траектория формирования политики развития, основанного на НТИ, теоретические основы инновационного развития и зеленого развития в китайской политике в области НТИ, а также значение этих парадигм в контексте Китая. В данной статье также выдвигается гипотеза о появлении двух различных траекторий в политике Китая в области НТИ посредством принятия инновационного развития и зеленого развития, что ставит НТИ в основу парадигмы развития Китая. Исследование тщательно анализирует официальный дискурс Китая, помещая эти парадигмы в контекст устойчивого развития и подчеркивая их решающую роль на пути Китая к технологическому прогрессу и устойчивому развитию. Анализ эволюции политики Китая в области НТИ, как она представлена в официальном дискурсе, дает представление о стратегической роли, которую играют наука, технологии и инновации в формировании социально-экономической траектории Китая, а также о глобальных последствиях, вытекающих из его программы преобразовательного развития.

Ключевые слова
4-я ПР, Инновационное развитие (IDD), Зеленое развитие, Наука, технологии и инновации (НТИ), меры STS

JEL: O38.

Abbreviations

AI	Artificial Intelligence
CD	China Dream
CPC	Communist Party of China
GD	Green Development
IDD	Innovation-Driven Development
IoT	Internet of Things
MIIT	Ministry of Industry and Information Technology
ML	Machine Learning
MOF	Ministry of Finance
MOFCOM	Ministry of Commerce
MOST	Ministry of Science and Technology
NDRC	National Development and Reform Commission
SIPO	State Intellectual Property Office

1. Introduction

Four decades of reform and opening-up (改革开放 Gǎigé kāifàng) in China sustained the overall development agenda on several fronts, e.g. agriculture, industry and services. Science, Technology and Innovation (STI) (科学、技术和创新 Kēxué, jìshù hé chuàngxīn) have been central to this process. However, the falling growth rate, rising inequality, both income and regional, environmental pollution and the massive burden of State-Owned Enterprises (SOEs) have negatively impacted the Chinese economy. Nevertheless, China has been investing substantially in the fourth Industrial Revolution (4IR)[1], where technologies like Artificial Intelligence (AI) and New Energy Vehicles (NEVs) are emerging as the new driving forces. China's investment in R&D as a percentage of Gross Domestic Product (GDP) reached around 2.56% in 2022 (Statista, 2022). Moreover, its GERD tends to have a year-on-year increment (Gross Expenditure on Research & Development). These vast investments enhanced the innovative capabilities of Chinese individuals and firms: in 2023 China stood at 12th position[2] on the Global Innovation Index (GII) among the 132 economies (WIPO, 2023).

[1] See Schwab, K. (2017) for the scholarly discussions on the Fourth Industrial Revolution.

[2] For the coherent understanding of the Chinese position at Global Innovation Index, we should compare it with same-set of economies. For that matter, China ranks 1st among the 33 upper-middle-income group economies and at 3rd among the sixteen economies in South East Asia, East Asia, and Oceania. (WIPO, 2023)

Year	GII Position	Innovation Inputs	Innovation Outputs
2020	14th	26th	6th
2021	12th	25th	7th
2022	11th	21st	8th
2023	12th	25th	8th

Innovation-Driven Development (IDD) *(*创新驱动发展 *Chuàngxīn qūdòng fāzhǎn)* is a further expansion of STI capabilities in China's economic statecraft. It is a core agenda of President Xi's development philosophy. In 2016, Xi announced the achievement of three stages of innovation-driven development for China (Zhao, 2016, pp. 55–68). The first is to transform China into an innovative country by the end of the second decade of this century; the second is to make China one of the most innovative countries by 2030; the third is to turn China into an innovation powerhouse by 2050.

Although China missed the industrial revolution powered by coal-fired steam engines, it is progressing rapidly in emerging technologies in the Industry 4.0 or Globalisation 4.0 era (Hu et al, 2018). Technologies like AI are transforming the economic production patterns of the globe. Therefore, the ownership of these critical technologies and their indigenous development can fuel national development. In this context, AI and New Energy Vehicles will help address several critical issues, including those of unsustainable growth and environmental degradation. Ideas on innovative development, coordinated development, green development, open development and shared development have become most significant (Hu et al, 2018). Innovative and green development policies have proved to be a cornerstone of the Chinese economy in the Xi era.

2.1 Research objectives

Three central research questions guide our exploration: the trajectory of policy framing on STI-Driven development, the theoretical underpinnings of Innovation-Driven Development and Green Development (绿色发展 *Lüsè fāzhǎn*) in Chinese STI politics, and the general significance of these paradigms for the country's progress. This paper thoroughly dissects China's official discourse, framing these paradigms within the Sustainable Development context and highlighting their crucial roles in China's technological and sustainability advancement. The analysis of the evolution of STI politics in China as portrayed in official discourse offers insights into the strategic functions of science, technology, and Innovation in moulding China's socio-economic trajectory alongside global implications stemming from its transformative development agenda.

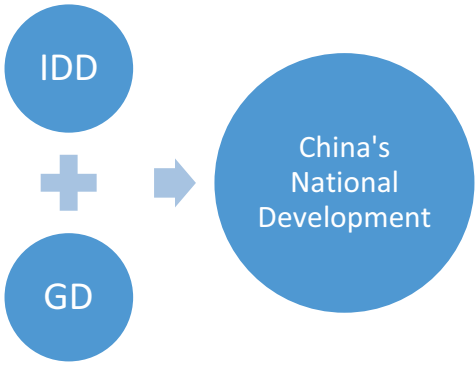
2.2 Hypothesis

This paper hypothesises the emergence of two distinct trajectories within China's STI politics through the adoption of Innovation-Driven Development (IDD) and Green Development (GD), positioning STI at the core of China's development paradigm.

2.3 Research methodology

The proposed research methodology for Innovation-Driven Development (IDD) and Green Development (GD) in China is centered on reviewing primary Chinese policy

documents and involves studying the primary sources like official government reports and speeches and secondary sources for a broader context. Thematic and chronological coding will be used to identify policy themes and trace their evolution over time, while quantitative and qualitative content analysis will help evaluate policy rationale and gauge its impact. Comparative and contextual analyses will explore historical, political, and cultural factors that influence policy choices and their synergies. The paper employs the interdisciplinary approach to the research.



3. Discussion(s)

3.1 Science, Technology, Innovation and Development

Theorisation is essential for understanding the trajectory of the Chinese economy. In the pre-reform period, China followed a Soviet-style heavy industrialisation path where the state was involved in all economic and production-related activities. Later, strengthening the scientific and technological capabilities was the primary focus of the reform period. Through expanding S&T capacities, productivity and national competitiveness were enhanced. That is why, to understand the phenomenal development of China's economy in the past four decades it is essential to focus on STI strategies. Technological upgradation and product development in China have been carried out through various models such as China's Development Model (CDM), Development State (DS), Institutionalism, and others.

Contrary to the Washington Consensus (an amalgamation of the free market and liberal democracy), the Beijing Consensus described the system where market forces worked in an authoritarian state and technological innovation was the key driver of growth (Ramo, 2004). However, several scholars have negated this theory. For instance, Hsu et al. (2011) proposes that the CDM is empirically more relevant and analytically more rigorous than BC. Again, Hsu and others defined 'Janus-faced state-led growth' as the economic imperative of CDM (Hsu et al., 2011: 4). Several scholars argue that CDM, as a more appropriate economic development model, best suits late

developers. Here, the state is a crucial actor in policy determination and is the key market driver. However, there are other theoretical approaches which describe the nature and role of the state in China's growth story, such as local state corporatism (Oi, 1992), the entrepreneurial state (Duckett, 1998) or the regulatory state (Shue, 1995). Apart from these, the researcher Yette To (2022) listed some of the theoretical models as follows: a 'socialist developmental state' (White & Wade, 1988), the 'entrepreneurial state (Blecher, 1991), a 'diffuse developmental state' (McNally & Chu, 2006), 'state-led capitalist developmentalism' (Gallagher, 2005), 'state capitalism' (Bremmer, 2009) (Bremmer, 2009) etc.

However, as a state-centric development model, the Beijing Consensus (BC)[3] and China's Developmental Model (CDM) undermine the institutions' role in the development and technological upgradation. We, therefore, need a development model for a transitioning country like China that draws a broader picture; Institutionalism as a developmental theory, in which institutions are regarded as the drivers of development, may provide such a model. Institutionalism shows that material development and technological upgradation are closely related to institutions supporting science and technology innovation. In economic statecraft, institutions that also include policies, legal and regulatory apparatus, and accepted norms and behavior of the general public play a vital role in development. Acemoglu and Robinson (2010)[4] argued that institutions are the key players behind economic development across various geographical regions. Most of them are modelled on their Western counterparts, which may point to the vital importance of these institutions in China's STI-driven development story.

Joe R. Campbell (2013) argues that since 1978, China's most significant technological strength has been its ability to adopt foreign technology and promote export-oriented industrial production. The future, however, is in 'green technology', where Chinese domestic and foreign firms have growth potential. Further, Campbell asserts that China's credibility as a green-tech leader would depend upon developing its less energy-intensive development model. He further suggests that apart from creating new avenues for green-tech (clean-tech) industrial production, China needs a comprehensive and sustainable mobility model for its 1.4 billion people.

Varaprasad S. Dolla (2015) delineates the development of S&T institutions and policies in contemporary China. Prof Dolla posits that the S&T policy framework is narrow and needs to incorporate social variables. He underscores the need for a science audit in measuring science and technological development. Further, he argues for democratization and pro-poor science policy.

In response to the question of whether policies can positively impact innovation, Bessen (2010) suggests that there are variations between nations' abilities to develop

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[3] For further scholarly discussions on the various contours of the China Model and the making of the Beijing Consensus in the political economy of development, see (Kennedy, 2010), (Li et al., 2010) and, (Ambrosio, 2012).

[4] For further discussions on how Institutions affects economic and political development of a country, see Acemoglu and Robinson (2013).

new technologies and that this could be determined by such factors as innovation policies, economic institutions, culture, or geography. Bessen and Meurer (2008) propose that government contracting and prizes are more effective means than patents for promoting and sustaining innovation. It is generally accepted that innovation and development show a positive correlation. Innovation creates new types of production methods, and the entrepreneurs who propagate innovation create opportunities for business investment and employment for the general public, thus causing a positive spillover effect in the economy. This process has been described by the eminent economist Schumpeter, for whom development was a historical process of structural changes brought about by innovation and technological upgradation (Ruttan, 1959) (Liberto, 2022).

In her book, Xiaolan Fu (2015) explores the ways of China becoming a leading innovative nation through the strategy of compressed development. The book's core objective is to provide a systematic, comprehensive, and rigorous study of China's pursuit of innovation. The analysis in the book is made at the firm, industry, region, and country levels, presenting an overall picture of China's national innovation system. The journey towards innovation in China has involved the participation of state and market and hence private and public entrepreneurs. Comparing China with other developing economies like India and developed economies like the US, the author concludes that China's economic development results from the enhancement of its science, technology, and innovation capabilities.

Vitalina Babenko et al. (2020) contends that the ideological approach to Chinese development was centred on Deng Xiaoping's theory of technological progress. According to this approach, China's economic development and innovation system are intertwined and have emerged as major obstacles to foreign economic globalisation. The article examines China's innovative economic system. It uses several factors for analysis, including Gross Domestic Product (GDP), Balance of Payment (BoP), Foreign Direct Investment (FDI) (both inward and outward investment), stocks, and annual data. Babenko et al. (2020) challenges the mainstream belief that the Chinese National Innovation System (NIS) is unstable. Instead, she argues that the combination of administrative and market mechanisms within the NIS creates a unique working mechanism that guarantees the economy's long-term sustainability.

In their paper, Li Zheng et al. (2020) evaluate the discussions surrounding China's innovation system and propose a concept of 'Innovation with Chinese Characteristics.' They argued that state played a significant role in institutional reforms during the reform era, and strengthening S&T capabilities had been instrumental in China's robust economic growth over the past four decades. The authors also discuss the strategies adopted by the Chinese authorities to enhance S&T capabilities and promote industrial production, including acquiring foreign technologies and expertise and moving up the global value chain through international mergers and acquisitions (M&As). They highlight the importance of 'Forward Engineering', coupled with parallel learning from FDI firms, where university spin-off firms play a greater role in product development. However, the authors acknowledge the shortcomings of this strategy, including

the duplication of S&T projects, lack of transparency in S&T management, and low efficiency in fund usage.

Wang, Quan-Jing et al. (2019) investigate the impact of government ideology on innovation and outline its main implications. The study uses a sample of 110 countries and covers the period between 1995 and 2015, with trademark and patent applications selected as the key indicators of technological and innovation progress. As scholars have noted, technological innovation is at the core of management and economic development. The findings reveal that a left-ruling party tends to hinder the progress of technical innovation, while a right-wing ruling party promotes the emergence of new technology. The study employs the generalized method of moments (GMM) technique for estimation, enhancing the accuracy of the findings.

Baek (2005) identifies key elements of the East Asian development model that China has adopted, such as state control over finance, government support for state-owned enterprises (SOEs), import substitution industrialization in heavy industry, reliance on export markets, and high domestic savings rates. These characteristics mirror those of Taiwan more closely than Japan or Korea, due to China's dual economic structure separating public and non-public sectors. Baek suggests that even with corporate governance reforms, the core attributes of the East Asian model will persist in China.

Expanding on the relationship between state and market, Dickson (2003) explores the evolving dynamics between the Chinese Communist Party (CCP) and private entrepreneurs. Contrary to the expectation that economic liberalization would spur political change, Dickson demonstrates that private entrepreneurs in China tend to align with state interests, maintaining a cooperative rather than oppositional stance. This alignment underscores the state's continued influence over economic actors and suggests a unique model of state capitalism.

Evans (1995) provides a broader theoretical framework for understanding the state's role in economic transformation, introducing the concept of "embedded autonomy." He contrasts predatory states like Zaire with developmental states like Korea, emphasizing that successful state intervention requires a balance between internal coherence and societal engagement. China's developmental state exhibits these traits, as evidenced by its ability to guide industrial transformation while maintaining strong state-society ties.

Douglas (2016) delves into the paradox of China's technological development, where inefficient financial systems coexist with vibrant high-tech firms. He identifies hybrid firms—combining ethnic Chinese management with foreign financing—as crucial drivers of technological progress. These hybrids leverage the strengths of both domestic and international systems, circumventing the inefficiencies of China's domestic financial institutions and illustrating an alternative pathway for technological advancement.

Knight (2014) further explores the characteristics and sustainability of China as a developmental state. He highlights the institutional mechanisms, such as fiscal decentralization and patronage relationships, that have fostered economic growth. However, Knight also points to the socioeconomic challenges that rapid growth has

created, suggesting the need for broader government policy objectives beyond mere economic expansion.

Wang et al. (2019) investigate the impact of government ideology on innovation, revealing that right-wing ruling parties tend to promote technological innovation more effectively than left-wing parties. This finding adds nuance to the understanding of political factors influencing technological development and underscores the importance of political context in shaping innovation policies.

Woo-Cumings (2019) revisits the notion of the developmental state, critically assessing its relevance and applicability beyond Japan. The collective insights of the contributors highlight the interplay of political, bureaucratic, and economic forces that shape developmental trajectories in East Asia, providing a comparative perspective that includes China's unique experience.

Zhao (2010) addresses the broader question of whether China's development model can replace the Western model of modernization. He argues that China's economic success within an authoritarian framework challenges conventional modernization theories, offering an alternative model that combines free market mechanisms with strong state control to ensure economic growth and political stability. However, Zhao also acknowledges the limitations and potential drawbacks of this model.

China's development model, characterized by elements of the East Asian developmental state and unique adaptations, has profoundly influenced its trajectory in science, technology, and innovation. The state's strategic intervention, coupled with the integration of market mechanisms and hybrid organizational forms, has enabled China to achieve remarkable technological progress.

This paper argues that the theorization of science, technology, and innovation-driven development in China reflects a dynamic interplay between state intervention, technological progress, and institutional dynamics. From the pre-reform period's heavy industrialization to the reform era's focus on strengthening S&T capabilities, China's development trajectory has been characterized by a unique blend of market forces and state-led initiatives. The emergence of theoretical models like the China Development Model (CDM) and the Beijing Consensus (BC) highlights the central role of the state in driving innovation and economic growth. However, scholars like Varaprasad S. Dolla (2015) argue for a more inclusive policy framework that considers social variables and promotes democratization and pro-poor science policies. Additionally, the importance of institutions in supporting science and technology innovation is emphasized, with theories like Institutionalism shedding light on their role in facilitating technological progress. Looking forward, the challenge for China lies in transitioning towards sustainable development models, particularly in green technology, to ensure continued economic growth while addressing environmental concerns.

3.2 Innovation-driven development (IDD)

Innovation-driven development (IDD) is a further expansion of STI capabilities in China's economic statecraft. It is a core agenda of President Xi's development philosophy. In

2016, Xi announced the achievement of three stages of innovation-driven development for China (Zhao 2016, pp. 55-68). The first is to build China into an innovative country by the end of the second decade of this century, and the second is to move China to the forefront of innovative countries by 2030. The third is to make China an innovation powerhouse by 2050. Xi Jinping announced his plan for innovation-driven development in 2016 as part of China's broader strategy to transition its economy from reliance on low-cost manufacturing and exports to one driven by innovation and technology. This shift aimed to address challenges such as overcapacity in traditional industries and the need to upgrade the economic structure for sustained growth. China recognized the importance of enhancing competitiveness in the face of rising labor costs and increasing competition from other emerging economies. By focusing on innovation, China aimed to move up the global value chain, producing higher-value products and services. Furthermore, innovation was crucial for addressing challenges related to environmental sustainability, energy efficiency, and resource conservation. Overall, Xi Jinping's announcement reflected China's acknowledgment of the imperative to adapt to changing global economic dynamics and position itself for sustainable growth in the future.

Scientific and technological Innovation has always been echoed in the writings and speeches of Chinese leadership. In Mao's economic purview, apart from class struggle and the struggle for production, scientific experiments had counted as one of the three great revolutionary movements for building a powerful socialist country[5].

Again, Mao reiterated the importance of planning for scientific and technological advancements as "the Chinese people should have long-range plan, strive to change the economic, scientific, and cultural backwardness of China within a few decades, and quickly reach the most advanced level in the world" (Hu et al., 2018, pg. 20). Based on the above premises, Chinese government came up with the policy of Long-Range Plan of Scientific and Technological Development, 1956-1967. It was the first long-term plan for Chinese scientific and technological development to build up its scientific strength, which intended to transform the Chinese economy at a grander scale. This first program charted out the fifty-seven areas of focus, including 'peaceful' use of atomic energy, wireless electronics, semiconductor technology, automation technology, computer technology, jet-propelled and rocket technology, etc. (Embassy of the People's Republic of China in the Syrian Arab Republic, 2009). Mao Zedong's introduction of the Long-Range Plan of Scientific and Technological Development, 1956-1967, was a strategic move shaped by both geostrategic considerations and national imperatives. At the geopolitical level, the plan responded to the dynamics of the Cold War era. With the United States and the Soviet Union engaged in a race for scientific and technological supremacy, China sought to assert its presence on the global stage by investing in advanced research and development. The launch

[5] Note on "The Seven Well-Written Documents of Chekiang Province Concerning Cadres' Participation in Physical Labour" (May 9, 1963), quoted in On Khrushchov's Phony Communism and Its Historical Lessons for the World, pp. 71-72.

of the Soviet satellite Sputnik in 1957 heightened the sense of urgency, underlining the significance of technological prowess in geopolitical competition (Bradley, 2007). Domestically, the plan was driven by Mao's vision of transforming China's agrarian economy into a modern industrial powerhouse. Investing in scientific and technological development was seen as essential for achieving economic modernization goals, promoting industrialization, and increasing productivity across various sectors. Furthermore, enhancing scientific capabilities was imperative for strengthening national defense, as highlighted by the plan's focus on areas such as atomic energy and aerospace technology. Ideologically, the plan aligned with Maoist principles of self-reliance and independence, aiming to reduce China's dependence on foreign technology and expertise. Overall, Mao's introduction of the Long-Range Plan marked a significant step towards positioning China as a major player in the global scientific and technological arena, while advancing its domestic socio-economic goals in alignment with its ideological framework.

The Chinese leadership has also insisted on technological catch-up. As Mao elucidated, "We cannot insist on the ready-made principle of technology development in various countries around the world; that is, we cannot crawl behind others step by step. We must break the pattern and develop China into a great power of socialist modernization in a short historical period using advanced technology as far as possible (Hu et al., 2018, pg. 20-21)."

Successive leadership also emphasizes the leading and catching up positions in science and technology. As the harbinger of reform and opening up in China, Deng Xiaoping (1978) equated science and technology as one of the productive forces at the National Science Conference 1978.

1985, December: Communique of the 3rd Plenary Session of the 11th CPC Central Committee: To actively develop economic cooperation with various countries worldwide based on equality and mutual benefit based on self-reliance, and to strive to adopt world-class advanced technology and advanced equipment.

1995, September: the 5th Plenary session of the 14th CPC Central Committee rejuvenated China through science and education. It lists the following aims[6]:

1. Accelerate the commercialization and industrialization of scientific and technological achievements.
2. Actively develop high-technology and related industry
3. Strengthen basic scientific research, focus on cutting-edge science, overcome critical difficulties, and strive for breakthroughs in the key fields.

Deng Xiaoping's emphasis on science, technology, and innovation (STI) as drivers of development stemmed from a careful analysis of both national and geopolitical factors. At the national level, Deng recognized the imperative of leveraging STI to propel economic growth and modernization. Geopolitically, Deng Xiaoping's push for

[6] Recommendations for the 9th Five-Year Plan for Economic and Social Development and the 2010 Long-Range Goal, adopted at the 5th Plenary Session of the 14th Central Committee of the Communist Party of China on September 28, 1995 (excerpted in Hu et al. 2018:21)

STI-driven development was informed by China's desire to enhance its international standing and competitiveness. The commitment to economic cooperation with other countries, as outlined in the 1985 Communique, highlighted China's aspiration to engage with the global community on equal terms while actively seeking advanced technology and equipment. This strategic approach positioned China as a key player in global technological innovation and development, aligning with Deng's vision of China's rise as a modern, prosperous nation. Moreover, the emphasis on rejuvenating China through science and education at the 1995 Plenary session underscored Deng Xiaoping's recognition of STI as crucial for addressing national challenges and achieving sustainable development. By focusing on breakthroughs in key fields and fostering an environment conducive for technological advancement, Deng aimed to propel China towards becoming a knowledge-based economy, capable of competing at the forefront of global innovation. Overall, Deng Xiaoping's advocacy for STI-driven development was a result of a comprehensive analysis of both domestic imperatives and global dynamics. By strategically prioritizing STI, Deng sought to harness China's scientific and technological potential to drive economic growth, enhance national competitiveness, and elevate China's role on the world stage.

Then President Hu Jintao reiterated several times that science and technology are the main factors of productivity growth and a major driving force behind economic and social development. There will be a new way of scientific innovation with unique, China-oriented, characteristics (Na, 2004).

2006, January: National Medium- and Long-term Plan for Science and Technology Development (2006-2020)

2012, November: The 5th Plenary session of the 18th CPC put innovative development at the core of all national development and also made the following decisions about the general direction of the process:

1. From "marching towards science" to "breaking with tradition to achieve leaps in development";
2. From "Science and technology constitute one of the China's productive forces" to "science and technology is the primary productive force";
3. From "the strategy to rejuvenate China through science and education" to "improving the ability for independent innovation."
4. From "building an innovative country" to "an innovation-driven development idea" and then ultimately to "adhering to innovative development, and shaping world-leading development that is based on innovation, and maximizing first-mover advantages".

2015, March: Opinions on Deepening the System Reform and Mechanism and Speeding up the Implementation of the Innovation-Driven Development Idea.

Policies from Mao to Xi clearly reflect the evolving policy paradigm related to innovative practices.

Table 1. Major policies related to Science, Technology and Innovation-Driven Development and their key components

Sr. No.	Policies related with STI-Driven Development	Major Focus Area	Publication Date	Issuing Agency
I	1956-1967 Long-Range Plan of Scientific and Technological Development	57 major areas identified, self-reliance	1956	—
II	1978-1985 Draft of National Scientific and Technological Development Plan	To adopt world-class advanced technology & advanced equipment	1978	—
III	5th Plenary Session of the 14th CPC Central Committee	To rejuvenate China through science & education and; STE[7] to be closely combined with Economy	September 25-28, 1995	CPC Central Committee
IV	Recommendations for the 9th Five-Year Plan for Economic and Social Development and the 2010 Long-Range Goal	To accelerate the commercialization and industrialization of scientific and technological achievements.	March 5, 1996	CPC Central Committee
V	Report to the XVII National Congress of the Communist Party of China	Independent Innovation with Chinese Characteristics	October 15, 2007	National Party Congress of CPC
VI	National Medium and Long-term Plans for Science and Technology Development (2006-2020)[8]	To create an innovative country by 2020.	2006	The State Council, PRC[9]
VII	Strategic Emerging Industries[10]	To identify seven strategic industries which become the cornerstone of industrial modernization and technological development in China	2010	The State Council and several other central agencies such as, NDRC, MIIT, MOFCOM, MOST, MOF, SIPO

[7] STE refers to the Science, Technology and Education.

[8] (Cao et al. 2006)

[9] (The State Council of People's Republic of China, 2006)

[10] Here is the list of selected seven strategic emerging industries;

1. Energy efficient & environmental technologies
2. Next generation information technology (IT)
3. Biotechnology
4. High-end equipment manufacturing
5. New energy
6. New materials
7. New-energy vehicles (NEVs)

Table 1. Continued

Sr. No.	Policies related with STI-Driven Development	Major Focus Area	Publication Date	Issuing Agency
VIII	Several Opinions of the CCCPC and the State Council on Deepening the Reform of the Institutional Mechanism and to Accelerate the Implementation of Innovation-Driven Development Strategy	The idea of Innovation-driven development (IDD) is at the core of overall national development.	2015	State Intellectual Property Office (SIPO) of the PRC
IX	Notice of the State Council on the Publication of "Made in China 2025" 国务院关于印发《中国制造2025》的通知[11, 12]	Moving China into a 'Innovation-Driven Development' stage of production, especially in the Industry 4.0 era to reduce China's independence on foreign manufactured goods	2015	The State Council
X	National Innovation-Driven Development Strategy Outline.		2017	The State Council, PRC[13]

List curated by author, Source: Various internet databases.

3.3 Green development (GD)

The need to address environmental degradation and energy security is one of the causes driving China's adoption of green development strategies. High carbon emissions and serious environmental deterioration have resulted from the nation's fast industrialization and reliance on coal (Gan, 1992). One important tactic for lowering pollutants and increasing energy efficiency has been green investment (Ren et al., 2021). However, the uncertainty surrounding its effectiveness required a fundamental change in development and energy plans (Hallding, 2009). With an emphasis on both economic growth and environmental preservation, China's policies on sustainable development

[11] (State Council, 2015)

[12] MIC 2025 lists the Tech high priority sectors in which Chines government is aspiring to becoming a world leader. Here is the list;

1. Information Technology (AI, IoT, smart appliances)
2. Robotics (AI, ML)
3. Green energy & green vehicles (energy efficiency and NEVs)
4. Aerospace equipment
5. Ocean engineering and High tech ships
6. Railway equipment
7. Power equipment
8. New Materials
9. Medicine and Medical devices
10. Agricultural Machinery

[13] (State Council, 2017)

and environmental protection have changed over time (Zhang & Wen, 2008). China is the largest developing country in the world, so these policies are also important for the whole world.

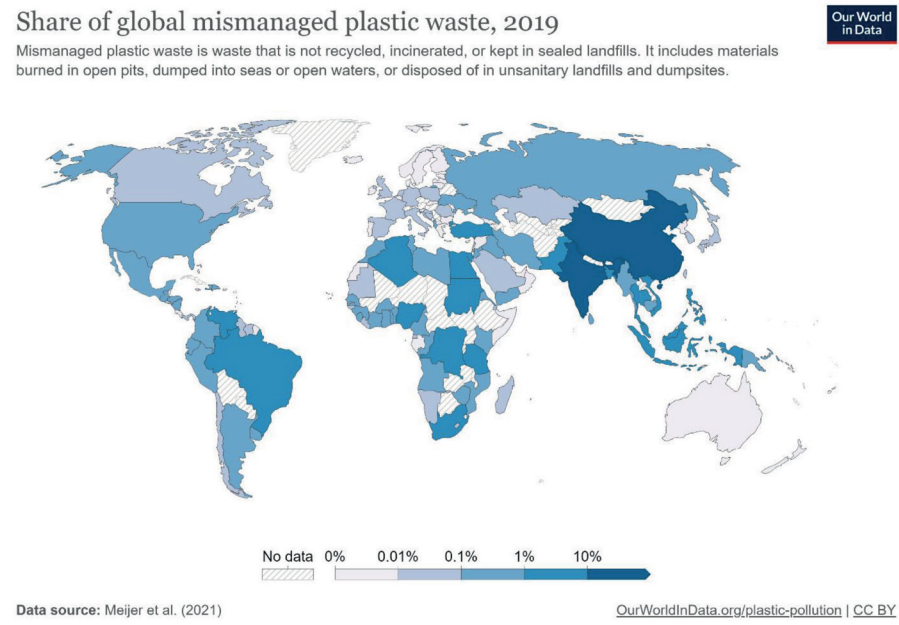
Green growth means fostering economic development, at the same time ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies (OECD, 2011). Organisation for Economic Cooperation and Development (OECD) defines green development as a practical way to achieve sustainable growth using less natural resources. It is not, however, equal to sustainable development. As OECD noted, green growth will "… provide practices and flexible approaches for achieving concrete, measurable progress across its economic and environmental pillars, while taking full account of the social consequences of greening the growth dynamic of economies. Green growth strategies focus on ensuring that natural assets can deliver their full economic potential on a sustainable basis. That potential includes providing critical life support services, air and water, and the resilient biodiversity." (OECD, 2011)

In the research literature, "greening" the policy framework is seen as upgrading and sustaining the innovation model. For example, green growth has already led to enhanced productivity by reducing waste and energy consumption and creating incentives for more efficient use of natural resources. Also, green growth has brought about the opening up of new markets by creating demand for green goods, services and technologies such as New Energy Vehicles (NEVs). Its foremost result is fiscal consolidation: governments have raised green taxes granting subsidies to the makers of green mobility, i.e. Electric Vehicles (EVs).

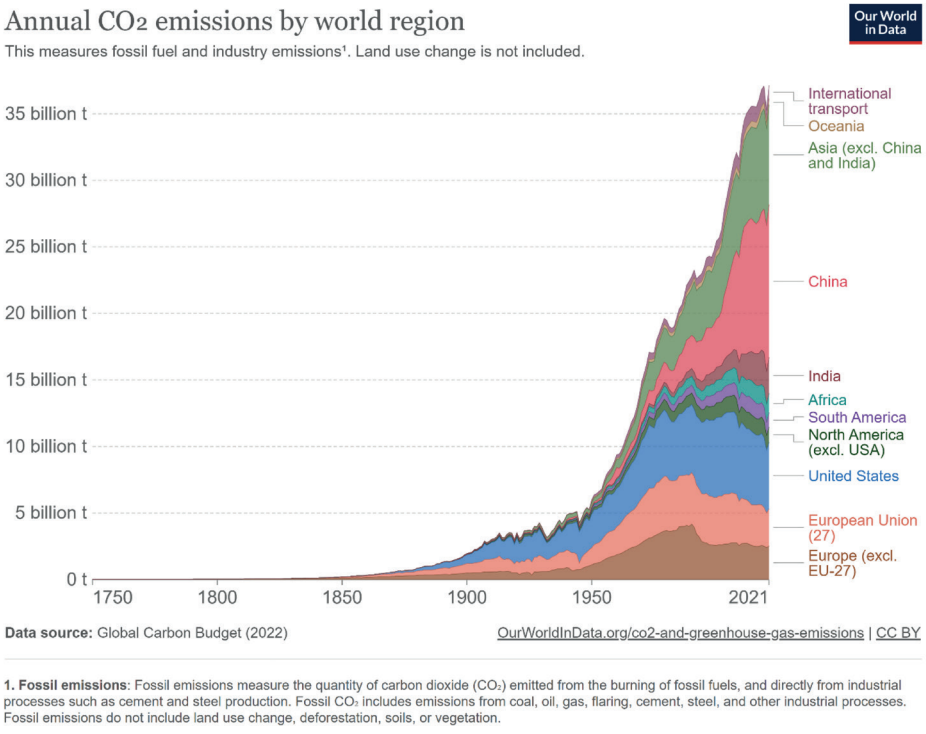
China's rapid economic growth on its way of development and globalization has come at a high environmental cost (Kan, 2009). From a statistical standpoint, China has faced considerable challenges in terms of its environmental performance. As of 2021, the country held the unenviable title of being the world's largest emitter of greenhouse gases (GHGs), contributing to a staggering 27% of global emissions (Bloomberg News, 2021). This surge in emissions is primarily attributed to China's rapid industrialization, which has seen its carbon emissions double over the past two decades.

The adverse environmental effects extend beyond carbon emissions, with approximately 66% of China's urban population, equivalent to 240 million people, exposed to various forms of air pollution (Li, 2003). Recognizing the gravity of these environmental issues, China has taken steps to address them globally. The nation has committed to the 2015 Paris Agreement, pledging to reduce carbon emissions by an impressive 60% to 65% from 2021 to 2030 while also setting a target for lowered carbon emissions around 2030.

President Xi has identified combating pollution as a primary objective, categorizing it among China's 'three tough battles,' alongside poverty alleviation and enhancing financial stability (Xinhua, 2018) (Liu, 2018). President Xi emphasized the need to accelerate the development of an ecological civilization system to ensure that significant improvements in the ecology and environment are made by 2023, and that the goal of building a beautiful China is essentially achieved (Sullivan, 2023).



Picture 1. Share of global mismanaged plastic waste, 2019. (After OurWorldInData.org)

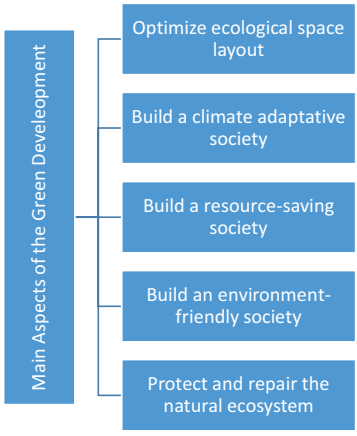


Picture 2. Annual CO2 emissions by the world region. (*Source*: OurWorldInData, 2023)

Water Pollution in China: To some spectators, water pollution in China is the country's worst environmental issue (Gibson 2018): 90% of the country's groundwater is contaminated by toxic human and industrial water dumping. Plastic pollution has also plagued China, as the country is the world's largest producer and consumer of plastics. According to one report, China is home to one-third of the world's single-use plastic production facilities; in 2020 alone, China produced about 60 million tons of plastic waste.

As China grapples with the complex interplay between development and environmental conservation, it is essential to trace the logic behind China's "green development" idea. This section hypothesizes that the environmental degradation and robust development in the last four decades in China led to a greener, more sustainable policy making. The idea of green development is ingrained in ancient Chinese history and philosophy, as the wisdom of "integration of humans and nature" is prevalent in ancient Chinese history and philosophy. However, classical Marxism also provides the ideal base for policy greening as Marxist dialectics propagate the idea that human history continues natural history. As Karl Marx put forward, "Human history is itself the reality of the natural history, i.e., the process in which nature becomes human." (Marx & Engels, 1972 quoted in Hu et al, 2018). The term "green development" was adopted at the 5th Plenary session of the 18th Party Congress (October 26-29, 2015) as a new theoretical paradigm for China's current and future development initiatives. In 2002, in the report of the 16th National Congress of the CPC (November 08-14, 2002), sustainable development was incorporated into the goal of building an all-round moderately prosperous society. Further, the 17th party congress discussed the aim of building "a resource-saving and environment-friendly society". In continuation of the greening of the economic policy," the construction of the ecological civilization" was presented as one of the five primary goals of building an all-round moderately prosperous society by 2020.

3.3.1 Requirements for Green Development (GD)



List 01. Main aspects of the Green Development (GD). Illustration by the author.

In Chinese discourse, Green development is interpreted as an organic unity of policies related to the economic, social and natural systems (Hu et al., 2018, pp. 65-66). Further, green development has been hypothesized as the cornerstone of all levels of development, such as political, economic, cultural, and social construction. The Chinese conception of growth is projected as all-round green, cyclic, and low-carbon development. In the Chinese discourse, all natural beings are treated as living entities. Policymakers insist that the mountains, forests, lakes, rivers, and fields are like a living community. This also echoed in the speeches of the Chinese leadership. For example, "Civilization will be prosperous in the case of ecological prosperity, and will decline in the case of ecological decline" (Jinping, 2003). As of September 07, 2013, President Xi Jinping stated, "We want not only green hills and blue waters, but also gold and silver mountains. We prefer green hills and blue waters, rather than gold and silver mountains, and green hills and blue waters are gold and silver mountains." (Xinhua, 2013)

China's legislative efforts for green development are grounded in a multifaceted approach that combines philosophical principles, pragmatic responses to environmental challenges, and strategic considerations for long-term sustainability. Ancient Chinese philosophy, emphasizing the integration of humans and nature, provides a foundational basis for environmental conservation. Marxist dialectics in its turn underscore the interconnectedness of human history and natural history, guiding China's approach to balancing economic growth with environmental protection. The incorporation of sustainable development goals into China's national agenda, as seen in the 16th and 17th National Congresses of the CPC, reflects a growing recognition of the need for environmental sustainability amidst rapid economic growth. The adoption of "green development" as a new theoretical paradigm at the 5th Plenary session of the 18th Party Congress in 2015 further demonstrates China's commitment to prioritizing environmental considerations in development initiatives. Overall, China's green development policies aim to achieve a harmonious balance between economic prosperity and environmental protection, addressing both national imperatives and global environmental challenges.

3.3.2 Measures for Green Development in China's Five-Year Plans

10th Five-Year Plan includes the following provisions related to green development:

a) sufficient utilization of clean energies such as natural gas, hydropower and nuclear power;
b) promoting renewable energy generation, such as solar Photovoltaic (PV) and wind;
c) advancing clean coal technology;
d) diminishing and decreasing reliance on coal targets;
e) Achieving sustainable development of energy.

11th Five-Year Plan:

The principles of resource-saving and environmentally friendly society were introduced in the 11th five-year plan (Central Committee of the Communist Party of

China, 2006). Also, resource and environment issues were included as significant goals. Further, in the 11th Five-Year Plan, a 'binding indicator system' (including resource and environmental objectives) was suggested to clarify and strengthen government responsibility. It was stated that goals related to green development would be connected with the assessment of civil servants and government officials (Hu, 2018, p. 63). Green development policies were to accelerate economic development according to the 12th Five-Year Plan (Central Committee of the Communist Party of China, 2011). Several other indicators were added concerning resources and environmental indicators. The **12th Five Year Plan (FYP)** also contained measures for ensuring better environmental quality for cities and towns, including a "blue sky day" target and other mandatory emissions targets (APCO, 2010, p. 05). Further in this plan, China pledged to have 15 per cent of its energy come from non-fossil fuels by 2020 (from 8.3 per cent in 2009 to approximately 11 per cent by 2015) (APCO, 2010, p. 06). **13th FYP (2016-2020)**, or the *Recommendations for the 13th Five-Year Plan for Economic and Social Development* (Central Committee of the Communist Party of China, 2016), set the targets related to reducing the carbon industrial and non-industrial emissions and increasing resource development and utilization efficiency, effectively controlling energy and water consumption, land construction and total carbon emissions. Further, the 13th FYP also intended to reduce the total discharge of major pollutants.

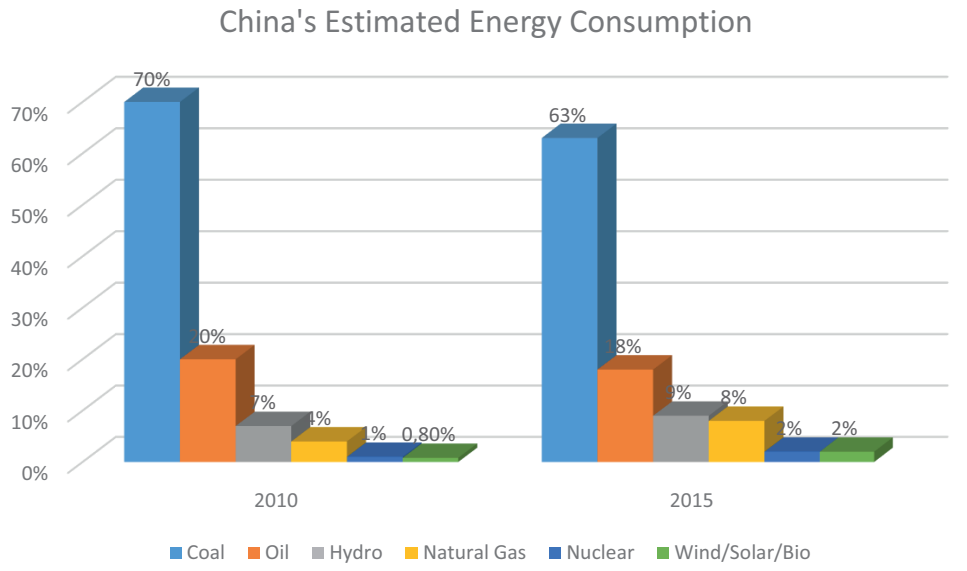


Chart 01. China's estimated energy consumption as stated in the 12th Five-Year Plan (APCO, 2010)

4. Conclusion

This research paper sheds light on the intricate dynamics of science, technology, and innovation (STI) in China's development trajectory, elucidating its profound impact on

economic growth and environmental sustainability. Through a comprehensive analysis of China's STI policies and official discourse, this study reveals the strategic plans of innovation-driven development (IDD) and green development (GD) paradigms to address the pressing national issues and geopolitical realities.

The hypothesis posited in this paper regarding the emergence of two distinct trajectories within China's STI politics through the adoption of IDD and GD has been substantiated through empirical evidence and theoretical analysis. The adoption of IDD reflects China's commitment to fostering a culture of innovation and technological advancement, driven by national imperatives such as economic development and global competitiveness. Conversely, the emphasis on GD underscores China's recognition of environmental concerns and the imperative of transitioning towards a more sustainable development model, driven by both domestic environmental challenges and international pressure to address the climate change agenda.

By framing IDD and GD within the context of sustainable development, this research highlights their crucial roles in China's journey towards technological advancement and sustainability. Moreover, the analysis underscores the significance of STI in shaping China's socio-economic trajectory and its implications for the global development dynamics.

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