Ca' Foscari
University
of Venice

Master's Degree in
Language and Management to China

Final Thesis

From isolation to innovation: the development of technology in China from the late 1800s and its global implications

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Academic Year
2023 / 2024

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Abstract

The presented thesis aims to explore the development of science and technology in the People's Republic of China, a process which officially started with the reforms implemented by Deng Xiaoping in the late 1970s, however some sprouts of it can be found at the end of the Qing dynasty and during the Maoist period. The first chapter will analyze why China realized it needed said reforms, and it will deal with how underdeveloped the country was in terms of technology at the end of the 19th century and during the Maoist period, when compared to the rest of the world. The second chapter will explore the changes that the "Reform and Opening up" (改革开放 *gaige kaifang*) brought, and it will also focus on the changes happened in between the late 1990s and the early 2000s with the rise of technocracy. The third chapter will analyze in depth how Xi Jinping's governance took the matter of science and technology to an unprecedented level. Finally, the fourth and last chapter will be divided into two parts, both of which will focus on how the scientific and technological development influenced the relationship between China and the West: the former will deal with the United States; and the latter with the European Union.

Keywords: science, technology, reform, opening up

前言

本文重点讨论了近现代中国科学技术的发展与变迁，其中涵盖三个关键的历史阶段，分别是中国的科技发展初步探索阶段、改革开放阶段以及科学技术蓬勃发展阶段。明清时期，中国的外交关系还仅仅局限在周边的邻国，与西方的国家则没有太多的接触。后来，基督传教士在中国的传教实现了中国与西方国家的第一次接触，十六世纪至十七世纪，西方国家的传教士将西方先进的科学知识引入到了中国。

一、鸦片战争结束后，中国开始觉醒，并开始了科技初步探索阶段

十九世纪末，鸦片战争结束了以后，中国在西方列强的压迫下打开了国门。鸦片战争中的惨败，使一些清朝官员意识到了自己的国家是多么地软弱与落后，进而导致了“洋务运动”的兴起。“洋务运动”的倡导者希望通过引进西方先进的科学技术来提升本国的综合实力，进而打败西方列强，维护清王朝的统治。尽管此次开放是被迫的，但也对中国产生了一定的积极影响。在政府的资助下，一些中国学生获得了出国学习的机会，他们将西方先进的思想与技术带回了中国，在一定程度上促进了清王朝科学技术的发展与进步。在“洋务运动”时期，中国的科学技术发生了一定的变化，国外的投资也开始进入到了中国，但这并不足以打败西方列强。第一次世界大战在欧洲爆发了以后，进入中国的国外投资也随之减少了。清朝灭亡了之后，留学美国的几位中国学生创立了中国科学社，旨在强调科学与技术对国家的重要作用，1919 年的五四爱国运动也再次突出强调了国家科学技术发展的重要性。

1949 年中华人民共和国成立了以后，中国政府与苏联开展了合作，这对于刚刚成立、孤立无援的新中国来说，是至关重要且成效显著的。在苏联援助新中国开展工业化建设过程中，苏联输出工业机器和先进技术给中国，中国则输出原材料、农产品、食品和轻工业制品给苏联，自然也就实现了两国的双赢。苏联先后共派遣了一万多名各领域的专家和技术人员来到中国，并为中国培养出了一大批的科研技术人才，帮助中国快速实现了工业化，并创造出了诸多领域的第一，例如第一颗原子弹、第一辆汽车、第一辆坦克、第一架飞机等等。但是在二十世纪五十年代末期，由于中苏双方多方面的矛盾和冲突，导致了中国与苏联的合作终止了。

二、改革开放后，中国开始拥抱世界，科技领域高速发展

在 1978 年至 2013 年这近四十年的时间里，中国发生了翻天覆地的变化，尤其是中国的国际角色以及科学技术发展得到了很大的提升。同苏联之间的合作终止了以后，中国决定向美国靠拢，而后与其他的西方国家也陆续建立了外交关系。2001 年，中国加入了世界贸易组织，事实证明，这一决策对中国的现代化进程是至关重要的。

1978 年，中国开始实施“改革开放”政策，这一时期，中国的科学技术发展受到了空前的重视。中国政府陆续在深圳、珠海、汕头、广东以及厦门五个地区建立了经济特区，外资企业也相继在大陆成立了自己的办事处。外国直接投资（Foreign Direct Investment，英文缩写为 FDI）使得中国可以引进国外先进的技术来促进本国的科学技术发展。

此外，在改革开放以后，中国的教育领域也发生了重大的历史变革，政府开始高度重视教育事业，确立了教育优先发展的战略地位，走出了一条中国特色社会主义教育快速发展之路。改革开放初期，中国教育经历了一系列的改革，如恢复高考制度、实行教育体制改革、拓展职业教育、推进基础教育、加强师资培养等。这些改革使得中国教育逐渐走向了多元化和多样化，特别是通过恢复高考制度，使得更多的人有机会接受高等教育。二十世纪末至二十一世纪初，越来越多的学生受益于中国的新教育政策，这为中国国家输送了一批又一批高素质的科学技术人才，进一步促进了中国科学技术的快速发展。

邓小平于 1978 年所推行实施的改革开放决策打开了此后三十多年中国经济增长的密码。改革开放之后，中国政府高度发展国内经济，同他国之间的深度合作，进一步提升了中国本国的自主研发能力。现任主席习近平高度重视科技创新，并将创新摆在国家发展全局的核心位置，不断强调科技创新在全面创新中的引领作用。2020 年 9 月习近平强调中国急需科技和创新，预示北京将在下一个五年规划中，重点布局被“卡脖子”的高科技产业，应对美国在科技领域的强势打压。中国的“十四五”规划同样强调了“自力更生”这一概念，而且还详细阐述了中国提升自主研发能力的道路方向以及政策实施。此外，中国政府还启动了《中国制造 2025》（Made in China 2025）战略，《中国制造 2025》计划通过“三步走”实现中国制造强国的战略目标。第一步，到 2025 年迈入制造强国行列；第二步，到 2035 年中国的制造业整体达到世界制造强国阵营中等水平；第三步，到新中国成立百年时，中国的制造业大国地位更加巩固，综合实力进入世界制造强国前列。

为了实现“十四五”规划以及“中国制造 2025”国家战略，中国政府增加了对信息通讯、海洋工程装备、航空航天设施、新能源汽车等多个领域的研发投入。而且制定完

善了相关的法律法规。中国已经十分清晰发展本国自主创新能力的必要性，并正在实施一系列的政治战略以减少对外国技术依赖。

三、中国科技水平走向世界中心，科技创新受到压制

本文的最后重点分析了现如今中国科技领域在国际舞台上所面临的局面和挑战。改革开放之后，中美两国在政治、经济、文化等领域的交流与合作不断深化。然而，随着时间的推移，中美关系也经历了起伏和波折。现如今为了减缓中国经济技术的发展脚步，美国政府已经对中国一众科技公司实施了经济方面的制裁。然而这些制裁手段同时也给那些同中国科技公司建立紧密合作的美国企业带来了麻烦。比如在美国政府的强迫下，谷歌公司不得不停止同华为之间的合作，这就导致很多的中国用户无法再使用谷歌公司的软件系统，因此也丢失了一部分客户群体。后来，为了保护这些受到负面影响的美国企业，美国政府逐渐放宽了对中国企业的限制。

除此之外，美国政府针对字节跳动（ByteDance）公司所实施的制裁也备受人们的关注。该公司于 2017 年推出了国际版的“抖音”— TikTok ，该软件在国际上也受到了众多网友的欢迎。但是由于在使用 Tik Tok 的过程中，字节跳动公司会对美国用户的信息进行收集，为此 2019 年的 10 月份，一些美国参议员提议要求对字节跳动公司进行风险调查，避免给美国的国家安全带来威胁。2020 年，美国总统特朗普表示 TikTok 的用户数据收集对美国构成了威胁，于是美国政府便通过行政手段阻止其在美国的运营活动。

在那之后，一些欧州国家也开始效仿美国，并对中国的科技公司在欧洲的发展进行了制裁。2019 年意大利表示华为可以参与 5G 核心设备的招标活动，但是在 2020 年，意

大利政府由于担心华为成为中国通过西方电信基础设施从事间谍活动的途径，便将华为排除在了 5G 网络建设之外。在此之后，法国也加入了制裁华为的队伍。起初，法国政府并没有限制华为在本国的销售及推广，但是在 2020 年 7 月份，法国政府宣布禁止购买华为公司的一切产品。西班牙的通讯公司（Telefónica, S.A）一直很依赖华为公司，在西班牙本国的 3G 到 4G 内核中都使用了华为的套件设备。但是在美国政府的不断施压下，从 2019 年开始，华为与西班牙电信之间的合作也面临着很大的不确定性。

四、结论

本文重点分析了近现代中国在经济技术领域的发展历程。二十世纪初，由于国内与国际环境动荡不安，科学技术事业发展的物质条件极差，所以中国的科技发展十分缓慢缓慢。新中国成立了之后，中国政府开启了国家工业化的初步建设阶段，且在苏联的帮助下，工业化目标取得了一定的进展，但是速度依然缓慢。到了改革开放以后，中国的面貌发生翻天覆地的变化，而且在国际舞台上的影响力也彻底发生了转变。中国的快速发展，改变了国际格局，同时也影响了中国同他国之间的双边关系发展。

但是现如今中国的快速崛起，使得许多西方国家变得不安，一系列的制裁手段接踵而至，目的无疑都是为了减缓中国前进的脚步。截止目前来看。针对西方国家所给予的制裁，中国一一都做出了回应，并且在一定程度上也损伤了西方国家的经济利益。在整个经济全球化的背景之下，国与国之间的互相依赖也越来越深，经济贸易战争损伤的是双方国家的利益，没有任何一方是可以逃避损失的。

西方国家对中国所采取的限制，使得中国不得不提升自身的自主研发能力，摆脱西方国家的科技壁垒，进一步增强自主研发的能力。只有掌握了核心技术的自主权，才能降低西方国家对中国实施制裁所造成的负面影响。

Introduction

The aim of this research paper is to explore how the development of science and technology changed throughout the last two centuries in China, highlighting historical periods characterized by deep attention on the matter by the leadership, periods of sino-foreign collaboration, and moments of isolation from the rest of the world.

During the centuries of the empires, China had some contact with foreign countries, especially its neighbors, such as Japan and Korea, yet it had no contact with any of the Western powers. The only time a Chinese dynasty had interactions with the West was because of the Jesuit missionaries, who, between the 16^{th} and 17^{th} century, imported into the Qing empire advanced Western scientific knowledge. Aside from this exceptional contact, the empire has mostly been isolated.

The first chapter will analyze the abrupt opening some Western countries forced on China at the end of the 19^{th} century, after the Opium Wars. Despite the opening being imposed on the country, it was not a completely negative experience. Foreign investments started flowing into China, causing a group of bureaucrats to launch the Western Affairs Movement to push the empire toward self-strengthening with the hope that one day it would defeat the foreign invaders. In this period, the Chinese scientific and technological fields underwent major changes which resulted in fast-paced development, which was not sufficient to defeat the Western powers. The military sector was reformed, and foreign standards were adopted for armaments and training. Additionally, the educational field underwent major changes thanks to both the adoption of Japanese models and to Chinese students attending universities abroad. During the nationalist period, the Science Society of China was founded, highlighting the important role science and technology played for the people, and with the May 4th Movement of 1919, additional emphasis was put on scientific and technological progress. After the defeat of the nationalist army and the victory of the communist army, China started a collaboration with the Soviet Union which proved to be vital in an era of almost complete isolation. This alliance resulted in rapid Chinese progress in the fields of sciences and engineering thanks in part to study abroad programs and to Soviet experts working in China. The most important result of this collaboration was the successful testing of the first Chinese nuclear bomb in the Xinjiang province that took place in 1964. While the Great Leap Forward and the Cultural Revolution slowed down the process of scientific and technological development of the country research and innovation did not stop completely, and a special effort was put in the defense field, and space program.

The second chapter will cover the main events that happened after Mao Zedong's death until the early 2010s when Xi Jinping became President. In these nearly forty years, China underwent major reforms and transformations, especially on the international scene, and in the scientific and technological fields. First and foremost, after the rupture of the relationships with the Soviet Union, China decided to lean toward the United States, for various reasons that will be quickly analyzed in the first part of the chapter. From that moment onwards, China started new collaborations with numerous countries in the West. This whole process culminated in China's entrance in the World Trade Organization in 2001. With Deng Xiaoping's reforms the Chinese economy opened up and importance was put on science and technology, especially with the launch of the Four Modernizations Project. Special Economic Zones were established, leading to the creation of sino-foreign joint ventures and wholly foreign-owned enterprises in China. Foreign direct investments started flowing in, contributing to the technology transfer, and the government started increasing the amount of national R&D investments. The educational system also went through major changes which resulted in an increase of university research. All this attention to education, science and technology led to the rise of technocracy, which kept growing until the 2010s. Between the 1990s and 2010s in fact, many politicians had graduated from scientific and engineering schools and had previous work experience in the fields, which helped them better understand how to implement the reforms of the period. However, some consequences were not expected, so Deng Xiaoping had to relaunch the reforms in 1992. This topic will be analyzed in the last part of the chapter.

The third chapter will begin by analyzing the progress made by China after four decades since the Reforms and Opening Up project was launched. It will cover the main goals and objectives set by the Chinese government on the matter of scientific and technological innovation, such as self-reliance and more independence on technologies keys for national development. The chapter will analyze the two main projects launched by the government: Made in China 2025 – connected to the Chinese Dream of 2049 – and the 14^{th} Five-Year Plan with its 2035 objective. The first one focuses on transforming the country into a world-class industrialized country and a world manufacturing workshop by 2025. The final objective of this project is in 2049, the country's centennial of its foundation, the final aim of which being the "Chinese Dream" which is the national goal to become a culturally advanced, prosperous, and modern socialist country and a global leader in manufacturing. The second national goal is set by the 14^{th} Five-Year Plan which aims at increasing national innovation. To reach both objectives, the government has increased its spending in R&D and certain fields, such as aerospace, and will see an increase in funding and research. R&D is inevitably connected to patents and intellectual property protection, and since China is slightly behind on intellectual property protection when compared to other advanced countries, the government set its goal to improve regulations and laws on the matter.

Finally, the fourth and last chapter will be divided into two sections, both of which will analyze the evolution of the Chinese relationship with countries in the West in a neutral light. The first section will cover the Sino-American relationship, while the second part of the chapter will cover the Sino-European relationship. Both these relationships started in the late 1970s, when the Chinese government began improving the country's image on the international scene, after the Maoist isolation from Western countries. The section of the chapter dedicated to the Sino-American relationship will also analyze the evolution and intensification of the trade and technological frictions that arose in recent years between the two countries. It will cover both sides analyzing how both countries have reacted to the other's measures, such as the series of sanctions imposed by both countries on one another, and the issues with Huawei, and Google. The section related to the Sino-European relationship will analyze how the European Union reacted to the Sino-American friction.

This paper was written after the consultation of both scientific, academic and governmental resources concerning all the actors involved, in order to cover and analyze the different points of view. In the last chapter, when writing about the Sino-American or the Sino-European relationships, resources from all three sides have been studied, to ensure a fair presentation of the facts.

Chapter 1: China's Underdevelopment and the Initial Wave of Reforms

1.1. From the Opium Wars to the Fall of the Qing Empire

China is famous for numerous scientific and technological discoveries and inventions, such as silk, tea, porcelain, paper, printing, the magnetic compass, and gunpowder, just to name a few. Some of these inventions – in particular gunpowder, printing, and the magnetic compass – were almost taken for granted by the Chinese society of the time. However, in Europe, they were defined as the key difference between the modern civilization, i.e. people of their day, and the ancient civilization, i.e. Greeks and Romans (Elman, 2006). It is not casual that these three inventions, together with paper, were considered the "Four Great Inventions" (四大发明 *si da faming*). Even though it is not confirmed whether or not these inventions appeared for the first time in China or in Europe, they are considered to have appeared around the same time in both continents (Brombal, 2016).

After almost two millennia of being an isolated empire, China had to face the Western powers at the end of the 19th century. Although there had been contacts with the West before – especially during the 17th century when the Jesuits imported European elements, such as mathematics, astronomy, and other sciences and technologies – the interactions between the two parts had almost always been peaceful. This relationship rarely became a conflict, and never reached the level the Opium Wars had (Wilkinson, 2015). The European Jesuit missions marked an era in which China became a privileged destination for intellectual and scientific exchanges (Brombal, 2016).

The end of the first Opium War (1840 – 1842) marked the beginning of the Chinese era of the so-called "unequal treaties" (不平等条约 *bu pingdeng tiaoyue*), which lasted for over a century. With the expanding control of the Western powers over the Chinese empire, foreign investment also increased until the beginning of World War I, when Western resources had to be redirected to Europe to face the conflict. However, the development brought by these investments were completely driven by Western capital, so it was only spread in areas of major foreign influence and did not allow for uniform development throughout the country. Moreover, they mostly focused on the railway sector and the mineral industry, so the influence they had on the Chinese economy was extremely limited. In addition to military losses, the flow of foreign investments made the empire realize how underdeveloped it was when compared to the Western powers, provoking some Chinese bureaucrats to decide how to solve this issue. In spite of a group of officials who decided to ignore the situation, another part of the government decided to react by empowering the Manchurian monarchy. This movement – called the Western Affairs Movement (洋务运动 *yangwu yundong*) – arose around 1860, and brought reforms that reinforced the Confucian mindset and created a new moral and political atmosphere (Sabattini & Santangelo, 2005).

One of the fundamental ideas of the Western Affairs Movement was to introduce and learn the advanced techniques and sciences from the Western powers, but only in an instrumental way, maintaining a core of traditional Chinese culture (L. Liu, 2023). Some of the slogans for this concept were "Chinese Morality, Western utility" (中道西器 *zhongdao xiqi*), "Chinese as the basis, Western as the additional" (中本西末 *zhongben ximo*), and "Chinese in command, Western for assistance" (中主西辅 *zhongzhu xifu*) (Wilkinson, 2015). The most popular was "Chinese knowledge as the core, Western knowledge as the instrument" (中学为体，西学为用 *zhongxue wei ti, xixue wei yong*) and it was ideated by Lin Zexu 林则徐, and Wei Yuan 魏源 (Shi, 1998). The introduction of Western technology and methods, the development of modern forms of communication and heavy industry are clear examples of what this movement brought to the Qing dynasty. The empire purchased ships and arms from the Western powers and used them as a model to learn how to modernize its own ships and arms (Sabattini & Santangelo, 2005). One example of this development is the capital of the Fujian province, the city of Fuzhou, which became the largest and most modern of all the Chinese military defense industries established in the 1860s thanks to the use of French know-how (Elman, 2006).

An additional concept of the Western Affairs Movement ideated by Wei Yuan was to "learn from the barbarians in order to gain command of them" (师夷长技以制夷 *shi yi changji yi zhi yi*) which led the Chinese empire to study the advanced military technology of the West with the purpose of becoming self-reliant and resisting foreign aggression (G. Li, 2023).

These reforms were not only limited to the military sector, but also spanned to the field of education and the exam system: the Japanese system became the educational model, the traditional curricula were modified, and new subjects based on "new Western knowledge" were introduced (Sabattini & Santangelo, 2005). The fact that Japan was chosen as a model is not incidental, it was chosen because Japanese scholars had already translated Western ideas, therefore Chinese scholars only had to translate those new concepts from Japanese into Chinese, which was easier. Zhang Zhidong 张之洞 urged students to study in Japan rather than in Europe for different reasons. First and foremost, it was closer to China and therefore cheaper than any European destination. In addition, Japanese scholars had already selected the best books from Europe, therefore Chinese students could graduate faster and return to their home country sooner. The similarity of habits and culture would also help those students with their life abroad (Wilkinson, 2015). To improve the educational system, between 1866 and 1867 the Qing court added the Department of Mathematics and Astronomy at the Beijing School of Foreign Languages which was created to teach students about modern sciences such as chemistry, physics, and mechanics (Elman, 2006).

In addition to military improvements based on foreign techniques and to reform the educational system, the Western Affairs Movement realized how important talent support was, therefore, it started training specially skilled personnel in fields such as translation, diplomacy, laws, science and technology, business and management, machine building and more. It also sent students abroad, mainly to Europe and to the United States, to learn from technical schools, including foreign language schools, and military schools (L. Liu, 2023) to build back the country starting from its military. After returning to China, these students became the backbone of the industry, and continued to promote studying abroad opportunities (G. Li, 2023). Moreover, between 1875 and 1898 some Western subjects, such as mathematics, science, and economics, were added to the civil service examination (Wilkinson, 2015).

Following the abolition of the imperial exam system in 1905, to solve the issue of not having properly trained professors, some were sent abroad, mainly to Japan, to become more specialized in their fields (Sabattini & Santangelo, 2005). Japanese victories against the Qing in 1895 and Russia in 1904, showed that the neighboring country had been able to successfully master Western studies (Wilkinson, 2015). This also explains the increase in the number of students sent abroad after the defeat of the Sino-Japanese war (1894 – 1895) (G. Li, 2023).

It is important to note that after the defeat of the empire during the Boxer Rebellion (1899 – 1900), the winning Western powers imposed a huge indemnity on China, however, the United States:

> "decided to return the surplus portion of the Boxer indemnity to China with the stipulation that they be used to send Chinese students to study science and technology in the United States. American policy makers expected these students, when they returned to China, would extend American influence and help facilitate trade between the two countries. The first batch of students was selected and sent to the United States in 1909" (Z. Wang, 2002)

It is worth mentioning that despite fewer students going to Europe or to the United States to study, those who did, managed to graduate from university, while the majority of those who went to Japan never achieved a degree beyond middle school (Wilkinson, 2015). However, no matter the destination, sending students abroad to learn from the West in order to bring new knowledge back to the motherland is a technique also used in the future, especially after the reforms implemented by Deng Xiaoping in the late 1970s.

Nonetheless, the Western Affairs Movement ended after thirty-four years, with the outbreak of the first Sino-Japanese war (1894 – 1895) because of the inability of the dynasty to control the ruling class and the vast freedom of the regional bureaucrats. This became evident during the Boxer Rebellion when the Chinese side was wholly defeated after using traditional weapons, showing how tight of a grip cultural tradition still had on the Chinese people, and how unwelcome the foreign powers were becoming in the empire. Therefore, the reforms implemented by the Qing dynasty were not as efficient (Sabattini & Santangelo, 2005). However, it is important to remember that, even though the Western Affairs Movement only lasted less than forty years, it promoted the long process of Chinese modernization (L. Liu, 2023). It also laid the foundation for the modern defense industry system, it drove private capital into the modern industrial production, but most importantly, it promoted the development of technical talents (L. Liu, 2023). As a result of this movement, new arsenals, technical schools, and translation bureaus arose, and the Chinese society saw an increase in military technology and education in Western sciences (Elman, 2006).

1.2. The Nationalist Experience (1912 – 1949)

After the fall of the Qing empire, the Republic of China was founded in 1912. When World War 1 began in Europe, the Western powers had to redirect back to Europe most of the investments flowing into China, and this represented a boom for the modern Chinese industrial system. It also meant that the Chinese imports from the West drastically decreased, while exports of goods such as silk and tobacco increased. Nanyang Tobacco Manufacturing, founded by the Jian brothers, quickly became a competitor of the British-American Tobacco Company, as it started using foreign technologies developed in the United States and Japan. (Samarani, 2017). This is a prime example of adapting from Western technologies, to then utilize those same technologies to surpass the West.

In June 1914, some of those students who studied in the United States founded the Science Society, which a year later became the Science Society of China. At the beginning, the society had its headquarters in the United States until 1918, when it moved to Shanghai marking this as the first time a scientific society was present on Chinese soil. "The tension in the world at the eve of World War I stirred nationalist sentiment among these Chinese students who wanted to do something for their country. The group […] felt that what China lacked most was science" (Z. Wang, 2002). The society also founded a journal which had two main purposes: it was a mean of scientific communication among the members of the society, and it was also a way to popularize science among the Chinese literary public, both with the main goal of making China strong and respected within the international community. After a year, the society went under re-organization and became the first comprehensive scientific society of modern China: the most important step taken was the addition of a section entirely dedicated to the translation of scientific texts into Chinese. After many students had returned to China, they took "leading scientific and engineering positions at universities, industrial firms, and governmental agencies" (Z. Wang, 2002).

Due to this scientific interest, during the May 4th Movement (四五活动 *siwu huodong*) of 1919, Chinese students and intellectuals thought that in order to modernize the country, Chinese traditional culture had to be erased, as it was the obstacle for the development of science, because it was an opposite concept to Chinese intrinsic culture. This idea was created one year before the 1919 movement by Chen Duxiu 陈独秀 who in 1918 wrote that because he supported Democracy and Science, he had to destroy Confucianism, rules of etiquette, Chinese culture quintessence, chastity, old ethics, old art, old religion, old literature, and old politics (Y. Liu, 2013). He also said that:

> "西洋人因为拥护德、赛两先生，闹了多少事，流了多少血，德、赛两先生才渐渐从黑暗中把他们救出，引到光明世界。我们现在认定只有这两位先生，可以救治中国政治上道德学术上思想上一切的黑暗。
>
> Xi yang ren yinwei yonghu de, sai liang xiansheng, nao le duoshao shi, liu le duoshao xue, de, sai, liang xiansheng cai jianjian cong heian zhong ba tamen jiuchu, yingdao guangming shijie. Women xianzai rending zhiyou zhe liang wei xiansheng, keyi jiuzhi zhongguo zhengzhi shang daode xueshu shang yixiang shang de heian.
>
> Western people, because of their support for Democracy and Science, have caused so much trouble and shed so much blood that Democracy and Science gradually rescued them from the darkness and led them to the bright world. We now firmly believe that only these two gentlemen can cure all the darkness present in Chinese politics, morality, academia, and ideology" (Y. Liu, 2013: p 6. Translated by the author).

It is important to note that, in the Chinese original text, “Democracy” and “Science” are not called by their official translation (respectively 民主 *minzhu* and 科学 *kexue*), but rather they are called by a transliteration of the English words preceded by the title “Mr.” (respectively 赛因斯先生 *saiyinsi xiansheng* and 德谟克拉西先生 *demokelaxi xiansheng*). Therefore, they can also be translated as “Mr. Democracy and Mr. Science”. They represented China’s New Culture Movement and introduced the transformation of the country from ancient society to modern civilization (Xu, 2017). Mr. Democracy and Mr. Science became the slogan of many intellectuals seeking societal change in that period (Wilkinson, 2015).

As Wilkinson said:

> “Science and practical studies were emphasized in the schools during the Nanjing decade. The institutionalization of the sciences in newly established professional associations and universities took place for the most part at that time. National scientific research bodies were established, and several universities set up research institutes. Foreign scientists were invited to lecture. The influence of the students who did not study the classical curriculum but instead went abroad to master the new studies although slight at first gathered momentum.” (Wilkinson, 2015)

Between 1922 and 1928, a large group of Chinese students, who decided to attend schools abroad, opted to go to Germany, as it was becoming more appealing for the study of politics, history, geology, and metallurgy. Sun Yat-sen 孙逸仙 also tried – but failed – to get military and technical help from Berlin, which was recovering from the loss of World War I. This led the nationalist leader to turn toward the Soviet Union, which was looking at China as a possible country in which to spread its communist influence, since it had failed to do so in the West. (Samarani, 2017). After Mao Zedong 毛泽东 took over the country in 1949, the alliance between the two communist countries strengthened.

However, the most important economic boom was seen during the 1930s, when emphasis was put on the communication, transport, and manufacturing sectors. This is also due to the fact that the consequences the economic crisis of 1929 had on China were not as hard as they were for the Western countries. Nonetheless, they started in 1933 and lasted for longer than in the West (Samarani, 2017).

The Marco Polo Bridge Incident – also known as the Luguo Bridge Incident (卢沟桥事变 *lugou qiao shibian*) – that took place on July 7th 1937, marks the beginning of the Second Sino-Japanese War (1937 – 1945) which led to the subsequent Chinese Civil War (1945 – 1949) resulting in the victory of the Communist army led by Mao Zedong and the loss of the Nationalist army led by Chiang Kai–shek 蔣介石 (Samarani, 2017).

1.3. The Collaboration with the Soviet Union (1950 – 1969)

Despite being a low-income country, from the 1950s through the 1970s, China pursued a strategy of high science and technology effort (A. G. Z. Hu & Jefferson, 2008).

After Mao Zedong took over the country and founded the People's Republic of China on October 1st, 1949, the main goals he set were to fight poverty and underdevelopment caused by the previous wars, and to build a modern nation. In the first five years since its foundation, the People's Republic of China had to face constant social tension, both on a national level due to the situation in Tibet, and on an international level caused by the worsening of the relationship with the United States due to the American support to Taiwan, and the Chinese involvement in the

Korean War. However, this period is also characterized by the beginning of the Sino-Soviet cooperation, that lasted for almost two decades (Samarani, 2017).

Under the Soviet influence, China implemented its first Five-Year Plan in 1953, which however was officially ratified in 1955. The Plan required the collectivization of rural areas, a strict centralized planning, and the creation of a technocratic leadership that would implement this and the future Five-Year Plans. The Plan was created for an economy that was not industrially advanced and had to be strongly guided by a socialist state in order to develop capital that would successively be invested in the development of heavy industry. It is worth noting that when the Soviet Union implemented its first Five-Year Plan (1928 – 1932) it was more economically and industrially advanced than China was in the early 1950s. However, it is probable that China decided to implement this type of plan because it seemed the only solution to modernizing an underdeveloped country, and also because it had been worked successfully for the Soviet Union. Because the Chinese foreign policy was "leaning to the side of the Soviet Union", the country was isolated from the rest of the world, so it only traded with the Soviet Union, which became China's largest external commercial partner. Western countries, following the United States example, increased the isolation of China, making it impossible for the country to buy materials, machinery, and technology directly from the West, so the Soviet Union earned export revenues (B. Zhang et al., 2006).

Developing the country was an important task which required financial and technical help, and since China was isolated from the Western powers, in February 1950 it signed the "Sino-Soviet Treaty of Friendship, Alliance and Mutual Assistance" (中苏友好同盟互助条约 *zhongsu youhao tongmeng yuzhu tiaoyue*) with the Soviet Union. This happened after Mao Zedong went to Moscow to join the negotiations in 1949 (Samarani, 2017). This alliance was also possible thanks to the political concept of communism both countries had adopted. Moreover, the Soviet Union had hoped China would join the Soviet bloc since the late 1940s when the communist military was gaining triumphs against the army led by Chiang Kai-shek (B. Zhang et al., 2006).

The Treaty "laid the foundation of modern technology and industry in China and as well as it promoted the development of Chinese scientific research" (B. Zhang et al., 2006). The Soviet Union helped China build a Five-Year Plan for economic development by mobilizing manpower and material resources and it assisted with the organization of a planned economy system with industrial projects. It also assisted its neighbor by providing equipment and technology, and by sending consultants and experts to China. In exchange, China had to provide the Soviet Union with raw materials (B. Zhang et al., 2006).

As Zhang said "the importance that China attached to learning from the Soviet Union was apparent in the gradual improvement in the introduction and assimilation of equipment and technology" (B. Zhang et al., 2006). Imitation, in fact, is an effective way for an underdeveloped country to produce its first industrial commodities, it lowers the risks of failure, and it can produce direct economic gains. Therefore, China gradually understood how the new technology worked and gained designed capability, increasing internal development. As Zhou Enlai 周恩来 said in 1956, as a result of learning from Soviet Union, Chinese engineers had mastered a lot about how to design and construct modern factories, mines, bridges, and water conservation. China improved a lot on the design of large machines, locomotives, and ships. Given the technological and economic improvements made by China since the alliance with the Soviet Union started, by 1957 the Chinese demand for Soviet equipment decreased (B. Zhang et al., 2006).

Since the beginning of the Sino-Soviet collaboration, China not only copied Soviet technology and designs, but also imitated the Soviet educational system, mainly for higher and secondary education. The goal was to train professionals for industry and construction. Before the Soviet influence, universities in China were copies of schools in Europe, the United States, and Japan. Soviet science and technology were connected to visions of a planned economy, therefore between 1949 and 1951 old colleges were reorganized, and new engineering schools were created. Moreover, the Chinese graduate education system underwent some reforms (B. Zhang et al., 2006).

In 1952, the Soviet and Chinese governments signed a convention allowing Chinese students to study in the Soviet Union. The phenomenon of Chinese students going to study in the Soviet Union can be divided into four stages that took place from 1950 to 1965. In the first stage (1950 – 1953) students were strictly selected, and quality was preferred over quantity. In the second stage (1954 – 1956) students were mainly selected to study engineering. In the third stage (1957 – 1958) graduate students were preferred over undergraduate students. The fourth and last stage (1959 – 1965) was characterized by a reduction in exchange opportunities, in fact, after 1960, only around a few dozen of students went abroad to study. All students going to the Soviet Union to study were required to learn Russian for at least a year. Students sent abroad had the opportunity to study technology and its various applications, so that once they returned to China, they could address practical problems. After 1958, many students returned home after graduating abroad and started applying the new knowledge. In general, short-term students or trainees had the most immediate impact on technology transfer (B. Zhang et al., 2006).

With the outbreak of the Korean War in 1950, China felt threatened by the American army being closer to the Chinese border, so it began purchasing armaments from the Soviet Union through the loans provided by its communist neighbor according to the "Sino-Soviet Treaty of

Friendship, Alliance and Mutual Assistance". The Chinese direct involvement in the war eased Stalin's suspicions about China, which led to an expansion in cooperation between the two countries. However, Soviet leaders never fully trusted China, and likewise, neither did China fully trust the Soviet Union. Therefore, they were reluctant to provide China with advanced weapons. Nonetheless, they eventually did, as Khrushchev needed the Chinese support within the Soviet bloc during his campaign to remove Stalinism in 1956. Thus, in 1957 the Soviet Union provided China with advanced military technology. This only lasted for a couple years, and by 1959 the Soviet Union started restricting high-tech transfers. This behavior was also caused by the widening of the ideological gap between the two countries: they had, in fact, different interpretations of communism and socialism. In March 1969, the Sino-Soviet relationship ended with an armed clash at the border (B. Zhang et al., 2006).

Another issue that the Sino-Soviet collaboration encountered was that after five years of receiving Soviet aid, Chinese leaders' confidence in the country's capabilities increased, therefore, as mentioned above, in 1957 Chinese demand for Soviet equipment decreased. Moreover, in 1958 Mao Zedong proposed that China should surpass English and American economic indices within the next two years. To achieve this goal, he launched the so-called Great Leap Forward (大跃进 *da yue jin*) which ended up with China suffering from a great setback and famine. In the same year, Chinese experts started challenging their Soviet colleagues, and some started refusing their suggestions or even Soviet standards (B. Zhang et al., 2006). China was in fact growing confident about its recent developments and was ready to rely on itself and not count on other countries anymore.

Given the deteriorating relationship between the two countries in the late 1950s, starting from 1956, the Soviet Union began unofficially mentioning that it would start withdrawing the aid it was sending to China, yet nothing actually happened, and the collaboration continued as usual. However, in 1959 it announced that the support to develop the Chinese nuclear weapon program would be postponed by two years, because of the negotiations the Soviet Union was having with Western countries about limiting nuclear testing in the world. In July 1960, it withdrew experts and consultants from China. By calling back its scientists, the Soviet Union also took back designs, drawings, and technological data, which stopped most of the ongoing projects and industries in China. As a response, China threatened to not comply with the agreements it had with the Soviet Union and stopped exporting agricultural products and minerals as expected by the Treaty. In April of the same year, the Soviet Union also started restricting the number of Chinese students allowed to study abroad, and it rejected many of those previously selected by the Chinese institutions. In 1966, with the beginning of the Great Proletarian Cultural Revolution, Soviet students in China had to return to their home country, and Chinese students had to leave the Soviet Union to take part in the Revolution. This marked the end of the student exchange opportunities with the Soviet Union and, as mentioned above, in 1969 the collaboration between the two countries came to an end due to armed conflict at the frontier (B. Zhang et al., 2006).

Despite the abrupt and armed clash that marked the end of the alliance between the two countries, it is still worth mentioning that as a result of the Sino-Soviet collaboration, China learnt about new and modern technologies, and improved its technological and scientific field. Even though in the late 1950s the Western powers and the Soviet Union were having negotiations on limiting the amount of nuclear testing, this did not prevent or stop China from developing its own nuclear program, which was a successful process. In 1964, indeed, China was able to test its first nuclear bomb (Brombal, 2016). The positive consequences of the Sino-Soviet collaboration can also be seen in the era after the alliance had ended, in spite of the difficult times China had to go through.

1.4. The Great Leap Forward (1958 – 1962) and the Cultural Revolution (1966 – 1976)

After the abrupt split between China and the Soviet Union in the early 1960s, China was cut off from its technology source, leaving the country with no alternative technology partners and very little market access to technology. Thus, China approached a state of technological autarky for a decade from the mid-1960s through the mid-1970s. During this period, China's strategy was to import a handful of factories that embodied specific industrial technologies and replicate them domestically. A few key technologies in metallurgy and synthetic fibers were transferred in this way, and incremental improvements were made on some Soviet-legacy technologies, such as electricity generation, where equipment was scaled up to larger more efficient units. China's inability to achieve more than a modest rise in living standards during the quarter century after 1949 reflects the relative ineffectiveness of the innovation system (A. G. Z. Hu & Jefferson, 2008).

As previously mentioned, the Great Leap Forward was created to enhance China's productivity so that the country could reach the level of modern and developed countries such as England and the United States. During the Nanning conference held in January 1958, Mao Zedong proposed that the country should focus on the "technological revolution" (技术革命 *jishu geming*), without, however, leaving behind the ideological and political revolution it had been carrying out. He proposed that everyone should study technology and science because he believed that only this would quickly improve labor productivity and boost the Chinese economic and technological situation. He believed that this type of revolution and technological development could only be carried out through mass movement. All city committees were instructed to immediately make plans for technological innovation and put them into effect (Mao, 2013). During this movement, most villages and farmers were involved in the technological revolution which had important impacts on agricultural production and the people's daily lives. Two examples of this revolution in the agricultural field were irrigation and water conservancy, and fertilizer accumulation which would increase production in general. The first project required the excavation of irrigation projects, such as dikes and embankments. To excavate trenches that would be used to transport water, due to the lack of modern construction machinery, Chinese farmers had to use traditional methods, such as shoulder picking and manual lifting. Because of the tight work schedule, to accelerate construction progress, farmers not only worked tirelessly, but also strived to find ways to improve their work. Therefore, they created and improved transportation vehicles, but they also included semi-automated and animal powered soil movers. This shift from human transportation to vehicle transportation played an important role in involving as many people as possible, because machines also gave the elderly and teenagers the opportunity to work on the land, increasing the number of workers and therefore boosting production (Y. Zhu, 2010). Within the technological revolution, evidence of how thorough this movement was, four main fields were considered important: mechanization, semi-mechanization, automation, and semi-automation (Mao, 2013). It appears clear how technological development was still at the core of the leadership. As a result of this development, farmers were able to improve production and receive aid from mechanized machinery (Y. Zhu, 2010).

However, in spite of all the strong efforts made, this technological revolution turned out to be a failure, as many technology experts, engineers, and other technical personnel were left on the sidelines, because the movement incentivized mass collaboration over the work of single, yet skilled, individuals. Another reason for the failure of the revolution was that political decisions replaced technological decisions, because of the grip politics had on many fields, such as technology. The reason behind the launch of the Great Leap Forward Movement, was barely a technological reason, but rather a political one, to surpass modern countries, therefore the technological revolution was not organized and planned while taking into consideration technological objective laws of development and progress. The mobilization of masses is an indicator of the leftist fervor of the time, but is also a cause of the failure of the movement (Mao, 2013). Moreover, the media of the time publicized exaggerated data to push and motivate the Chinese people to continue working for their country. The data advertised by the media led people to believe that the rural part of the technological revolution was achieving its goals, when in reality it was not. In spite of the hard work of the people, the technological revolution had a short period of expansion and blooming, but after a little it died, and it did not yield the expected results. Many farmers died of fatigue or illness caused by the lack of rest and the lack of proper nutrition (Y. Zhu, 2010).

Another important event that characterized the late Maoist period was the Great Proletarian Cultural Revolution (无产阶级文化大革命 *wuchan jieji wenhua da geming*), or more simply the Cultural Revolution (文化革命 *wenhua geming*), which was a decade (1966 – 1976) known for the mass movement that had the goal of purifying the country from the ideals opposed to those of Mao Zedong and of communism in general. It also restored Mao Zedong as the central figure of the country (Samarani, 2017). The consequences this movement had on the Chinese people are well-known, especially the "re-education" of intellectuals, among which we can find Deng Xiaoping 邓小平. This period destroyed science and engineering education, and more generally, it strongly damaged the educational system. Indeed, between 1966 and 1969, Chinese universities admitted no new undergraduate students, and no graduate students were admitted until 1977. Not until 1990 did enrollment in four-year programs increase significantly. Only having a few science and engineering graduates, China had fewer research scientists than other smaller countries had (Freeman & Huang, 2015).

For these reasons, this decade is often considered a "dark period" of Chinese history, when all intellectual and scientific work was forcefully stopped because of political reasons. However, this is not entirely true, and not all political criticism of intellectual works had a negative impact on the development of science and technology. A clear example is the fact that Albert Einstein's works were translated into Chinese to be criticized by the masses. In spite of this being a negative circulation of his ideas, however, this spread his works throughout the country influencing not only scientists, but also political figures, such as Hu Yaobang 胡耀邦 (D. Hu, 2017).

The great losses suffered by the Chinese army during the Korean War, as mentioned above, pushed the cadres to act to better protect the country. Therefore, they decided on the development of the atomic bombs program in 1955, and on the development of strategic missiles technology, under Soviet advice. In March 1956, the Aviation Industry Committee was founded, and Qian Xuesen 钱学森, an American-educated Chinese aerospace engineer, was given the guidance of the newly established institution. The Committee was divided into two parts, one was in charge of the research, and the other one was in charge of administration. The former became the first Chinese institution that did research on missile technology. This institution continued to grow, even though at a slower pace and during the economic crisis caused by the Great Leap Forward. Additionally, later on it expanded to include missile testing and manufacture. By 1964 the Chinese economy had improved and was more stable, so the research on satellites and missiles resumed at full speed (C. Li et al., 2017).

During the decade of mass criticism and political movement that is the Cultural Revolution, the development of missiles and space programs encountered some difficulties, however both fields received the support of the political elite, as national defense had become a priority, given the unstable international environment surrounding China at the time. In spite of the low success ratio China had when it began working on its space program, the efforts made proved to be successful when in 1970 it was able to launch the first DFH-1 satellite, becoming the fifth country in the world to do so independently, with Japan beating China by only two months. In 1976 China launched three JB-1 satellites, two of which resulted in a successful operation. The achievements made in launching and recovering satellites placed China as the third country in the world to acquire satellite recovery technology. Confident because of these successes, the Chinese space program started developing the SG-1, which was a manned spaceship. The team began working on structure design, astronaut selection and training, aerospace medical research, and equipment testing. The program only lasted from 1971 to 1974 and was then suspended due to the lack of proper technological preparation, and the lack of urgent national demand for this type of technology. The main focus then shifted to satellite research (Li et al., 2017).

Space programs were not the only field that flourished during the Cultural Revolution, thermonuclear weapon testing, and the cultivation and popularization of hybrid rice (1976) were other important developments of the time. Moreover, between the 1960s and the 1970s the Rural Cooperative Medical Care was created with the purpose of providing the rural population with free and low-cost basic healthcare, and it lasted until the early 1980s when the Communes system was abolished (D. Hu, 2017).

It is clear that the Cultural Revolution was not an easy period, neither politically nor scientifically. The successful projects that flourished in that decade are not a result of the movement, but rather the result of a constant struggle of intellectuals against the political movement. In fact, the development of science and technology in the late 1960s and 1970s was uneven and precarious. Technology fared better than sciences, and in the scientific field applied sciences struggled less than pure sciences. On the other hand, all the projects that could prove useful for national defense and security flourished and received the most attention from the leadership. This was a response to the hostile international environment (D. Hu, 2017) and was also a method China had to improve its reputation on the international stage (Li et al., 2017).

On January 8th 1976, former Foreign Minister and Vice Chairman of the People's Republic of China Zhou Enlai passed away, followed by Chairman Mao Zedong on September 9th 1976 (Samarani, 2017). This year also marks the end of the Cultural Revolution, the end of the Maoist period, and the beginning of the new era characterized by Deng Xiaoping's reforms, opening up of the country, and continuous scientific and technological development.

After the Maoist period, China was left with two main legacies. First, the highly centralized system of innovation concentrated Chinese research capabilities within government institutions, leaving the country unable to develop a broad set of research capabilities that could sustain the productivity growth needed to raise national living standards. Secondly, the treatment of invention as a public good, therefore there were no laws or policies on creation and protection of intellectual property rights. These two legacies, however, hindered the creation of a robust national innovation system. The situation would change with the new era and the leadership would take important measures for the development of science and technology and for the creation of a flourishing innovation system.

Chapter 2: The Reform Era and the Development of China

2.1. China Opens Up to the World

During the Ming and Qing Dynasty, China implemented a self-seclusion policy, which evolved into a strict closed-door policy. After centuries of isolation, China was underdeveloped and as mentioned in the previous chapter, this had severe consequences on the economy and the country's growth. After the collaboration with the Soviet Union, which was the only foreign relationship China had during its isolation of Maoist era, the country started to become more developed and industrially advanced. It has to be pointed out that the isolation China was in during the Maoist period was not completely a choice of the Chairman, but it was also dictated by the United States who cut the recently founded People's Republic from the West, leaving the country forced to only have relationship with the Soviet Union (J. Wu, 2005).

Despite these past events, a few years before his passing, Chairman Mao Zedong started turning toward the United States, because the troubled relationship with the Soviet Union had worsened due to different factors. Some events that caused the further rupture between the two countries include, but are not limited to, the Sino-Indian war in 1962, when the Soviet Union clearly supported New Delhi, the tensions on the Taiwan strait, which highlighted the cold Soviet diplomacy, and the Cuban missiles crisis in October 1962 when Beijing initially supporting the Soviet Union, but after the crisis came to an end, the Chinese government accused Khruschev both of provoking the Americans, and of not being strong enough to win against President Kennedy's threats. However, the conflicts at the border and the issue of nuclear weapons were the two main reasons why the Sino-Soviet relationship ended (Samarani, 2017). After the rupture of the relationship with the Soviet Union, China turned toward self-reliance, and adopted a "self-seclusion policy" which resulted in a stagnant foreign trade situation, until the 1970s when things started to change (J. Wu, 2005).

Due to the situation with the Soviet Union, in 1968 the Chinese government proposed to the United States to improve their diplomatic dialogue, their relationship started again in 1970, and in 1971 Henry Kissinger, President Nixon's Secretary of State went to China to prepare Nixon's trip to Beijing in 1972 (Samarani, 2017). In the same year, China also normalized its diplomatic relations with Japan, and adopted a policy of developing trade relations with other Western countries (J. Wu, 2005). It has to be said that China moved toward the West also for defensive reasons, as the country feared a military attack by the Soviet Union (Samarani, 2017).

On October 25th, 1971, the People's Republic of China gained a seat in the United Nations Security Council, taking Taiwan's place. This marked the beginning of a new era for China on the international scene as numerous countries followed the American example and started diplomatic relationships with the People's Republic (Samarani, 2017). It appears clear how right before and right after President Mao Zedong's passing, the Chinese leadership guided by Deng Xiaoping took actions to end the isolation the country was living in to approach modern Western countries whose collaboration was vital for the Chinese modernization process.

Between 1977 and 1978, China imported as many sets as possible of large-scale manufacturing and mining equipment, and in 1978 it signed contracts for US$ 7.8 billion for equipment related to chemical fertilizers and metallurgy. Immediately, import and export trade grew and in the same year its volume was 38% higher than it was in the previous year. President Deng Xiaoping understood that the closed-door policy China had adopted in the past only damaged the national economy, so he started working on opening the country to the rest of the world. This process included the adoption of an export-oriented strategy, which exploited Chinese comparative advantages in labor-intensive industries in return for foreign exchange (J. Wu, 2005).

Since China is one of the founding members of the General Agreement on Tariffs and Trade (GATT), which was founded in 1948 and in 1995 became the World Trade Organization (WTO), in 1986, the Chinese government applied to restore its status as a founding member. This highlights the Chinese determination to further open up and become a fundamental player on the economic international scene. After fifteen years of negotiations, in December 2001 China was finally admitted to the WTO which led the government to implement reforms in many areas related to trade. The accession of China to the World Trade Organization meant that the country had accepted the rules of globalization, at least to some extent, and the country became an attractive environment for capital, technology, and talent from overseas to build an open economy (Samarani, 2017).

Since 2001 China has expanded its opening up which consequently boosted national development. Entering the World Trade Organization also promoted new development opportunities for China, to be shared with the world (Chang & Bin, 2021). This event in Chinese is called "entering the world" (入世 *rushi*) which is the abbreviated form of "entering the World Trade Organization" (加入世界贸易组织) (Zhonghua renmin gongheguo shangwubu, 2019), and it highlights the importance of this step toward a more open and internationalized economy.

2.2. “Reform and Opening Up” and the Four Modernizations

Right before the reform period in the late 1970s, China was one of the poorest nations in the world, with a predominantly rural and agricultural economy. Before Deng Xiaoping became President, the country had just experienced twenty-five years of centralized economic planning, the failure of the Great Leap Forward, and the chaotic decade of the Cultural Revolution. Industry was inefficient and concentrated in specific areas, not covering the whole country (Hofman, 2018).

Deng Xiaoping was the chief architect of the Chinese Reform and Opening Up process which guided China toward becoming the developed country it now is. He seized the opportunity of the expulsion of the “Gang of Four” to reform the country and start a new era. He also believed that to achieve modernization, China had to learn skills from foreign countries, however without simply copying their designs (J. Li, 2014).

Deng Xiaoping believed that science and technology were the first productive forces (科学技术是第一生产力 *kexue jishu shi diyi shengchanli*), and this concept has also been inherited by current President Xi Jinping 习近平. Deng Xiaoping, indeed, believed that the development of science and technology was the most important step for the national economic construction, and he shared this belief in multiple occasions, such as in 1978 at the opening ceremony of the National Science Congress, in 1988 during his meeting with President Husak of Czechoslovakia, and in early 1992 during his visit to the South of China. Since the Reform and Opening Up was launched, a series of initiatives have been implemented to promote scientific and technological innovation, which also contributed to Chinese economic growth (Yu, 2018). The first and most important step to promote development of science and technology, in fact, was to issue related policies that could create an environment where innovation can bloom, and enterprises working in the field can build strategic alliances and share benefits. The government, in fact, adopted innovation incentives and created information platforms for the exchange of scientific information (J. Wang & Hua, 2021).

In 1975 Deng Xiaoping ordered a revision of scientific policies in China with the purpose of laying the foundation for a reform of national research institutions, first and foremost the Chinese Academy of Sciences (中国科学院 *zhongguo kexueyuan*) which the Chairman entrusted to his colleague Hu Yaobang. This and other reforms marked the beginning of the reform era for China, an era in which innovation, science and technology became the main focus of the leadership after the decade of the Cultural Revolution, when, as mentioned above, science and technology had to fight to not be suppressed (Brombal, 2016). Officially, in 1978 Deng Xiaoping ordered the country undergo a modernization process for science and technology, this time in a more structured and organized way. It becomes evident the central role the state played – but is also still playing – in this type of reforms (Silvestri, 2021a).

Between the end of 1978 and the beginning of 1979, a project called "Four Modernizations" (四个现代化 *si ge xiandaihua*) was launched by the Chinese government. The so-called modernizations were: agriculture, industry, science and technology, and defense. This reform project started during the 19^{th} National Congress of the Chinese Communist Party in 1977, and focused on the economic modernization of the country, while the role of ideology became less important, and it also introduced the idea of liberalizing more the economy (Samarani, 2017).

As Whyte said, in that period "millions of […] victims of the Mao era were rehabilitated and encouraged to contribute to the 'four modernization' " (Whyte, 1993). This process brought both old and young brilliant minds together which inspired critical thinking in China until 1989. The Chinese Communist Party also imposed on itself a restraint; therefore, ordinary citizens could have a “zone of indifference”. Although this sort of freedom was given for economic reasons, that is to allow expertise and innovation to freely flow in the country without excessive political interference, this also lowered people’s fear to share independent ideas and critical opinions in comparison to the Maoist period (Whyte, 1993).

Reforms in China were gradually implemented, starting from the agricultural modernization. The household responsibility system was introduced, alongside township and village enterprises. Small steps were taken to open up the Chinese economy to foreign trade, but its effects became visible and significant only starting from the 1990s. Gradual moves were also taken on the financial sector, and state-owned enterprises underwent a reform. The Chinese leadership of the time opted for a gradual approach in many fields to prevent any political resistance, moreover experimental reforms allowed authorities to gather information on the effects these changes had and that could not be anticipated, and to develop the necessary policies to implement said policies. If the experiment proved to be successful, then the reform would be applied to other sectors, and expanded to more regions. In order to successfully implement different reforms in different parts of the country, the government decided to decentralize this aspect, turning the country into a “laboratory” of experimental reforms (Hofman, 2018).

In 1984, the industrial sector reform was launched, which led companies to pay a fee on their profit, and managers to have more decisional autonomy. In 1985 more reforms were approved for the scientific and technological field, and in the education field. Resources were re-allocated, mainly in areas such as science and technology, and international cooperation; new educational methods and concepts were introduced, and schools gained more autonomy (Samarani, 2017).

On the economic field, one of the major changes of the time was the shift toward an export-oriented economy, which meant an increase in exports, while foreign capital flowed into the country. This helped the Chinese economy grow at a steady pace, and it also helped increase employment, transform the industrial sector, and enhance the country's competitiveness on an international level. With the expansion of globalization, China acquired many manufacturing activities from developed countries, improving its vertical skills and the national manufacturing industry. China worked as a subcontractor in the global manufacturing value chain (J. Li & Nan, 2017).

2.3. Sino-foreign Joint Ventures and Foreign Direct Investments

The process of modernization China went through starting in 1978 was led by the state which was able to coordinate all the actors involved in the process, promoting the spread of knowledge, adoption of new technologies, and the emergence of innovative practices (Silvestri, 2021a).

Since 1971, when the People's Republic of China was recognized as a country by the United States, the nation has experienced a rapid increase in GDP and industrial production. This process was due to the growth of foreign direct investments which influenced and improved technological capabilities of the country (Coisson, 2016).

In 1979 China signed the "Bilateral Agreement for the Scientific and Technological Cooperation between China and the United States", with the goal to acquire technological know-how. During these years, technological transfer was happening not only thanks to the United States, but also thanks to Japan, France, Germany, and the United Kingdom (Silvestri, 2021a).

One of the most important side projects of the Reform and Opening up era was the creation of four "Special Economic Zones" (经济特区 *jingji tequ*) that were launched in 1979. These zones were located in Shenzhen, Zhuhai, and Shantou, in the Guangdong province, and Xiamen, in the Fujian province (Samarani, 2017). The establishment of these special economic zones was one of the first steps China took down the path of opening up the country. In fact, as mentioned above, the first reforms were only implemented in certain regions, to lower the risk of failure. Moreover, the cities chosen to become a Special Economic Zone were places near Hong Kong, Macao, and Taiwan, which were all homes to overseas Chinese. The purpose of these special cities was the introduction of experimental forms of economic international collaboration through the inflow of foreign investments, technology, and advanced management methods, such as the creation of sino-foreign equity joint ventures, sino-foreign contractual joint ventures, and wholly foreign-owned enterprises (J. Wu, 2005).

In those years, China started developing a gradual process toward the development of its scientific, technological, and innovative skills. Before the reforms of 1978 and 1979, these fields were controlled by the central government through public research institutes, government funds, and most importantly, they were completely dependent on the technology and know-how transfer happening in sino-foreign joint ventures (Silvestri, 2021b). These types of enterprises attracted numerous foreign investments and it generated a great deal of foreign trade, which resulted in rapid economic development (J. Wu, 2005).

Attracting foreign direct investments was very important for China, because it enabled the country to obtain valuable capital resources, and also it brought advanced technology, management skills, access to foreign markets, and competitive pressure, all of which were extremely important for the national economic development. Foreign direct investments have increased year by year since the late 1970s, and in 2002 China surpassed the United States and became the country using the largest amount of foreign direct investments in the world (J. Wu, 2005).

In the 1990s there was a rapid growth of investments by multinationals, which mainly were responsible for research and development (R&D) projects. This increase of capital and technology intensive projects, and of technological content of foreign invested projects enhanced China's ability to participate in the international scene (J. Wu, 2005).

In 2001, 90% of domestically owned large and medium enterprises purchased imported technology, while foreign-invested enterprises purchased nothing in Chinese domestic technology markets. Domestic firms that combined in-house R&D with imported technology were more likely to become successful exporters. Therefore, incentives for domestic firms to develop their own R&D, while also using foreign technology transfer, supported the growth of opportunities for Chinese-owned companies to compete on international markets (A. G. Z. Hu & Jefferson, 2008).

All these changes mentioned above, motivated many enterprises to search for new process and product innovations needed to enable survival and to increase wages. Nonetheless, while China's enterprises increasingly established their own independent R&D operations, by 1990 the share of the enterprise sector in total national R&D spending was still low. Furthermore, within the enterprise sector, nearly two-thirds of total R&D spending was still controlled by state-owned enterprises. At the same time, more than 5,000 research institutes that accounted for one-third of the country's scientists and engineers remained largely under the supervision of one or more government agencies and fundamentally unchanged throughout the 1980s and most of the 1990s (A. G. Z. Hu & Jefferson, 2008).

By 2000, these conditions had either changed dramatically or were on the path toward fundamental change. In 2000, 60% of the country's R&D spending was funded and performed by the enterprise sector. Moreover, with the acceleration of ownership restructuring in the latter half of the 1990s, by the year 2000, the majority of enterprise-funded R&D was performed outside the state-owned enterprise sector (A. G. Z. Hu & Jefferson, 2008).

Table 1 (A. G. Z. Hu & Jefferson, 2008: pp. 295) shows how Chinese R&D intensity increased between 1991 and 2003, with a more sharp increase between 1995 and 2003, after it decreased between 1991 and 1995. Numbers marked with "a" represent data for the following year; numbers marked with "b" represent data for the previous year.

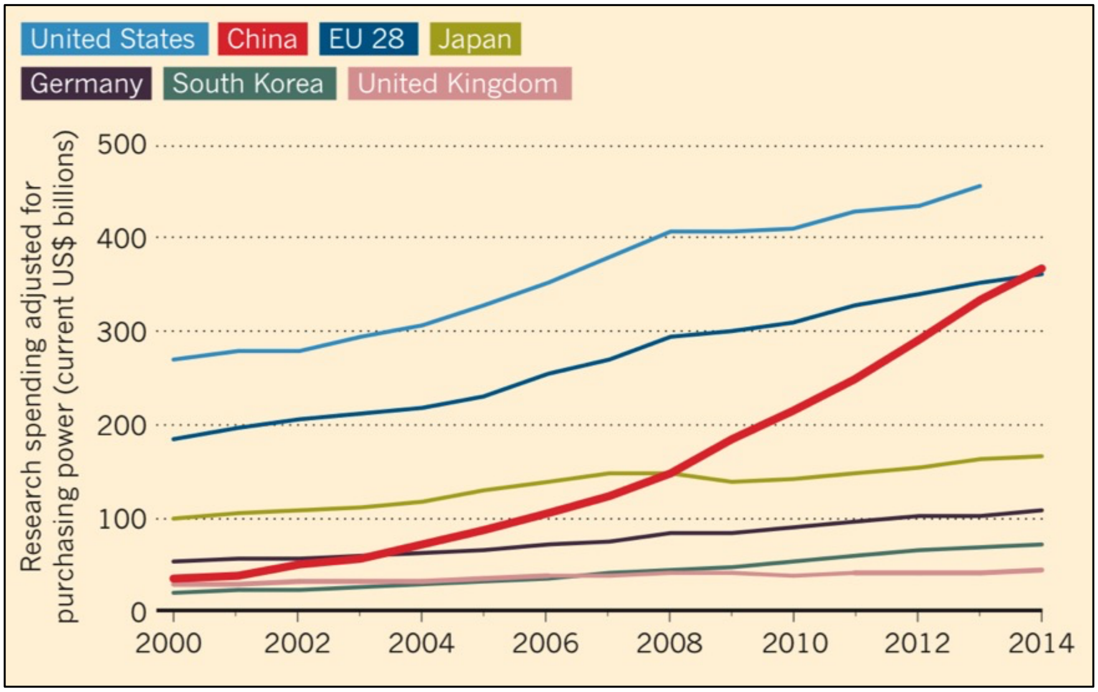
Table 1: Comparative measures of R&D intensity between 1991 and 2003.

R&D expenditure/GDP	**1991**	**1995**	**2000**	**2003**
China	0.74	0.60	1.00	1.23[a]
USA	2.72	2.51	2.76	2.62
Germany	2.52	2.25	2.49	2.50
Japan	2.93	2.89	2.99	3.12[b]
Korea	1.92	2.50	2.65	2.96
Taiwan	—	1.78	2.05	2.16
France	2.37	2.31	2.18	2.20
Italy	1.23	1.00	1.07	—
Brazil	0.46	0.69	1.05	—
India	0.85	0.77	0.86	—

The R&D level of China is very high considering the living standards of the country at the time (A. G. Z. Hu & Jefferson, 2008).

Table 2 (Van Noorden, 2016: pp. 453) shows the increase of Chinese R&D spending from 2000 until 2014 compared to other countries. The steep increase in R&D spending is evidence of how important the development of research is for the Chinese government.

Table 2: Comparison of Chinese R&D spending with other countries from 2000 until 2014.



In the late 1990s, the number of scientists also increased, from 12 scientists and engineers per 10,000 people in 1998, to 15 over the course of six years. This period also saw an increase in matriculating and graduating students for fields such as sciences and engineering (A. G. Z. Hu & Jefferson, 2008).

In 2006 the government issued the "Medium and Long-Term Plan for the Development of Science and Technology (2006 – 2020)" which set the goal of transforming China into an innovation-oriented country by 2020, and into a world-class scientific power by 2050. That year also marked the shift of focus from importing know-how from abroad, to assimilation, absorbance, and re-innovation. However, this did not mean that China stopped its collaboration with foreign countries, on the contrary, it strengthened its bilateral collaborations with other countries on the matter. This process was facilitated by government intervention and supervision (Silvestri, 2021a).

The plan had three main objectives that had to be completed by 2020: increasing the nation's gross expenditure on R&D as a percentage of GDP to 2.5%, increasing the contribution of science and technology progress to economic growth to 60% or more, reducing the degree of dependence upon foreign technology to 30% or less, and lastly, making China one of the top five countries in the world in terms of number of invention patents granted to its citizens and citations of international scientific papers to its authors. By 2020, all the objectives except for the first one have been reached. In fact, national gross expenditure on R&D reached 2.4% and not the projected 2.5%, despite the steady increase of R&D of the last fifteen years. The contribution of science and technology progress to economic growth reached 59.5% in 2019, representing a significant improvement; therefore, the second target seems attainable. Although in 2016 the Chinese government stopped using the degree of dependence upon foreign technology on its misleading nature, the indicator did decline to 31.2% in that year, attributing to rapid growth of domestic investment in R&D and shrinking foreign technology imports. Lastly, the number of patents filed with the US Patent and Trademark Office, European Patent Office, and Japan Patent Office had increased from 524 in 2005 to 5323 in 2018, elevating China's ranking from the 13th to the 3rd. Moreover, citations to Chinese international scientific papers have increased since 2006, leading to the rise of China's international standing from the 13th to the 2nd (Sun & Cao, 2021).

2.4. Technology Transfer through Education

Starting from 1978, Deng Xiaoping attempted to build a more meritocratic system that would restore morale and improve incentives. This new system reinstated practices of the pre-Cultural Revolution period, such as competitive examinations, grade-based academic practices, direct entry into colleges, and urban jobs available to middle school graduates. Workplaces started selecting people on the basis of competitive examinations, and people who had a position in teaching in the late Maoist era had to pass a test to maintain their jobs. New educational categories opportunities were opened, such as graduate studies to earn advanced degrees and also to go study abroad (Whyte, 1993).

Since the 1980s investments in university research started increasing, reaching an annual growth of 15%, a rate only rivaled by the United States in the post-Sputnik era, and nowadays China has become the second country in the world for investments in R&D. The government, indeed, believed that a development and improvement in the scientific and technological field would contribute to the country's overall economic development. The idea that science and technology could benefit society is also due to the Leninist roots the Chinese Communist Party had (A. Chen et al., 2016).

As mentioned in the previous chapter, the adoption of modern Western-style universities in China started in the 1890s after the reforms of the Qing Dynasty, but only in the 1930s universities added curricula on scientific and engineering training. During the period of the collaboration with the Soviet Union, because the government goal was to revive and modernize the industrial capacity, the Russian model was adopted, but it mainly only focused on teaching, rather than on research. The Chinese Academy of Sciences dealt with basic research, while research institutions tackled applied research. After the end of the Cultural Revolution, the government had to step in and take measures to encourage industrial and technological development (A. Chen et al., 2016)

Table 3 (A. Chen et al., 2016: pp. 894-895) summarizes the principal laws and policies implemented on the matter from 1949 until 2015.

Table 3: Main university technology transfer-related laws and regulations enacted from 1949 to 2015.

Date	Name of the policy	Description of the policy
September 1949	Common Program of the Chinese People's Political Consultative Conference	Basic definition of the role of science in development of Chinese Society
March 1951	Instructions on Strengthening the Contact between the Chinese Academy of Sciences and Industry, Agriculture, Health, Education and National Defense	Scientists should engage in research with benefits to society
January 1975	Constitution of the People's Republic of China	Research should be combined with productive labor
March 1978	National Science and Technology Development plan Outline from 1978 to 1985	S&T should play an increasingly large role in production and research should be combined with production and application
March 1984	Patent Law of the People's Republic of China	Granted inventors the right to patent inventions
January 1985	State Council's Interim Provisions on Technology Transfer	Encouraged a market for state-funded technology
March 1986[1]	High-technology Research and Development Plan Outline (namely the 863 Program)	Program funded to stimulate the development of defense-oriented technologies
May 1987	Opinions on Science and Technology reform in Universities	University education and research should contribute to production and URIs and firms should cooperate
June 1987	Technology Contract Law of the People's Republic of China	Guaranteed technology contracting parties' lawful rights and interests in maintaining order in technology markets

[1] The original source writes "November 1986." however, there is a mistake. As explained in section 2.7, program 863 gets its name from the Chinese date system, therefore it was launched on March (the third month) of 1986.

August 1988	China Torch Program	High-technology development plan that eased regulations, provided support for facilities to attract foreign companies, and encouraged the establishment of indigenous firms in special zones throughout China, many of which were located close to URIs. This facilitated the development of USPs
July 1993	Scientific and Technological Progress Law of the People's Republic of China	Called Chinese "Bayh-Dole Act" and granted universities the rights to commercialize government-funded technology and IP
May 1996	Law on Promoting the Transformation of Scientific and technological Achievements	Meant to promote, guide, and standardize state-funded IP technology transfer at URIs
May 1998	Law meant to create world-class Universities (namely the 985 Project)	Provided massive funding to selected universities so that they can become world-class
March 1999	Regulations on Promoting Scientific and Technological Achievement Transformation	Encouraged S&T personnel to invent new technologies and transfer them to develop high-tech industries
April 1999	Regulations on Universities' Intellectual Property Protection and Management	Gave universities IP rights and encouraged them to contribute to S&T industrialization
August 1999	Decisions on Enhancing Technological Innovation, Developing High Technology, and Realizing Industrialization	Encouraged and supported universities to establish USPs and improved their IP management systems
November 1999	"211 Project" Construction Planning	Funded construction at approximately 100 universities in a variety of key subjects
June 2002	Opinions on Giving Full Play to the Role of Universities' Scientific and Technological Innovation	Further encourage university S&T innovation and promote the combination of science and education in order to improve NIS
December 2003	Enterprise State Asset Transfer Interim Measures Order No.3	Meant to regulate and standardize technology transfers to firms of state assets under SASAC's purview
December 2007	National Technology Transfer Promotion Action Program	Meant to build an innovation system of industry-university-institute to promote the transformation of S&T into productivity

December 2007	National People's Congress (NPC, the Legislature) Revised the Science and Technology Progress Law	Meant to enhance technology transfer and encourage local government support for research cooperation between industry and universities
June, 2008	National Intellectual Property Strategy Outline	Meant to increase China's IP creation, utilization, protection, and management ability
November 2010	National Patent Development Strategy (2011 – 2020)	Declared 2020 goal to become a country with high levels of patent creation, utilization, and protection
September 2012	Opinions on Deepening the Reform of Scientific and Technological System and Speeding up the Construction of National Innovation System	Supported enterprises and URIs in working with each other by setting up an R&D platform and innovation strategy alliance
March 2015	Opinions on Deepening the Reform of Systems and Mechanisms and Speeding up the Implementation of Innovation-driven Development Strategy	Plan to gradually separate URIs and their subsidiary enterprises (UOEs) and they should no longer create UOEs. Also, to strengthen IP management
August 2015	Law of Promoting Scientific and Technological Achievements transformation of the People's Republic of China (2015 Revision)	Meant to standardize and speed-up the transformation of S&T achievements into economic benefits

In 1978, a new science policy was introduced stating that Chinese science and technology should support social and economic development. It also declared that the connection between academic research and industrial needs was weak, and therefore it had to be strengthened. With the Patent Law of 1984, the number of patents issued by each university became a metric for evaluations. In 1987 the State Education Committee stated that universities must more actively participate in the development of science and technology that would improve national development and enterprise growth. Therefore, since then, the Chinese government began increasing university research funding, and in the same year university technology transfer started being more encouraged. In fact, in 1986 the government passed a policy giving universities more responsibility for the management of their budgets, and in 1995 there was an increase of university independence. In

1993, thanks to the Scientific and Technological Progress Law, science research gained more freedom, which also encouraged scientific exploration and technological innovation. Starting from 1999, universities were incentivized to commercialize their high technology achievements, and they also started establishing their own firms (A. Chen et al., 2016).

Between the early 1980s and the late 1990s, the Chinese government pushed for universities to cut costs, and to find external sources of income. Because of this pressure, universities all over the country started founding university-operated enterprises to commercialize their newly developed technology. After Chinese firms became more technologically capable in the late 1990s, university-operated enterprises started decreasing, until 2015 when the government implemented a law to officially reduce them. This decline of university-operated enterprises was due to the increase of government funds for research, therefore universities did not have the need to create profit anymore (A. Chen et al., 2016). The profitable transfer of technology from universities to firms that would commercialize this technology started in the United States in 1980 with the Bayh-Dole Act, and since then other countries have started passing similar laws so that universities could gain a profit selling their technology to external firms (Hayter et al., 2020).

All the policies and laws implemented since the 1980s played a significant role in increasing investments in R&D in China, and also led the country to become a major contributor to the global scientific community (A. Chen et al., 2016). In 2003 China accounted for 5% of the total world's scientific publications (A. G. Z. Hu & Jefferson, 2008). Nowadays, Chinese scientific production competes with that of more advanced countries, and China is the third largest producer of scientific articles, behind the United States and the European Union: it produces 20% of the global scientific articles (Brombal, 2016). The huge improvement China did on scientific publications is significant, in fact, between 1997 and 2001 the country produced 1% of the 1% top-cited publications. Nowadays, however, things have greatly changed (Xie et al., 2014).

In 1990, the percentage of Chinese doctorates awarded was 5-7% of those awarded in the United States. However, in 2010, it reached the American percentage, and most of the new doctors graduated in natural sciences or engineering. This is due to the constant increase of investments in R&D, which is 2% of the country's overall GDP, the same as the European Union. In the 13th Five-Year plan, China set a goal to increase investments in R&D to 2.5% by 2020 (Brombal, 2016), however it hasn't been reached yet. Nonetheless, this does not mean that investments in the field are decreasing, in 2019 they have increased by 12.5% compared to the previous year (Silvestri, 2021a).

Moreover, in order to make higher education more accessible to its people, the Chinese government more than doubled the number of higher education institutions from 1,002 in 1998 to 2,263 in 2008. In addition to the creation of new institutions, it also worked on restructuring, upgrading, and enlarging existing ones (Xie et al., 2014)

In 2002, China reported that in the country there were 4,347 research institutes, and 744 of these were directly supervised by the central government, including 98 institutes that comprise the Chinese Academy of Sciences. More than one half of the Chinese government R&D funding is channeled to those research institutes under the central control. It appears clear that research institutes are at the core of research in the Chinese science and technology system (A. G. Z. Hu & Jefferson, 2008).

Another important factor that helped China develop since the late 1970s was the return of Chinese scientists and engineers who studied in the United States and in Europe, who helped build the country, just like after the foundation of the People's Republic of China. These students are called "sea turtles" (海归 *haigui*), and their contribution to the development of science and technology was vital for the country. Since they had studied and worked in advanced industrialized countries, they had been influenced by Western thoughts, and they were less attached to the Chinese traditional culture, resulting in a more open and flexible mindset (Coisson, 2016).

As mentioned in the previous chapter, the phenomenon of Chinese students going abroad to learn from advanced countries and then coming back to the motherland to help national development is nothing new and has been happening since the Opium Wars. Just like in the 19th century, also in the 20th century returnees led the country out of poverty and backwardness, with their most important contribution in the development of science and technology. In the 21st century the Chinese leadership started paying more attention to returning students. Some of these returnees are responsible for the foundation of theoretical physics in China, the launch of the first satellite, and also the building of the internet as we know it today (H. Wang, 2014).

Returning students not only helped improve the scientific and technological fields, but also brought back new standards for the education and research fields. They pushed the Chinese research institutions to adapt to the international community, and to smooth this passage, some of them became teachers and professors. Currently, most presidents of universities in China are returned students, and half of the Chinese winners of scientific awards are also returnees. In 2014, 81% of the researchers working at the Chinese Academy of Sciences, and 54% of those working at the Chinese Academy of Engineering had had an experience studying abroad (H. Wang, 2014).

However, it has to be pointed out that not all students who go abroad to study come back after graduation, some prefer to stay in the new country, which is – most of the time – the United

States. The percentage of Chinese students who decided to stay in the United States was 85% in 2011. To solve this issue, in 2009 the Chinese Ministry of Human Resources and Social Security put forward the “Action Plan for Overseas Scholars to Serve the Country” with the purpose of attracting more students to return (H. Wang, 2014).

Moreover, the Chinese government also tried to attract talent from abroad by targeting overseas Chinese-born scientists, especially those working in the United States with two programs. The “Changjiang Scholars Program”, which was launched in 1998, first offered scientists incentives that were mostly on a short-term visiting basis. Then, in 2008, the government launched the Thousand Talent Program called “The Recruitment Program of Global Experts” with the explicit goal of raiding first-tier foreign research institutions for senior-level scientists. Aided in part by the global financial crisis, the program attracted numerous overseas Chinese scientists back to their homeland. Even as the number of students studying abroad continued to increase, the ratio of returnees to exits rose from 30.56% in 2007 to 38.54% in 2008, and again to 47.23% in 2009. By April 2012, the program had attracted 2,263 scientists to work in China (Xie et al., 2014).

Nevertheless, no matter the numbers, these “sea turtles” played an important role in promoting Chinese innovation and research achievements and also helped reforming the educational system. These changes also boosted the internationalization of research (H. Wang, 2014).

2.5. The Rise of Technocracy

In 1979 the "One Child Policy" (一孩政策 *yihai zhengce*) was announced, alongside with more laws that had the purpose of re-building the Chinese judiciary system after the Cultural Revolution, which resulted in the creation of the new Constitution in 1982 (Samarani, 2017). The "One Child Policy" however, had been difficult to implement since the beginning, because in the reforms era migration restrictions were slightly loosened so people could move from rural areas to cities to find better job opportunities, so authorities encountered difficulties keeping track of where people were to make sure the policy was being respected. This is one of the consequences of re reforms that Deng Xiaoping did not anticipate (Whyte, 1993). This policy is one example of how experts, such as scientists, began working in close relationship with politics. Technocracy was born.

A technocracy is "a nation run by people who are in power because of their technical expertise" (Y. Liu, 2016). Starting in the early 1980s, China was beginning to develop into a technocracy. With the new reform era, technocratic leaders have risen in China starting from the early 1980s, until there was a fully technocratic leadership in the 1990s. This deep transition is explained by the increasing demand for highly educated candidates with technocratic expertise who were meant to guide China's rapid industrialization and economic modernization projects. After the 12th Party Congress of 1982, the ruling class was a group of leaders with professional job experience, and among their positions we can find industrial managers, economic planners, and engineers. Before 1982, the percentage of technocrat members of the 9th, 10th, and 11th Central Committees was only around 2%. It increased to 17% in the 12th Central Committee and went up to 20% in the 13th Central Committee. During the 14th Central Committee, the percentage of technocrats was 32.80%, against 40.74% that were career bureaucrats. Lastly, during the 15th Central Committee, at least 55.4% of bureaucrats were technocratic leaders. However, this data has some limitations, as it was gathered without a specific definition of what defines a technocratic leader. Some scholars take into account the politicians' college major, some do not, but rather take into account if they have had any previous professional positions (R. Lin, 2020). Nevertheless, the rise of technocratic leaders between the 1980s and the 1990s is an undeniable fact.

The difference between a political leader and a technocratic leader, is that career bureaucrats usually have more experience in the political field, have a better understanding of how party and governmental organs work, and they also generally have better people skills when compared to technocrats, who are used to their technical jobs where they work with highly skilled people (R. Lin, 2020).

Between 1990 and 2013, 79.55% of provincial Chinese leaders received a college education. Table 4 (R. Lin, 2020: pp. 160) shows that among these, 55.44% were trained in a technocratic major and 38.91% in the humanities and social sciences. Particularly, leaders studying engineering accounted for 38.22%. Technocrats generally had career experience in industry, engineering, or economics (R. Lin, 2020).

Table 4: Academic majors of Chinese provincial leaders between 1990 and 2013.

	Obs.	%
Technocratic Major		
Physics/Chemistry/Biology/Geology/Mathematics	863	11.05
Engineering	2,984	38.22
Agriculture	364	4.66
Medical Science	117	1.50
Subtotal	4,328	55.44
Humanities & Social Sciences		
Philosophy	210	2.69
Economic/Finance	945	12.10
Legal Studies/Political Science	583	7.47
Education	57	0.73
Literature/Linguistics	958	12.27
History	227	2.91
Management	58	0.74
Subtotal	3,038	38.91
Unknown	441	5.65
Total	7,807	100.00

It appears clear that many politicians in today's China also have expertise in engineering and economics. This phenomenon does not only apply to lower-level politicians, but also the Presidents, in fact, Jiang Zeming 江泽民, Hu Jintao 胡锦涛, and Xi Jinping, all studied engineering. This system in China receives high levels of public satisfaction, providing a sound argument for legitimacy. This does not apply to Western countries, as they consider it an anti-democratic method (Y. Liu, 2016).

According to table 5 (R. Lin, 2020: pp. 161), only 15.77% of the elites were recruited into provincial leadership as professional specialists in industry, engineering, or economic planning, while a large number of career bureaucrats came to power, accounting for 64.32% of all provincial leaders. Party workers accounted for 52.45%, whereas government administrators were only 8.63%. To take insight into the tenures in industry, finance and engineering respectively, provincial leaders with 10-year tenure or longer provide 21.98% in industry, 10.76% in finance and 0.92% in engineering. Taking both the main career patterns and job tenures in professional occupations together, 32.26% of provincial leaders worked as industrial managers, engineers, or economic planners (R. Lin, 2020).

Table 5: Main career patterns of Chinese provincial leaders between 1990 and 2013.

	Obs.	%
Party Work	5,147	52.45
Government Administration	847	8.63
Mass Organization	251	2.56
Military	67	0.68
Subtotal	6,312	64.32
Industry	865	8.81
Engineering	90	0.92
Economic/Finance	593	6.04
Subtotal	1,548	15.77
Education	658	6.70
Police/Court	101	1.03
Personnel/Organization	144	1.47
Resource/Environment	364	3.71
Propaganda/Media	133	1.36
Others	554	5.64
Total	9,814	100.00

The mid-1950s and 1960s saw an effort of the Chinese Communist Party to fight illiteracy and improve educational credentials in order to build the state, placing emphasis on higher education. Moreover, faculty restructuring took place in many universities in the country with the priority of training technical experts and teachers and developing specialized colleges for industrialization and economic development. These changes lay behind the increase in numbers of university educated people, and a vast majority of technocrats in the 1990s attended university in those years. In addition, after graduating from college, they immediately found a job that matched their specialization, thanks to the graduate job placement plan which lasted from the 1950s until the 1980s (R. Lin, 2020).

As the regime's agenda shifted toward economic development, industrialization, and modernization, the demand for technical specialists became greater. However, this was an insufficient condition for technocratic dominance. Technocrats did not come to prominence in the 1950s when the party state promoted socialist reconstruction and Communist-style industrialization. Moreover, they did not come to prominence in the early years of the 21st century when the party state launched its growth strategy of innovation nation and the number of college students studying science, technology, engineering, and mathematics increased dramatically (R. Lin, 2020).

The importance of science in the political decision process has become more and more a key factor, especially in the early 2000s with the leadership of Hu Jintao and Wen Jiabao 温家宝. In those years, in fact, the two chairmen created the expression "scientific vision of development" (科学发展观 *kexue fazhanguan*) which highlighted the necessity to balance economic growth, social development, and environmental protection. This expression, however, lacks the idea that scientific and technological progress should also influence social and cultural inclusivity. In fact, social and human sciences are not considered useful for the country's development, because a technocratic approach is also more lucrative (Brombal, 2016).

In recent years, technocracy has received a boost, also as a result of President Xi Jinping's third term. In fact, the decision-making body – the Politburo – gained several members with qualifications or experience working in science or technology: six out of twenty five members now have a background in science, compared to just one member in the previous Politburo (Mallapaty, 2022).

2.6. The Unexpected Consequences of the Reforms

By 1985, problems started arising both in the economic and political fields, since opposition against the reforms was becoming more evident. In fact, by the end of 1984, the rapid rural growth had slowed down, and the second phase of agricultural reforms hit farmers' pockets. After the state abolished its mandatory grain purchase, prices dropped significantly. Farmers therefore started cutting back on grain production and started selling to the state only when prices were high. This resulted in many farmers leaving the rural areas to find more lucrative jobs in the industrial sector, or in cities (Saich, 2011).

Problems in the industrial sector had emerged when the economy transitioned to a market-influenced system, prices controls were lifted and enterprises had more incentives, resulting in a surge in inflation in 1985. The government had to slow down its growth goals, keeping it steady but healthy: this would have helped a gradual implementation of the reforms (Saich, 2011).

In the summer of 1986, it had become clear that within the political leadership there was a severe division, and the students' demonstrations of that year gave the opponents of a more radical reform the opportunity to remove Hu Yaobang. These demonstrations had less grip on the broader society when compared to those of 1989, because in 1986 students were considered to be well-off and because their demands found little rapport with the public at large. In 1989 criticism of corruption found a more sympathetic response (Saich, 2011).

Reforms continued after major changes in the leadership, such as the retirement of older officers of the army, the creation of the Central Advisory Committee for the elderly cadres, and the announcement of cost cutting measures in the government. Zhao Ziyang 赵紫阳 moved toward giving enterprises more freedom and autonomy. However, this did not help the economic situation. Inflation increased, and disgruntlement grew among people, erupting in the demonstrations of 1989 (Saich, 2011).

One of the most important events of the following years was the tour to South of China Deng Xiaoping took in early 1992 with the purpose of relaunching the reforms, which were believed to be vital for the party's legitimacy. He called for an economic growth of 8-9%, which reflected the emerging consensus that too rapid economic growth would see the return of previous problems and the increase of inflation. Moreover, in that period Jiang Zemin proposed that foreign capital should not be used only for enterprises, but could also be used in areas such as finance, commerce, tourism, and real estate, which boosted the construction industry (Saich, 2011). It was Jiang Zemin who stated that the development of the country should be achieved through science and technology, which is a way of proving that science and technology are the main productive forces, like Deng Xiaoping believed. Jiang Zemin also thought that technological innovation should be achieved through talent resources, and that any type of advancements and development depended on improving the quality of workers. Therefore he proposed that party committees and governments at all levels should always trust and care for intellectuals, offer them suitable working and living conditions, and take effective measures to further promote the well prevailing custom of respect science, respect knowledge, and respect talent (Fei & Ren, 2016).

After the passing of Deng Xiaoping, the country had to continue on the reform path without him. However, the uncertain national and international scene made it more difficult for the leadership to operate. In fact, between 1999 and 2001 the approach to reforms was more cautious. In 2001, Jiang Zemin launched the idea of the "Three Represents" (三个代表 *san ge daibiao*) which was adopted in the party Statutes the next year. According to this theory, the Chinese Communist Party represents the advanced social productive forces, the most advanced culture, and the fundamental interests of all people (Saich, 2011).

At the beginning of the 21st century, the Chinese leadership, guided by Hu Jintao, started addressing the negative side of the rapid development the country went through in the previous decades, more specifically, the government started dealing with social and territorial issues, as well as the severe problem of environmental pollution. To solve these aspects, the country underwent ambitious reform plans, especially in the public healthcare sector, and from 2013, when Xi Jinping was elected President, the leadership also dealt with corruption (Coisson, 2016).

In addition to the political issues, the reforms also caused social and environmental problems which became evident after a few decades after the launch of the reforms. Except for challenges of environmental decoupling, the concept of sustainable development also focused on poverty reduction, health care improvement, the provision of high-quality education, social inequality mitigation, and ocean sustainability. After forty years of development, China has become the world's second largest economy. The contribution from China to the global GDP has increased from 2.4 to 14.8%, the per capita GDP from CN ¥ 380 to CN¥ 54,000, the per capita disposable income from CN¥ 170 to CN¥ 24,000, and the outward foreign direct investment from CN¥ 297 to CN¥ 1,235,925 million. However, economic prosperity has been achieved at the expense of natural resources and the environment, which has led to excessive emissions including wastewater, waste gas, solid waste, and carbon dioxide that extended from the developed east region to the undeveloped west region (Y. Lu et al., 2019).

In 2012, the Chinese government proposed the concept of an "ecological civilization," which was made a national strategy. In addition, a revised Environmental Protection Law was enacted in 2015 which tightened requirements to their strictest levels in China's history. Thereafter, a series of strict environmental protection policies were implemented, such as Action Plans for the Prevention and Control of Water, Soil and Air Pollution (Y. Lu et al., 2019).

Because of its large territory, China has always had regional inequality. The regional gap in equality narrowed from 1978 to 1990, then sharply diverged from 1990 to 1997, stabilized from 1997 to 2005, and then finally decreased since 2005. This pattern coincided with agricultural reform in the late 1970s and the 1980s, the beginning of opening up, a substantive input of foreign direct investment in the late 1980s and the 1990s, and the Chinese government development campaign for the western regions, which has been in place since the 2000s. On the other hand, inequality in per capita disposable income doubled from 1978, reaching the highest from 1995 to 1997 and subsequently declining after 2005. No matter the trend of regional gap inequality or per capita inequality, there is a wide wealth gap between coastal and inland regions which is driven by historical and geographical reasons. However, it is also influenced by factors such as the flow of foreign direct investments and regional development strategies. During the 1970s, with government subsidies, northwest regions including Tibet and Gansu had the highest per capita disposable income. Since the 1980s, the income level of Guangdong and Shanghai has grown rapidly and is now the highest in China. Since the 2000s, the provinces with relatively high per capita disposable income levels have been distributed along the coast (Y. Lu et al., 2019).

The reforms and the urbanization process have also impacted Chinese society, especially when it comes to the rural-urban gap, increasing the regional differences in income, education, and healthcare. The current education level of rural areas is the same as that in cities in the 1990s. In 1990, the major causes of death for urban residents were cancer, cerebrovascular diseases, and heart disease, yet death rates of people living in cities were lower than those in rural areas. On the other hand, rural residents suffered more from respiratory disease and overall mortality was almost twice as high as it was in cities. Environmental pollution has been a major contributing factor to mortality in China (Y. Lu et al., 2019).

As a result of the economic reforms of the late 1970s, poverty levels decreased throughout the country. Poverty incidence in rural China has dropped sharply from 97.5% in 1978 to 4.5% in 2016. In fact, the number of Chinese citizens moving out of poverty accounts for 70 percent of the world's total from 1990 to 2015. In addition, as rural residents move to urban areas, the urban employment market has become competitive and some urban residents, therefore, face the challenge of a fall in living standards (Y. Lu et al., 2019).

2.7. Government Intervention to Achieve Self-Reliance

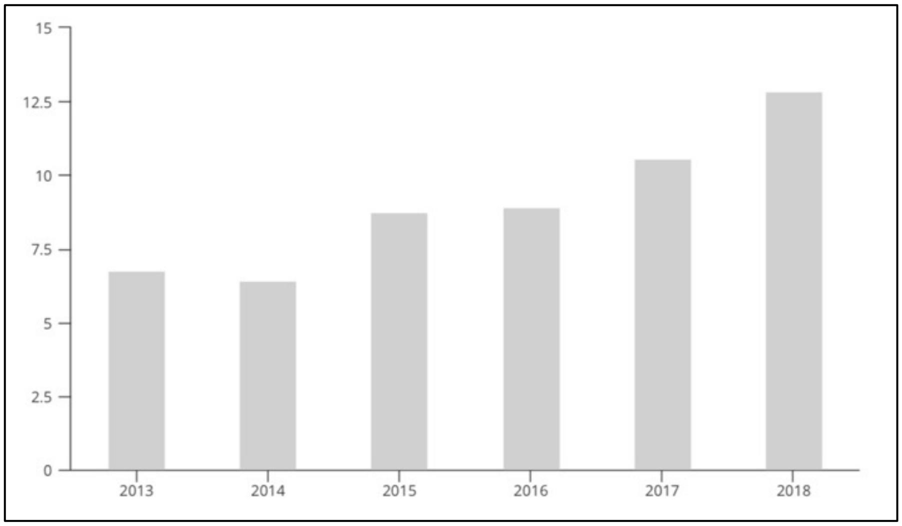
Self-reliance is an important concept that has been part of the Chinese political ideology since the beginning of time. During the empire years, especially near the end of the Qing dynasty, self-reliance was the goal the leadership tried to achieve through the Western Affairs Movement. However, it has become more important since the foundation of the People's Republic of China, and it means that the Chinese Communist Party will "retain ultimate control over China's economic development – an enduring consensus that has heavily influenced policy across generations of leaders" (Thomas, 2019).

However, self-reliance does not mean that the country will isolate itself or rely on autarky. This concept has changed its meaning throughout the years. For Mao Zedong it was a wartime necessity opposed to the Nationalist dependence on the United States. After 1949, he turned to the Soviet Union for assistance in building the country back after the wars. However, after the collaboration started showing its first results, the Chairman decided to improve self-reliance and depend less on the Soviet Union. During the reform period, Deng Xiaoping opened the country to foreign countries, but his goal was not to be completely dependent on their technology transfer. He wanted China to learn from the other countries for the purpose of strengthening the national economy and improving overall as a country. In fact, the Chinese word for self-reliance is 自己更生 (*ziji gengsheng*) which literally means "regeneration through one's efforts" (Thomas, 2019).

In more recent years, during Hu Jintao's presidency, the concept of self-reliance became "indigenous innovation" (自主创新 *zizhu chuangxin*) and it was officially launched with the "National Medium and Long-term Program for Science and Technology". Current President Xi Jinping is carrying on this idea, and he also intensified it. In fact, Xi Jinping started talking more often about self-reliance in 2018 as a response to the 2018 American measures against China. He also stated that self-reliance should be pursued and acquired in certain key fields, such as science, space, hydropower, and the internet (Thomas, 2019).

Table 6 (Thomas, 2019) shows the average mentions of self-reliance per month in a given year, from 2013 to 2018.

Table 6: Self-reliance mentions in People's Daily have trended upward under Xi Jinping's leadership.



For a long time in history, as mentioned above, China did not have its own technology capabilities, therefore it was forced to rely mainly on imports and purchases from abroad from international technology giants, such as Motorola, Nokia, and Siemens. Nowadays, however, some domestic vendors, such as Huawei, Putian, and ZTE have developed their own R&D capabilities and started having a share in China's mobile equipment and network markets. Nonetheless they still rely on foreigners when it comes to core technology. Because it realized it was dangerous to continue manufacturing as a lower-level imitator of foreign products, the Chinese government has been working on developing a national technology infrastructure to no longer rely on foreign technology. In fact, the Chinese government wants to have a stand in key technologies on an international level and it has set it a national strategy (Gao, 2015).

The Chinese government can intervene so actively in this field, because it almost entirely controls the whole economic system. Government interventions, in fact, shape innovation and technology progress, moreover, the government can motivate different tech players to take part in said progress. Some of the government interventions include, but are not limited to, building science parks, intervening in royalty negotiations, funding investments in R&D, procuring products, mediating competition in the private sector, and facilitating cooperation. Furthermore, the government can implement laws, policies, rules, and directives, but it can also promote the development of knowledge and innovation through education, which is a more "soft instrument" (Gao, 2015).

During the 20th National Congress of the Chinese Communist Party, a report was issued stating that the most important task was to strengthen the national strategic scientific and technological force. In fact, the most important of these modernizations was science and technology, and both the "863 Program" and the "973 Program" are proof of how much attention was put into developing these fields. The "863 Program" was also called the "National High-Tech Research Development Program" (国家高技术研究发展计划 *guojia gaojishu yanjiu fazhan jihua*) and was implemented on March 1986 (86/3 according to the Chinese system used for dates), and the "973 Program" was also called the "National Key and Basic Research Development Program" (国家重点基础研究发展规划 *guojia zhongdian jichu yanjiu fazhan hua*) and it was implemented on March 1997 according to the same date system. These two programs had the purpose of enhancing the Chinese international competitiveness in high-tech industries and in some basic research areas (Han, 2024).

In the 1980s, because of the constant development of high technologies, competition in the field was increasing rapidly, and countries like the United States, Japan, the Soviet Union, and other Western European nations started developing national programs to develop and strengthen high technologies through the promotion of R&D. Therefore, thanks to the work of scientists and researchers who previously had worked on satellites, China also started developing a program to improve high technologies, creating the "863 Program". In the 1990s, basic research became the core of maintaining national competitiveness. In 1994 the Clinton administration issued a report which emphasized the connection between basic research and national goals. In that period China was struggling with research problems, so the government decided to tackle the basic research field, therefore in March of 1997 members from the science and technology sector unanimously called for strengthening of basic research, which led to the creation of the "973 Program" (Han, 2024).

Thanks to these programs new technologies and new industries emerged, for example, computer assisted production systems, thermonuclear reaction technology, genetic engineering, gene technology, and many more. In the first phase of the "863 Program", which lasted fifteen years, 3,179 projects were launched in the field of information technology, accounting for 46% of the total number of projects, and scientific research funding was 30% of total funding. On the other hand, the "973 Program" aimed at solving major basic scientific problems related to the economic and social development, while at the same time it also fostered the exploration of fields such as agriculture, energy, energy information, natural resources, environment, population, and many more. After ten years since the implementation of the program, eighty eight projects were implemented in the scientific field, accounting for 22,9% of the total number of projects implemented (Han, 2024).

In addition to these two projects, the government also launched the "Project 211" in 1995 to upgrade the research capabilities of roughly a hundred universities, costing approximately US$ 2.2 billion in the first phase from 1996 to 2000. This Project was followed in 1998 by an even more ambitious program, "Project 985", dedicated to building world-class, elite universities in

China. The government provided generous funding and increased this over time for those select universities supported by Project 985. Peking University and Tsinghua University, for example, each received about US$ 300 million in the first phase, between 1999 and 2001, with the funding level more than doubled in a decade (Xie et al., 2014). The Chinese government also tried to attract talent from abroad by targeting overseas Chinese-born scientists, especially those working in the United States with some policies, which were previously analyzed in section 2.4.

Since the 1990s, in fact, China has adopted a policy for indigenous development and innovation. In early 1990s, the Ministry of Science and Technology set up the "Key Technologies R&D Programs of the 9th Five-Year Plan of China" (1996 – 2000), and within this Plan there was a specific program to develop national 3G technologies and standards. Taking advantage of its tight control over the national telecommunications industry, the Ministry of Posts and Telecommunications was able to assign the lead to the China Academy of Telecommunications Technology and the institution had the goal of developing a national standardization project for 3G. Moreover, the government also encouraged state-controlled firms to form joint ventures with foreign firms to jointly invest in technological innovation. This has a significant effect for Chinese firms, in fact, in 2005, Alcatel, Ericsson and Nokia established strategic alliances or joint ventures with Chinese firms Datang, ZTE, and Putian, respectively, to focus on the 3G standard system (Gao, 2015).

Considering all the efforts the Chinese government is making to strengthen the country; it is expected that the concept of "self-reliance" will become more prominent in the policies implemented. In fact, the future objectives of China and the goal of its transformation will be analyzed in one of the sections of the next chapter.

Chapter 3: The Modern Phase of the Reforms

3.1. Efforts to Improve Science and Technology After the Reforms

After around four decades since the launch of the Reforms and Opening up, Chinese science and technology rapidly developed and great progress has been made in fields such as basic science, engineering technology, agricultural science and technology, and information technology. Particularly in the fields of science and technology, China has stepped up from being a "follower", to "parallel runner", to a level of a "leader" (R. Chen, 2018). In fact, China now is a major contributor to these fields and employs an increasingly large labor force of scientists and engineers. It also produces more science and engineering degrees than the United States at all levels, especially undergraduate. Moreover, the quality of Chinese research has improved steadily. This was possible as a result of economic growth and educational expansion, both factors that have taken place in China since the beginning of the reforms in the late 1970s (Xie et al., 2014). As a result of these reforms, China has now decreased its dependency on foreign technology, as science and technology have gained an important role in the development of the country (Silvestri, 2021b).

In the 1990s, foundations for a collaboration between research and industry have been laid and, especially in the last twenty years, the National Innovation System (NIS) has become slightly more decentralized, despite the central government still holding most of the control. Through this process, numerous programs and objectives have been set, the entrepreneurship of professionals involved in science and research has been encouraged, and at the same time the amount of investments for innovation directly provided by the State has slightly decreased. This has facilitated a more fluid integration between the market and the innovation system, triggering a virtuous spiral of mutual strengthening between scientific research and marketing. Moreover, the construction of a system for the protection of intellectual property, the strengthening of the training system, and investments in research and development, both public and private, have continued tirelessly. However, it is worth mentioning that in some fields the state still invests in the creation of new infrastructures and guides the relations between the private and the public sector, while in other fields it just works alongside other investors (Silvestri, 2021b).

After Hu Jintao's term as President, in 2013 Xi Jinping became the President of the People's Republic of China. Xi Jinping wants China to become a great innovator country. In 2016, when he announced the 13^{th} Five Year Plan, he pointed out the three major issues hindering the country to reach its goal. The first one is that the education system does not leave room for innovation and imagination, so students are trained to be good performers, but not great innovators. Secondly, hierarchy is still too dominant in the Chinese system, so agreement is often chosen over discussion. Lastly, incentives for individual research are inadequate, resulting in little participation of scientists, and predominance of decisions from above. However, studying abroad, and contacts with the foreign world in general, are influencing students who are becoming more interactive, autonomous, and therefore more innovative. This led to an increase in Chinese exports of high technology. In 1998 it was just 3% of the total exports, while in 2010 it rose to 19%. This shift in production clearly shows the national goal of not being known just for the low cost of manufacturing, but also for the high quality of products. Moreover, foreign enterprises started establishing research centers in China, because scientists and engineers cost less than in other countries, and because thanks to their connection with the national market, it is easier for these enterprises to become players in the Chinese market (Coisson, 2016).

As mentioned above, the Chinese leadership wants China to become independent in those key technologies, such as semiconductors, automation, aerospace, and defense industry, to further develop other sectors connected to these areas. By enhancing the basic technologies, China aims to become more independent from foreign countries and to become an important player in the technological field (Silvestri, 2021b). The government, in fact, wants the country to move from the concept of “made in China” to “created in China” showing the main role the nation will have on the international field (Silvestri, 2021a). Moreover, the central government has been working on a collaboration between the military and the civil field, increasing the amount of dual-use technology in specific areas, such as aerospace, artificial intelligence, automation, and semiconductor. In 2017, in fact, President Xi Jinping created the Central Commission for the Development of Military and Civil Integration, and he is also the leader of it (Silvestri, 2021b). According to Xinhua News, the official national press agency, this commission will be the central agency whose task will be decision-making, deliberation and coordination of major issues regarding integrated military and civilian development (Xinhua News, 2022). Moreover, the government supports and incentivizes the integration between the public and the private sector to exploit the innovative potential of the market, and to lower the public expenditure for the defensive field (Silvestri, 2021b).

It is clear how many changes President Xi Jinping made in the organization of innovation policies. In addition to the “Medium and Long-term Plan for the Development of Science and Technology (2006 – 2020)”, in 2012 the government also issued the “Opinions on Deepening the Reform of the Scientific and Technological System and Speeding up the Building of a National Innovation System”, and in 2016 the “National Strategy for the Development Guided by Innovation” was launched. This strategy once implemented set three major objectives for the future:

first of all, China had to become an innovative country by 2020, secondly, by 2030 it had to be one of the most innovative countries, and lastly, by 2050 it had to achieve scientific and technological primacy. The document also states the importance of both scientific and technological development, and of institutional reform (Silvestri, 2021b). These objectives are in line with the 2025, 2035, and 2049 objectives that will be analyzed in the following section.

3. 2. The "Made-in-China 2025" Project and the "Chinese Dream"

By the end of 2012, China became a global leader in manufacturing operations and the second largest economic power in the world. The "Made-in-China" paradigm has been evidenced by products made in China ranging from high-tech goods such as personal computers and mobile phones, to consumer goods such as air conditioners. In fact, in 2014, China produced 286.2 million personal computers, which was about 90% of the world total, 109 billion air conditioners counting for 80% of the world total, 4.3 billion energy-saving lamps which approximately accounted for 80% of the world total, and its mobile phone production counted for a little over 70% of the world total. However, now the country is looking forward to climbing new heights in manufacturing. In 2015, China issued a ten-year national plan called "Made-in-China 2025" with the goal of becoming a world-class industrialized power from a world manufacturing production workshop in the decade between 2016 and 2025 (L. Li, 2018).

The plan was jointly launched by China's National Development and Reform Commission and by the Ministry of Science & Technology, with additional inputs from the Ministry of Industry and Information Technology and other institutions. The plan highlights the intention of the Chinese government to support an industrial transformation from labor-intensive production to knowledge-intensive manufacturing. The “Made-in-China 2025” project is the first step of a three-phase grand plan which will transform China into a world manufacturing power: the first phase covers the years from 2016 to 2025 and during this period China will strive to become one of the world’s manufacturing powers, the second phase covers the years from 2026 to 2035, when China will rise to the medium level in the world’s manufacturing power camp (L. Li, 2018) reaching the socialist modernization (社会主义现代化 *shehuizhuyi xiandaihua*) (Silvestri, 2021a), and lastly, the third phase will cover the years from 2036 to 2049, which is the final objective of this plan and the centennial of the foundation of the People’s Republic of China. In that year the country hopes to become the leading manufacturing power in the world (L. Li, 2018). By 2049, in fact, China wants to become a culturally advanced, prosperous, and modern socialist country, and key technologies play an important role to reach this goal (Silvestri, 2021b). These objectives have been announced during the 5th plenary session of the 19th Central Committee of the Chinese Communist Party, and the common goal of the projects is to increase productivity and the quality level of economic development (Silvestri, 2021a).

This first step focuses on improving the quality of products made in China, creating China's own brands, building a solid manufacturing capability by developing cutting-edge advanced technologies, researching new materials, and producing key parts and components of major products. One of the main objectives of the plan is to move from the concept of “made in China” to “designed in China” – also translated as “created in China” – improving the Chinese manufacturing and innovation system. Ten main industries have been prioritized: information technology, high-end numerical control machinery and automation, aerospace and aviation equipment, maritime engineering equipment and high-tech vessel manufacturing, rail equipment, energy-saving vehicles, electrical equipment, new materials, biomedicine and high-performance medical apparatus, and agricultural equipment (L. Li, 2018).

When in the late 1970s the government started implementing new policies, it focused on certain cities, called Special Economic Zones, and the same approach was used to implement the "Made-in-China 2025" plan. Ningbo, a port city in the Zhejiang province, was chosen to be the first pilot city to speed up the construction of its own industrial and manufacturing capability, collaborate with regional innovation systems, personnel training systems, and policy support systems, to create a healthy ecological environment and achieve diversity in development. Then, a second cohort of twenty to thirty cities will be selected to join the development effort (L. Li, 2018).

To reach its goal, China has started increasing its national R&D spending, as it did during the reform period. In the period between 2002 and 2015, the amount of investment in R&D has increased dramatically. In 2015, China spent around CN¥ 14,169 million on research and development, which is ten times as much as that of in 2002. During the same period, the expenditure on R&D has increased by 1000%. However, data indicates that, although China's GDP is continuously increasing, the foreign direct investment net flow and high-technology exports started to phase down in 2013. These statistics signal that foreign investors have gradually pulled out of the Chinese market. As a result, China has relied more on its own investment and domestic consumption of high-tech products. Since 2011, the percentage of GDP as industry value added has decreased from 47.56% in 2006 to 40.93% in 2015 (L. Li, 2018).

However, on one hand, China is no longer the lowest-cost labor market, and it is being squeezed by newly emerging low-cost producers such as Vietnam, Cambodia, and Laos. On the other hand, it is neither the strongest player in the high-tech arena. Advanced industrialized economies, such as the United States, Germany, and Japan, have all effectively deployed digital technology to create new industrial environments, produce new products and improve their well-established brands (L. Li, 2018). Baidu – the Chinese tech company that developed the famous search engine – however, has achieved similar accuracy in artificial intelligence with the Chinese language two years earlier than their American counterpart, because Chinese companies and the national government laboratories are making major investments in artificial intelligence. Enhancing manufacturing capability, research and development investment, and human capital will give China a head start to transform the "Made-in-China 2025" plan into action (L. Li, 2018).

As mentioned above, the final objective of this project is represented by the year 2049. This national goal is also known as the "Chinese Dream" (中国梦 *zhongguo meng*) or as the "Great Rejuvenation of the Chinese nation". This concept was announced by President Xi Jinping during the 19th National Congress of the Chinese Communist Party (Drozhashchikh, 2018). On November 29th 2012 current President Xi Jinping stated that the main goals of this project are building a moderately prosperous society in all aspects by the 100th anniversary of the founding of the Chinese Communist Party, and building a strong, rich, democratic, civilized, and harmonious modern socialist country by the 100th anniversary of the founding of the new China, and the dream of great rejuvenation of the Chinese nation (Q. Wu, 2015).

To achieve these objectives, the country has to improve the national political and economic situation in addition to eliminating social disparities and inequalities thorough progress. One of the means to fulfill the Chinese Dream is innovation is aerospace innovation which will contribute to the national economic welfare and to the international influence. The Chinese space industry started developing under the Soviet influence in the late 1950s and resulted in the successful development and launch of the first Chinese satellites. Since then, the satellite field continued to grow and communication, meteorological and navigational satellites were developed. Between the 1970s and the early 2000s human spaceflight developed, and this raised the country's international prestige (Drozhashchikh, 2018).

In addition to the efforts to improve the aerospace industry, the Chinese government also launched the "Belt and Road Initiative" (BRI) as a foreign policy to achieve the Chinese Dream. Subsequently, the government launched the "Digital Silk Road" in an attempt to realize a Belt and Road Initiative in the world of information and communication, with the objective of achieving techno-hegemony (Jun, 2022).

In order to achieve prosperity, the Chinese GDP has to grow, and predictions show that by 2021 the country is supposed to exceed the American one (Q. Wu, 2015). However, this did not happen, and according to the World Bank in 2023 the Chinese GDP was US$ 17.79 trillion while the United States had a GDP of US$ 27.39 trillion (World Bank, 2023). Moreover, to achieve the objective of national rejuvenation, the Chinese living standards have to rise to the level of developed countries, which is projected to happen by 2065, when the Chinese living standards will reach those of the most developed and high-income nations. To realize the complete rejuvenation of China, it is necessary to build a world-class economic, scientific, technological, educational, military and cultural powerhouse. Only when all these goals have been achieved will it be possible to achieve the full realization of the Chinese dream (Q. Wu, 2015).

3.3. Patents and R&D

Patents are strongly connected with R&D. They were introduced in the country in 1949 after the founding of the People's Republic of China but were abolished in 1954 when they were replaced by a system of awards for inventions under which creations belonged to the state and could be used free of charge. As mentioned in the previous chapter, the Patent Law of 1984, which came into effect in 1985, brought patents back. Since then, the law has been amended twice, once in 1992 increasing the number of years of validity for patents, and in 2000 introducing provisions designed to incentivize enterprise employees to innovate. To promote innovation, the government has passed over twenty regulations on the matter since 1984, and the Chinese Patent Law is now almost in line with international standards (P. Lin & Zhang, 2008).

The current Chinese law on patents divides innovation into three categories: invention, utility model, and external design. The first group represents all new technical solutions related to a product, process or improvement; the second category includes all new technical solutions relating to the shape or structure of a product that is not directly connected to its aesthetic proprieties; and lastly, the third group comprehends all new design of shape, patter, combination of color or aesthetic properties. The patent validity is twenty years for inventions, and ten years for the other two categories. As mentioned above, R&D expenditures have been increasing steadily since the 1990s and this was also due to the modern patent legislation which helped with innovation (P. Lin & Zhang, 2008).

Innovators fall into three categories: industrial enterprises, universities and research institutions, and individuals. The first group devotes R&D resources in order to come up with new products or technologies, those inventions belong to the enterprise itself, and most of the times they are immediately used for production leading to an immediate commercial benefit. Universities and research institutions are mainly funded by central or provincial governments, however funding from contracting with industrial enterprises has been increasing in the past years. Well-trained scientists are employed by these institutions and are required to conduct basic and applied research, which results in creating inventions with academic or commercial value. Single individuals develop inventions through their own funding, and if successful, they can apply for patent protection. However, to exploit their discoveries on a commercial level, they need to sell the patent to commercial users. This category is the one which contributed the most to Chinese patents between 1991 and 2005 (P. Lin & Zhang, 2008). As mentioned in the previous chapter, the number of patents given to Chinese scientists and the number of citations to Chinese international scientific papers rose in the past few years, moving China to the top of the group (Sun & Cao, 2021). One of the objectives of the 14^{th} Five-Year Plan is to increase the intellectual property protection by improving laws and regulations that already exist, and by creating new ones for the rising fields (Zhonghua renmin gongheguo zhongyang renmin zhengfu, 2021).

It appears clear how strictly connected patents, intellectual property protection, and research are, therefore improvements in any of these areas affect the others. As China's overall national strength continues to grow, the importance of R&D has become a national consensus, therefore China has been trying to optimize the organization of its research (J. Zhu, 2014). ASML Holding is an example of this trend. It is a Dutch company and one of the world leaders in the manufacturing of lithography equipment for the semiconductor industry, and it supplies tech giants such as Intel. (ASML, n.d.). The vice-president of the Chinese branch, Shen Bo, stated that the Chinese semiconductor industry is entering a new phase of rapid development and therefore the company is also improving its efforts to cultivate technological R&D talents in the country. China has also been increasing its actions to protect intellectual property rights which will help create a more market-oriented environment with a higher presence of international investments. (Chang & Bin, 2021).

In 2018, through a government work report, new R&D institutions were announced emphasizing the need to strengthen the construction of the technological innovation system, with enterprises as the main body, to create a number of new R&D institutions and innovative enterprises, and to reach the level of international competition. New R&D institutions are an open platform for integrating R&D, talents and technologies, and they not only focus on patents, but also interact with industry and finance to realize the docking of capital deployment of R&D and industry. In fact, over the years, some new R&D organizations have emerged in Beijing, and in the provinces of Fujian and Guangdong. However, they have not yet been clearly defined, and each place defines these organizations in accordance with its own needs and conditions for development. Said new R&D organizations are mainly placed in science and high technology fields, and the research team has the ability to integrate external science and technology resources. New R&D institutions have the characteristics of both research institutes and enterprises, so they can be regarded as either of them, but the definition of new R&D institutions, whether they are research institutes or enterprises, is rather vague (Z. Lu, 2021). At the same time, new R&D institutions are market-oriented, open, internationalized, integrated with industry, academia and research, and public welfare. This means that they are based on the R&D of key technologies common both to basic industries and cutting-edge research, so as to promote the development of other fields, with social and economic benefits coexisting, and with social benefits being the main emphasis. Openness refers to multi-party cooperation, industry-academia-research synergy, integration of technology development, scientific research, and scientific and technological achievements and industrialization, connecting the whole process of innovation. Internationalization mainly refers to reaching the international advanced level (Z. Lu, 2021).

The construction of new R&D institutions has been continuously accelerated, the management services have been improved, and the introduction of high-end talents has been significantly strengthened, which has promoted enterprises to improve quality and increase efficiency, with the three major competencies of operation and management, science and technology R&D, and business incubation being upgraded. With the introduction of government policies, new R&D institutions have been rapidly implemented across the country, and their scale and effect have achieved good results, and new R&D institutions have become a force to be reckoned with in China's emerging science and technology industry. Through a series of innovative mechanisms and systems, such as early and pilot testing, the vitality of different fields has been released achieving very fruitful innovation results (Z. Lu, 2021).

The importance of R&D is also reflected by the amount of governmental expenditures. In fact, the Chinese leadership stated that in 2024 it would spend CN¥ 371 billion (US$ 52 billion) on science and technology, and CN¥ 98 billion of this will be spent on research. The overall expenditure, if compared to 2023, is set to increase by 10%, and the rise for research funds is 13%, giving scientists more support for their research. Although the increase in spending has been significant, it is only a small part of the country's GDP. In fact, R&D spending in 2021 made up 2.4% of the Chinese overall GDP (Mallapaty, 2022), while in 2020 the United States spent 3.6% of their GDP on R&D (Mallapaty, 2024). Overall, China's spending on R&D has increased from 2.1% to more than 2.5% of GDP over the past five years (Mallapaty, 2023).

The term R&D covers three types of activities: basic research, applied research, and experimental development. The Chinese spending on R&D for basic research in 2019 was 6% compared to 16.6% for the United States. In addition to this low percentage, the majority of R&D expenditure goes to experimental development, jeopardizing the development of both basic and applied research, which may hinder a long-term prospect of scientific and economic development. Moreover, government contributions decreased to 20%, despite the "Medium and Long-Term Plan for the Development of Science and Technology (2006 – 2020)" called for governmental funding to reach 40%. To solve this issue, the Medium and Long-Term Plan selected sixteen so-called "Mega-Engineering Programs" with the purpose of meeting national economic and social developmental needs focusing mainly on core, common, and key technologies for the creation of major strategic products. In general these programs have driven the development of some key relevant industries (Sun & Cao, 2021).

In the last few years, despite struggling on reaching its economic growth targets which could represent an obstacle to the growth of R&D investments (Mallapaty, 2022), China has been increasing its spending on science, demonstrating a shift from an economy based on long-established sectors, such as real estate, to putting a greater emphasis on high-technology development (Mallapaty, 2024). In fact, China has been elevating science, especially during the 20th Congress in Beijing, when science and technology were at the front and center of the discussion (Mallapaty, 2022) with the purpose of boosting self-reliance and strengthening the field of science and technology. In addition to this, China also wants to race the United States on technological supremacy, as the American government blocked the Chinese access to key areas, such as artificial intelligence, semiconductor, and quantum computing, pushing the country to invest in its own R&D activities (Mallapaty, 2024).

However, there is still a quality gap in Chinese research. For instance, researchers produce more artificial-intelligence publications than do researchers in the United States, but American papers garner double the share of global citations. To solve this issue, China is trying to recruit international talent, call back Chinese talent from abroad, and train local scientists. Moreover, China also started expanding scientific cooperation with other countries, despite the country at the same time stresses the necessity to develop home-grown technology and self-reliance, which will subsequently restrict access to international collaboration (Mallapaty, 2023).

In order to tackle the "brain drain" issue, in 2008 China has launched the "Thousand Talents Program", an overseas high-level talent program intended to attract, within five or ten years, about two thousand leading scientists and professionals below the age of fifty-five, and of mostly Chinese ethnicity. Two years later, a similar program was launched with the aim of recruiting younger talent of forty years of age or younger. As a result of these two programs, the recruited personnel contributed to the development of their institutions by publishing papers that had higher impact on the international level, extending research areas, and uplifting the overall domestic performance on the scientific field. However, China is still experiencing scientific talent shortage as many overseas-educated Chinese students prefer to remain in the countries where they have studied, which will undermine the objective of becoming an innovation-oriented country (Sun & Cao, 2021).

Government intervention is nothing new for China, in fact, even in the past, the government took liberty to be involved in matters such as the economy, and the scientific and technological field is no exception. Thanks to state funding, the Chinese government invested in R&D, also preventing failure in certain areas, and fostering a competitive environment. One example of this practice is the direct governmental involvement during the global financial crisis, when the Chinese governmental funding rapidly increased to mitigate the negative effects of the crisis on emerging sectors and traditional industries, ignoring more fundamental areas which were key for the scientific and technological reform. This resulted in the slowdown in productivity growth (Sun & Cao, 2021).

3.4. The 14th Five-Year Plan and Self-Reliance

In late October 2020 the Chinese government outlined the 14th Five-Year plan which became effective at the beginning of 2021 and covers the years from 2021 until 2025. The main goal of this plan is to continue the country's innovation and modernization with the final objective of reaching self-reliance and self-improvement. As already mentioned in the previous chapter, the concept of self-reliance comes from the same concept of the Maoist era, which then became "self-innovation". It is, however, also a response to the 2018 American tightening of exports to China of advanced components and equipment, especially semiconductors and other equipment to manufacture advanced electronic devices. This topic will be analyzed in more depth in the next chapter.

China believes that the development of science and technology can support and sustain its industrial development in order to meet its national security needs. It would be wrong, nonetheless, to equate this concept with autarky. In fact, the 14th Five-Year Plan proposes to actively promote openness and cooperation on the scientific and technological field and in other areas, such as global epidemic control, public health, climate change and others (Sun & Cao, 2021).

The 14th Five-Year Plan opens with a summary of the objectives achieved with the 13th Five-Year Plan: the economic situation was overall stable and optimized, and the GDP grew reaching CN¥ 100 trillion, lowering the levels of poverty. The goal of building an innovation-oriented country has yielded substantial results bringing numerous scientific and technological achievements, in fields such as manned spaceflight, lunar and deep-sea explorations, supercomputing, quantum information, high-speed trains, and large aircraft manufacturing.

Therefore, successful efforts have been made toward the long-term objective of national rejuvenation (Zhonghua renmin gongheguo zhongyang renmin zhengfu, 2021).

On one hand, the plan points out China's advantages that could improve and promote further development, such as system and administrative superiority, sustained economic growth, rich material foundation, abundance of human resources, broad marketplace, and overall stable development. On the other hand, however, there is still social imbalance, especially in development and income distribution between rural and urban regions. The environmental problem still exists, and the level of national innovation is inadequate to sustain high-quality development (Zhonghua renmin gongheguo zhongyang renmin zhengfu, 2021).

In order to achieve the goals established for this plan, China set some principles that must be followed: follow the Party's leadership, continue with the reforms and opening up process to improve the modernization of the national governance, break down institutional barriers that hinder high-level development and high-quality of life, continue with the opening-up process to increase resources allocation and to continue boosting development (Zhonghua renmin gongheguo zhongyang renmin zhengfu, 2021).

The main goals of this plan are summarized in the section called "Long-Term Goals for 2035". By that year, China will have realized – if everything goes accordingly to the plan – its objective for socialist modernization as a result of the increase of economic, scientific and technological strength, placing China as one of the innovations-oriented countries. The country will also make efforts to promote international domestic cooperation through an open economy. The planned expenditure for R&D will increase by more than 7% annually and the intensity of investments will also rise. The government will also deduct expenses for R&D, provide tax incentives, and implement policies to support innovative products and services (Zhonghua renmin gongheguo zhongyang renmin zhengfu, 2021).

As China has set an objective of becoming a science and technology power, it will promote the development of key and core technologies and increase the effectiveness of innovation. National laboratories play an important role especially in areas such as quantum information, network communications, artificial intelligence, and other major innovative fields. Scientific research resources will be provided and shared among research institutes, enterprises, and institutions of higher education, while at the same time, the creation and development of new types of R&D institutions will be promotes, as well as the diversification of investors will be incentivized, and the opening of national scientific research platforms will be promoted (Zhonghua renmin gongheguo zhongyang renmin zhengfu, 2021).

In addition to increasing R&D and to incentivizing research institutions, China will also focus on cultivating scientific talents fostering young minds with international competitiveness expanding the rank of high-level engineers and highly skilled personnel. Moreover, in order to attract foreign talent, the government will improve its residency policies and the permanent residency policies establishing a skills-based immigration system (Zhonghua renmin gongheguo zhongyang renmin zhengfu, 2021).

3.5 E-Governance

China has become the leading country in the use of “e-governance” which is defined as “the use of the internet by governments to make it possible for people to use government services and be involved in making decisions” (Cambridge Dictionary, n.d.). This has been possible as a result of the commercialization and diffusion of technologies such as cloud, big data, artificial intelligence, and mobile payments, all of which produced a large quantity of data, even to an individual level (Silvestri, 2021b).

China is the first country when it comes to mobile payments, both for volume of transactions, evolution and diffusion of the necessary technologies, and for quantity of data collected. In fact, in the first half of 2018, the penetration of mobile payments reached 92.4% of the population. In addition to the development of big data and mobile payments, China is also focusing on the creation of smart cities, especially as a result of the collaboration between the private and the public sector. Artificial intelligence in the city of Hangzhou monitors traffic flows and traffic lights, and in case of anomalous events it is programmed to alert the local authorities (Silvestri, 2021b). Huawei implemented a similar project, called "smart and safe city" in the Italian region of Sardinia, more precisely in the Technological Park of Pula (CRS4, 2019). However, this area is still under development and citizens are not as involved (Silvestri, 2021b).

Technology in China is also used for health matters, with projects that aim to ease the access to healthcare through online registration, or that aim to improve patient-doctor interactions with diagnosis done remotely, both of which are results of investments of the private sector. The Covid-19 epidemic not only accelerated the development of digital healthcare but was also an occasion to test other areas of digital governance. People were tracked through cellular towers, satellites and biometrical recognition, all of which allowed the Chinese authorities to control flows of citizens. Tencent and Alibaba activated a service on their platforms able to generate a QR code which allowed, limited, or prevented freedom of movement of the Chinese people. Surveillance has also become more important in China; there are around 600 million CCTV cameras, which can recognize people and vehicles, even with low visibility (Silvestri, 2021b).

As mentioned above, in recent years Chinese artificial intelligence saw a rapid development, and it also started to be used in the judiciary system. In addition to the possibility to attend legal proceedings through video call, algorithms assist judges in the decision process resulting in a homogeneous judicial system. Moreover, procedures such as transcription of notes and organization of evidence, are no longer jobs carried out by qualified personnel, but have become automated. The development of this sector is the result of governmental strategies and the collaboration between the public and the private sector. This process started in 2017, with the implementation of the New Generation Artificial Intelligence Development Plan which aims at China reaching the primate in the sector by 2030, and the implementation of the Three-Year action Plan for promoting the development of next generation Artificial Intelligence Industry (2018 – 2020) which sets the detailed objectives to be reached in these three years (Silvestri, 2021b).

Chapter 4: Changes in Bilateral and Multilateral Relationships Brought About by Technology

China, Europe, and the United States have become the major centers of power that influence current and future global politics and economics. The relationship between these three began at the end of the Cold War, when the three counterparts came together against the Soviet Union. Both Europe and the United States have been pressuring China on certain matters, such as freedom, human rights, democracy, and Tibet. At the same time, the Sino-European relationships flourished when the two sides decided to try and contain the American hegemony. Moreover, both the American and the European leaders have aimed at reaping China's rapid economic growth, often competing with one another (Y. Wang, 2013).

It is clear, therefore, how the Chinese relationships with other countries have deeply changed throughout the years. In 1978 China became the commercial partner of numerous countries as it mainly exported simple products from consolidated industrial sectors, such as clothing and footwear. Nowadays, Chinese exports have become more aimed at products with higher technological value, such as cellphones, servers, and televisions, making China able to compete with other nations that specialize in these sectors.

With the opening of the country, as mentioned in the second chapter, Foreign Direct Investments started flowing into China as many foreign enterprises were attracted by the Chinese national market, by the low costs of manufacturing, and also by the government's policies to open up the economy. Therefore, many firms set up subsidiaries in China to serve the national and international markets. However, nowadays the situation is different both because the costs of manufacturing have increased and because the government's policies have become stricter. Chinese firms, on the other hand, started investing abroad, to explore new markets, but also to gain access to advanced technologies (Prodi, 2021).

4.1. The Sino-American Relations

As already analyzed in the second chapter, the Sino-American relations started in the early 1970s when President Nixon visited Beijing. After this event, other countries followed the American example and established official relationships with the People's Republic of China. Since then, the two countries have traded and collaborated under the form of joint ventures or wholly foreign owned enterprises, which also resulted in technology transfers that were vital for Chinese national development.

In 1998, the United States and China established a framework for cooperation by pledging to build a "constructive partnership". In 2005, the two countries held their first strategic dialogue, while the next year they launched the "Strategic Economic Dialogue". In 2009 the leaders of both countries decided to use this mechanism to undertake effective communication and exchanges about important economic issues concerning the two countries and the rest of the world (Y. Wang, 2013).

It is visible how the American relationship with China changed with time. During the Clinton administration, China was viewed as a "strategic partner", with President Bush it became a "responsible stakeholder", and the relationship became a "partnership based on mutual respect and a win-win cooperation" with President Obama. In 2017 the White House, under the Trump administration, stated that both China and Russia were “strategic competitors” (Kwan, 2020). Since then, the two counterparts have faced issues on the trading and technological fields.

In the past decades, China has undergone profound changes and developments in the technological sector, and in spite the Chinese internet presence is mainly focused on the domestic market, the country is currently moving from the techno-nationalist emphasis on developing home grown industries and technologies, to becoming more outwardly focused and more willing to pursue its own internet governance preferences. Nowadays, Chinese firms are becoming more internationally competitive. One example is the Chinese video-sharing app Douyin 抖音 which in 2017 was launched on the international market under the name “Tik Tok” and is now owned by the Chinese firm ByteDance. Another Chinese technology firm growing on the global market is Huawei. In December 2015, Huawei’s share of the international mobile vendor market was just 2%, however only four years later it had already risen to 10%. In Europe, Huawei’s market share grew from 4% to 18% during the same period. This, as expected, alerted the United States, which has been having most of the control and dominance of the internet market for the past decades (Cartwright, 2020).

As a result, in 2018, the American government began imposing sanctions on one thousand and three hundreds of products imported from China to which China responded by stating its readiness to impose additional tariffs of 25% in retaliation on one hundred and six American products. By late 2018, three rounds of sanctions had been imposed by both countries: the sanction imposed by the United States amounted at US$ 250 billion, while the Chinese amounted at US$ 110 billion. However, during the G20 meeting of December 2018, and once again in February 2019, President Trump announced a trade deal truce, as a result of progress in trade talks between the two countries, which raised hope that this hostile situation would end soon. On the contrary, on March 5th, 2019, President Trump announced a plan to increase additional tariffs on Chinese imports, on the ground that the counterpart had backtracked on commitments made in earlier negotiations. Nowadays, these trade issues have spread to the technological field too (Kwan, 2020).

In fact, in recent years the United States started working to eliminate any Chinese manufactured hardware and software components from its national network. This process falls under the name of "Clean Network" and has the objective of safeguarding interactions of individuals and firms from hostile actors, one of which is the Chinese Communist Party. The telecommunication firm of Huawei is considered as an extension of the Chinese surveillance system, and therefore is no longer welcome to freely work on American soil (Silvestri, 2021b). Huawei officials, however, denied these claims of espionage (Hosain, 2019).

To prevent these alleged Chinese espionage actions, the American government took some restrictive measures which include, but are not limited to, inbound foreign direct investments, selling of American technology to China, and usage of Chinese technology in federal tenders. This approach was also followed by the United Kingdom, Canada, Australia, and New Zealand in an alliance called "Five Eyes" (Silvestri, 2021b).

The imposition of American sanctions against China triggered an escalation of the dispute between the two countries. In fact, curbing any technology transfer to China has become an important policy for the United States to prevent, or at least slow down, the rise of the Asian opponent. In addition to increasing obstacles for China to import technology through American companies, the United States is also increasing its restrictions on national tech companies doing business with Chinese counterparts, the most important one of which is Huawei (Kwan, 2020).

Huawei is the world's largest supplier of telecommunications networks and the second biggest producer of smartphones and the leader in 5G technology. Since 2012, the United States has treated the Chinese company as a threat to national security due to the risks associated with allowing its hardware into American communication networks which could lead to Chinese espionage. In 2013, Huawei's Chief Executive Officer stated that if the company was bound to get in the middle of the relationship between China and the United States causing issues, Huawei would voluntarily exit the American market as it was not worth it to stay in that market and face restrictions (Cartwright, 2020). However, in May 2019, President Trump signed an executive order blocking American companies from using telecommunication equipment made by firms considered a national threat, therefore banning Huawei and some of its affiliated companies from doing business with the United States (Kwan, 2020). Since Huawei was blacklisted, American suppliers, partners, and buyers had to take permission from the United State Trade Department in order to conduct business with the Chinese telecommunication company (Cartwright, 2020).

Additionally, Google would no longer allow Huawei's smartphones to use popular applications like Gmail and Google Maps (Hosain, 2019). Google, in fact, suspended some of its business with Huawei in May 2019, and it blocked the access of the Chinese company to Android operating system updates. In spite of new Huawei products having access to the Android Open-Source Project version of the Android operating system, applications belonging to Google mobile such as the Google Play store, Gmail and YouTube would no longer be available. This did not affect Huawei products sold on the Chinese market, where products from the Google company are banned, however, it caused issues in foreign markets where Huawei operates in, particularly Europe. The Chinese company, in fact, has a growing market share in Europe, considering Android's share of the mobile phone market is 72% both globally and in Europe (Cartwright, 2020).

Google is just one example of an American company that was forced to cut ties with Huawei. Other tech companies such Intel, Qualcomm, and Broadcom also stopped supplying the Chinese telecommunications giant. This was ordered by President Trump to avoid a threat to national security (Hosain, 2019). The ban, however, not only hurt Huawei, but also hurt its American suppliers, therefore President Trump promised to ease the restrictions in order to minimize the negative effects of his action (Kwan, 2020). The Chinese company was aware that it was only a matter of time until it threatened the United States, therefore, after the American ban, the company declared that it had stockpiled enough chips to keep its phone running for months. Huawei, in fact, is one clear example of the Chinese national policy of technological superiority: in 2018 it passed Apple as the second largest producer of smartphones after Samsung (Hosain, 2019).

In addition to the ban on Huawei, ZTE, China's second-largest producer of telecommunications equipment, has also been targeted by American sanctions. As a result of this measure, the company was cut off from sourcing the American parts and components necessary to manufacture its products. This measure ended in July 2018, when the Chinese company agreed to and fulfilled its obligation to put US$ 400 million into an escrow account, pay a US$ 1 billion fine, replace its board of directors and senior leadership, and fund a team of American compliance officers to monitor the company for a decade (Kwan, 2020).

The case of Tik Tok is also similar. In October 2019, a group of American senators requested an assessment of the national security risks posed by the Chinese company collecting user data. In 2020, President Trump declared that TikTok's collection of data was a threat to the American people as the app could provide the Chinese Communist Party access to Americans' personal information, therefore a ban of transactions with ByteDance was set in motion. On the same day, similar restrictions were placed on other Chinese internet companies, including WeChat. To avoid the restrictive measures against the app in the United States, TikTok could be sold to an American company, such as Microsoft (Cartwright, 2020).

The American government has also started applying more restrictive measures against China in other fields. Universities are heightening scrutiny of research proposals from China and, in some cases, restricting collaboration. Visas for Chinese scientists are being delayed for conferences and exchanges, while visas for Chinese graduate students studying topics such as robotics or advanced manufacturing have been shortened to one year from five (Kwan, 2020). It is worth noticing that, although the Biden administration has not used such strong terms as its previous administration, it has still continued many of Trump's policies. Additionally, it has increased public criticism of China's human rights violations in Xinjiang and Hong Kong and countered Chinese adventures in the Taiwan Straits and the South China Sea. The Biden administration, in fact, has been placing a strong emphasis on democratic values in the battle between democracies and autocracies (Zhao, 2021).

In response to this offensive behavior perpetrated by the United States, in addition to raising tariffs on imports of American products, China has also started using its dominance of rare metals, and in May 2019 it declared that it would decrease its rare earths exports that are critical for sectors such as defense, energy, electronics, and automotive. Moreover it also announced it would establish its own list of unreliable countries, as the United States has done, and the National Development and Reform Commission has been tasked with organizing a study on establishing a national technological security management list system, with the aim of more effectively forestalling and defusing national security risks (Kwan, 2020). Additionally, China has taken tit-for-tat actions to confront the United States in almost every realm and everywhere in the world, which include, but are not limited to, expelling American journalists, banning them even from reporting in Hong Kong and Macao, sanctioning high-level American officials, advancing suppression in Xinjiang, tightening control of Hong Kong. Moreover, President Xi Jinping has highlighted the success of the Chinese "authoritarianist modernization" for example in the containment of the Covid-19 outbreak, which was turned by the Chinese leadership into a celebration of the capacity of their government, in contrast to the incapacity of the western governments to handle the crisis (Zhao, 2021).

A prolonged hostile situation like this between the two countries could depress the Chinese economic growth rate through supply-side factors, as some multinationals would relocate in order to avoid additional costs associated with American tariff hikes against Chinese products. As the United States tightens restrictions on the acquisition of American technology by Chinese firms, Chinese productivity growth might slow down. At the same time, the United States would also be hurt by this hostility. China is not only the world's second largest economy, but also the core of many global supply chains (Kwan, 2020). China, in fact, has fallen from the largest importer and trading partner of the United States to the third-largest importer and fourth-largest trading partner, and its share of American foreign trade has declined from 21% in 2017 and 15.6% in 2018 all the way to 13% in 2022 and 11.6% in 2023. The ranking of China's top three trading partners has also changed from the United States, the European Union and ASEAN in 2017 to ASEAN, the European Union and the United States in 2022 and 2023 (An, 2024).

Moreover, with restrictions on doing business with China becoming tighter and tighter, more American companies will have to move their operations from China to other locations at the expense of efficiency. As a result, the United States would not only lose its market share in China but would also have to import from more expensive sources. This situation might lead the rest of the world to choose one side, either China or the United States, as the relationship between these two countries influence global interactions (Kwan, 2020).

Lastly, the Sino-American relations will be affected by the next American President who will be elected in November 2024. If Trump becomes President for another mandate, the series of restrictions both on technology and trade might increase once again pursuing the “de-Chinaization” campaign of the supply chain (An, 2024).

4.2. The Sino-European Relations

Considering the lack of geographical conflict between China and the European Union, the two parts can easily be strategic partners with mutual needs, strong support and cooperation. Moreover, historically China has always supported European independence (Song, 2024). In fact, over the years, European countries have developed common interests in issues about China and have tried to jointly deal with these problems as a European whole, as revealed by the conflicts between China on the one side and European countries together on the other, over such issues as arms embargo, human rights, trade and investment, etc. (C. K. Chen, 2021). In 2021, for example, European sanctions were imposed on China over so-called "human rights issues" for the first time since 1989 which resulted in Chinese counter sanctions (Song, 2024). However, while these Sino-European conflicts might destabilize Sino-European relations from time to time, they have arguably played a role in facilitating and strengthening a sense of community among European countries and therefore contributed to the evolution of the European international society (C. K. Chen, 2021).

Contemporary Sino-European relationships started in 1949 when many European countries shifted their recognition of the Chinese regime from the Republic of China lead by Chiang Kai-shek to the People's Republic of China led by Mao Zedong. Since then, all European countries but one – the Vatican – have normalized their relationship with China. It is worth noticing that, despite the relationship between the two sides officially started in 1949, China and most European countries only began having significant interactions in the late 1970s after China slowly started embracing capitalist ideas as a result of the reforms launched by Deng Xiaoping (C. K. Chen, 2021).

In 1978 the first trade agreement was signed between China and the European Communities – which later became the European Union – and in 1988 the European Commission of the European Communities established its first representative office in Beijing. As a result, trade between the two sides began to grow with a subsequent increase in Foreign Direct Investment from European companies flowing into China. This phenomenon mainly took place in the so-called Special Economic Zones, which, as mentioned in the second chapter, were created to attract foreign capital and technology that were vital for Chinese economic development. After the crackdown of 1989, many European countries imposed economic sanctions on China and many western companies decided to reduce their investments in the country. However, due to the economic interests European – and in general western – countries had on China, the ties were normalized shortly after. Between 1995 and 2003, trade between China and the European Union doubled, and since then, China has surpassed Switzerland as the European Union's second largest trading partner following the United States only (C. K. Chen, 2021).

In 1998, the annual Sino-European summit was established, becoming the highest-level mechanism for communication between the two sides. This brought the two counterparts to develop a "comprehensive partnership" which in 2003 became a "strategic partnership" implying a deeper bilateral cooperation across various fields, such as politics, culture, economics, and society. The next year the European Union became China's largest trading partner, surpassing the United States and Japan, while in 2011 China became the European Union's largest trading partner, surpassing the United States (Y. Wang, 2013).

In 2008, all over the world, and especially in some European cities, protests against the 2008 Beijing Olympics erupted, and the political tension caused the annual Sino-European Summit to be canceled. Nonetheless, relations between the two sides were restored and went back to normal by the following year, which saw two Sino-European Summits, one for the one canceled in 2008 and the scheduled one for 2009. In spite of this turmoil, the strategic partnership between the two continued to grow (C. K. Chen, 2021).

Between 2016 and 2021, the economic relationship between China and the countries of the European Union improved, in particular the relationship with Italy was boosted and Italian commercial relations with China increased from 4.7% of the total commercial relations to 4.9%. Exports have increased more than imports with respectively a 26% and a 24% increase. Italy exports toward China are mainly technologies and machinery, while products branded as "made in Italy" only account for 20% of the total exports. However, surprisingly, Italy not only exports less machinery or automobiles when compared to Germany, but also less food and beverages: Italian groceries are only destined to fulfill a niche market's demand, while German beer, milk, and meat fulfill a larger market. Italian imports, on the other hand, are mainly electrical appliances and machinery (Prodi, 2021).

France's commercial relations with China increased from 4.4% to 4.8% of the total commercial relations of the country, imports increased by 23% and exports by 29%. Germany represents the most active country with China, in fact, their commercial relations increased by 6.7% to 7.2% of the total commercial relations, with imports increasing by 26% and exports by 29%, making Germany the only big country to have a commercial surplus with the Chinese counterpart (Prodi, 2021).

China has a different export strategy for different countries, for example the Chinese exports toward Italy mainly occur in the sector of clothing, footwear, house furniture, and household appliances which are all sectors in which the “Made in Italy” brand is strong, therefore China is directly competing with Italian companies in these sectors in many European countries. In fact, France imports products from these sectors, in the past it used to purchase from Italy, however, now it imports from China, because the country offers the same imports, but at lower prices, so France just changed from where it imports, without damaging its commercial sector. Moreover, France exports technology to China, such as components for Airbus or for nuclear plants. Therefore, the two European countries have a different commercial relationship with China. Overall, half of the 137 major commodities in the European Union rely on Chinese supplies, and of the thirty metals defined as "vital" by the European Union, nineteen are mainly imported from China (Prodi, 2021).

In the past few years, the European Union has become increasingly worried about its rising trade deficit with China and has accused China of dumping its products in the European markets at times. On the other hand, China has become increasingly unsatisfied with the European Union’s refusal to grant China the “market economy status” in the World Trade Organization, which has made it easier for the European side to win antidumping cases against China within the WTO framework. In addition, controversies over foreign investment have become obvious, as well. While Europe has become the biggest destination for China’s foreign investment, European investment in China seems to have much room for growth. To European countries, the problem lies in their concern that the Chinese market for European investment is not as open as the European market for Chinese investments. As a result, both sides agreed to conclude and sign a "Comprehensive Agreement on Investments". However, despite the two sides having officially concluded the agreement in principle in December 2020, the disputes still continue, and the agreement has been blocked by the European Parliament since May 2021 (C. K. Chen, 2021).

Bilateral commercial relationships between China and other countries, especially European ones, have also been deeply affected by the Covid-19 pandemic. The closures in February 2019 had an important effect on Sino-European relations. Decreases in European imports have influenced many sectors, such as electrical and electronic products, clothing, footwear, and the automobile industry. European, but world imports from China have increased in that period, especially for products such as disposable gloves and surgical masks. After this emergency, countries such as Italy, have decided to move the production of these products back to their homes, because they realized that depending on a third country in emergency situations was a risk for the society (Prodi, 2021). Even before the outbreak of the virus in late 2019, the European Union was already considering China not only as an economic competitor in its pursuit of technological leadership, but also a systemic rival promoting alternative models of governance. In fact, some European politicians, though they did not account for the majority, misinterpreted the fact that China was providing medical equipment to Europe as a geopolitical strategy to influence European governance. However, the bilateral cooperation between the two sides has continued. First the European Union donated large sums of medical kits to China when the virus was mainly contained to that one country, and later when it shifted to the West in March, China sent experts and medical equipment to Europe, as the country decided to share its experience with European countries (J. Zhang, 2020).

One of the most important actions implemented by China on the international scale is the Belt and Road Initiative. This project was launched in November 2013 by President Xi Jinping and in 2015 a more detailed plan was laid out with the purpose of boosting both the international and the Chinese economy, which are strictly connected (Huang, 2016). This initiative will continue to bring China and Europe even closer on the economic field. In addition to the European market, China has been trying to strengthen its economic ties with countries in Central Asia, Southeast Asia, South Asia, the Middle East, Africa, and Latin America by providing them with financial aids for the building of local and international transportation networks and infrastructure as well as many other projects for their economic development (C. K. Chen, 2021). The international community had mixed reactions to this initiative, some see it as the Chinese version of the American Marshall Plan, some see it as a mechanism for international economic cooperation, and others view this as a way of China to replace the American-led system and impose a "Chinese model" on the international scene (Huang, 2016).

When it comes to Europe, the Belt and Road Initiative aims at easing bottlenecks for cross border trade through the development of transport infrastructure, which could be advantageous for Europe (Herrero & Xu, 2017). In 2019 Italy became the first founding country of the European Union to sign the Memorandum of Understanding to join the Belt and Road Initiative, while other European countries did not. However, Italian exports toward China and Chinese investments in Italy did not increase significantly since the signature of the Memorandum, while countries such as France and Germany signed agreements of much greater magnitude than those signed by Italian enterprises, without, however, joining the Chinese vision of the Belt and Road Initiative (Prodi, 2021). In 2019, in addition to the Italian signature of the Belt and Road Initiative, the European Commission and the High Representative of the European Union for Foreign Affairs and Security Policy defined the People's Republic of China not only as a trading partner, but also as an economic competitor and a "systemic rival that promotes alternative models of governance". This highlights a change in the European narrative with China, in fact, in the past the main focus of this multilateral relationship was the cooperative aspect rather than the tensions between these countries. Despite these changes, Ursula von der Leyen, the President of the European Commission, stated that the collaboration between the European Union and China is vital for technology, commerce, climate, and defense of multilateralism (Gabusi, 2021).

A section of the previous subchapter analyzed the American measures restricting the imports of Chinese technology into the country, the European Union, however, avoided expressing a unique opinion on Chinese telecommunications. Nonetheless it asked the Chinese leadership for more transparency regarding data and security, and it called for a deeper analysis of the extra-European suppliers. The Italian government is acting in an ambiguous way on the matter, in fact Huawei and ZTE are still present in the country. As a result of the projects these two companies started in Italy, the number of available jobs increased. Despite the Italian bill on Golden Power granting the government special powers in order to safeguard assets of companies operating in strategic fields, such as 5G technologies, in 2019 Patuanelli, the Minister of Economic Development, stated that Chinese telecommunication agencies would be able to participate in tenders for 5G infrastructures. However, in 2020, with the excuse of diversifying its suppliers, Telecom excluded Huawei from tenders to acquire 5G equipment in Italy and Brazil (Silvestri, 2021b).

The French leadership seems to be in line with the American view. Until mid-2020, in fact, the French government allowed using Huawei components, except for critical parts of the network, however, in July 2020 the government urged not to buy components from the Chinese firm and announced that licenses with Huawei might not be renewed in 2028. Germany, on the other hand, has not taken any measures against Huawei yet, as it applies strict security policies to any of its technological suppliers. In Spain, Huawei and ZTE have been present on the national soil for years. ZTE has been selected as official 5G supplier by the company Orange, and the Telefónica Group has been relying on Huawei for 4G, despite the group has announced it would decrease its dependency on the Chinese company. Austria declared it would follow the European Union regulations, and work to diversify its suppliers. Denmark followed the same line and stated it would like to rely more on suppliers from allied countries. The Czech Republic distanced itself from Huawei, after a friendly cooperation, because the Chinese company was declared a threat to digital security. Estonia and Latvia followed the American example, while Poland and Romania are working to diversify their suppliers, which will inevitably lead to the exclusion of Huawei (Silvestri, 2021b).

Conclusions

As stated in the introduction, the aim of this paper was to explore the development of science and technology in China since the mid-1800s. A common thread that emerged in this thesis is governmental control and guidance in relation to the development of the country. In fact, all the improvements China underwent since the Opium Wars have all been implemented by the central government. As Wilkinson stated, a characteristic of Chinese development is that, even in the past, there has always been a strong governmental and official control, as well as many regulations regarding science and technology (Wilkinson, 2015). Elman stated that the importance of this field is a common thread of Chinese history, especially since the middle of the 19^{th} century (Elman, 2006).

The Chinese defeats suffered in both Opium Wars represented the occasion for some bureaucrats to realize how underdeveloped the country was. This led to the creation of the Western Affairs Movement, which had the objective of promoting development based on Western knowledge that would later be used to defeat the foreign invaders and restore the Chinese empire. Unfortunately, the project failed, and China was not able to expel the enemies from the country. The empire fell in 1911, leaving its place to the Republic of China, guided by Sun Yat-sen, which was followed by the foundation of the People's Republic of China led by Mao Zedong. The most important event that really boosted the Chinese science and technology fields of that period was the collaboration with the Soviet Union. After less than a decade of cooperation, the relationship between the two countries started to worsen, also due to the Great Leap Forward, and the Cultural Revolution. After Chairman Mao's death in 1976, the country was not in a better scientific and technological situation than it was in 1949.

The necessity for development was urgent, and Deng Xiaoping's Reform and Opening Up slowly began to change the country. As a result of his efforts, China opened up to the world, an improvement that proved to be vital for the national modernization process. This allowed China to gain access to foreign investments, technology, and know-how. At the beginning of the reforms, the central government acted as the major – and sometimes sole – investor in order to launch the new fields that were being developed. Nowadays, since these areas have expanded and grown, the state is slightly decreasing its direct intervention so that companies and private investors can enter the market and help the country further develop. This was also necessary in order to face the decrease of foreign investments.

In spite of the slow success of the 1980s, from the following decade the country's economy began growing steadily, transforming China into the world's second country for economic dimensions. The Four Modernizations and the Special Economic Zones played an important role in boosting the Chinese economy on the international scene. Similarly to what happened in the late 1800s, many students were sent abroad to learn from more advanced countries with the purpose of returning to China after graduating to help rebuild their homeland. Improvements and developments in the education field promoted the rise of a technocratic government. However, the reforms did not always have the expected results, and the leadership had to face protests in the late 1980s in addition to social and environmental issues in the early 2000s. Deng Xiaoping's legacy is immense, and since the boost he gave the country in the late 1970s, the Chinese leadership focused its actions on promoting national self-reliance, which is one of the main objectives of current President Xi Jinping. The 14^{th} Five-Year plan, in fact, stresses this concept, which is a national goal. The plan thoroughly explains the steps and measures China has to take in order to reach self-reliance in the scientific and economic fields.

All the efforts made by the central government to further develop these two main fields, as well as the educational system, brought about a rapid and steady improvement to the nation. As a result, China has now become one of the most advanced economies of the world. The country is now pursuing a strategy to decrease its dependency from foreign technologies and aims at supplying its own high-tech products to other countries. Foreign enterprises have started to establish research institutes in China, in order to exploit the lower cost of scientists and their connection with the local market. Despite the national goal being self-reliance for the near future, the country still depends on collaboration with foreign scientists.

Innovation is strictly connected with research and patents. As a result of the modern patent legislation in China, nowadays inventions are more protected than they were in the past, which incentivizes research and innovation. To pursue the goal of innovation, new R&D enterprises have been established with the purpose of further developing the scientific and high-tech fields. Moreover, they also have the goal to reach the international advanced level on the matter and to attract international talent. The central government is also taking actions to increase the national GDP spending on R&D, increasing it by 0.4% in the past five years.

This rapid development did not only bring positive results to the country, but it also brought negative consequences on the international scene. The Sino-American relationship has worsened in the past couple years given the quick and rapid development of China. The United States has been the leader of technologies for the past century and is now being challenged by a rising country with a lot of potential. The American government has taken action to slow down Chinese growth, however, it has caused issues to certain American companies which tightly collaborate with Chinese tech enterprises, such as Huawei or ZTE. The American government has eased its restrictions on Chinese firms to protect its own enterprises. Living in a globalized world means that all countries – willingly or not – affect one another. This interconnection of nations also influenced Sino-European relations, and some countries of the European Union decided to impose restrictions on Chinese companies, following the American government's decision.

The global situation and the multilateral or bilateral relationships with China are not definite yet. One of the most important events that will decide the direction of the Sino-American relationship in the near future is the election of the new President of the United States. The country will go down different paths depending on the winning candidate. It is reasonable to assume that China will respond to these actions. As previously analyzed, the European countries don't act as one bloc, but they make individual decisions on these matters. It is plausible to assume that those that have previously decided to limit access to Chinese technology in fields such as telecommunications might continue to do so, while other countries will maintain their collaborations with the Chinese enterprises. However, the slow progress in ratifying the Comprehensive Agreement on Investments between the European Union and China, suggests a shared undercurrent of distrust and increasingly colder relations between the two sides. This prediction can be further supported by the results of the last European Elections of June 2024, where right-winged parties gained significant victories in most European countries. These parties often advocate for a stronger national sovereignty and therefore will limit the access of Chinese enterprises to national technology.

On the other hand, it is probable that China will continue pursuing the national goal of self-reliance. To achieve this final objective, the country will have to continue lowering its dependence on foreign technologies, and it will have to impose its national products on the international markets. This way it can be self-reliant while at the same time it can keep exporting its commodities abroad. If the American and the European governments are not willing to grant access to their markets to Chinese technology, China will have to turn to other markets, such as the South American or the African ones, in addition to the Asian one.

However, as mentioned above, given the deeply interconnected global landscape, these predictions might materialize only if the international environment is conducive. The success of these nations will largely depend on the actions and policies of other countries.

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