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The Space Silk Road (SSR): An Avenue for China-Pakistan Space Cooperation

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ABSTRACT

The Belt and Road Initiative (BRI) is an ambitious Chinese undertaking that is simultaneously a surplus recycling mechanism and a multi-stage economic stimulus program. In recent years, the scope of BRI has expanded to include digital and space silk roads beside the original terrestrial and maritime silk roads. This paper is an attempt to analyze the benefits of the Space Silk Road (SSR) in particular, both to Pakistan and to the region in general. This is framed as an avenue of future Sino-Pakistan space cooperation. While the future benefits are numerous, some short-term benefits include spinoffs from innovation, high-quality research, promotion of STEM education, precision farming, weather monitoring, and better defense systems. However, to fully benefit from SSR, both the Chinese and Pakistani governments need to bring the private sector on board and cultivate public-private space sector cooperation so that both partners can exploit the benefits emanating from 'critical path redundancy' and 'interoperability'.

Keywords: Belt and Road Initiative (BRI), Space Silk Road (SSR), Pakistan, China, Space

1. INTRODUCTION

Belt and Road Initiative (BRI)

According to Asian Development Bank (2017), Asia is an investment-starved continent with a lag of USD 26 trillion in infrastructure investment and development for the period 2017-30, which roughly equals USD 1.7 trillion per year. In this context, then, the development of various transport and economic corridors in different parts of East, West, and South Asia is a welcome move, especially for those living in the underdeveloped parts of this continent.

The Chinese Belt and Road Initiative (BRI)[1] is one such initiative. Originally announced by the Chinese government in 2015, the BRI project has expanded since then, with overall investment estimates ranging from USD 1 trillion to USD 8 trillion (Perlez and Huang 2017; Ming 2018). The original BRI plan comprises two main transnational arteries or 'Silk Roads':

1. The **terrestrial**[2] Silk Road that starts from China, passes through Central Asia, and ends up in Eastern Europe,
2. The **Maritime** Silk Road that starts from the eastern Chinese port city of Quanzhou, and passes through the South China Sea, Bay of Bengal, Indian Ocean, Strait of Malacca, Red Sea, and finally into the Mediterranean Sea towards South-West Europe.

Figure 1: China's Belt and Road Initiative (BRI) Routes

Source: *Awan (2020).*

[1] Until 2016, the BRI was known as the One Belt, One Road (OBOR) project.
[2] This is a revival of the ancient Silk Road that formed the backbone of ancient international trade and cultural exchange.

While the BRI project can be explained via different politico-economic lenses, such as Varoufakis' Surplus Recycling Mechanism (SRM) approach (see Chohan 2018), the official Chinese policy attempts to explain it in five different dimensions – that it shall:

1. Promote **intergovernmental partnership** and cooperation between China and partner countries,
2. Construct and develop the **regional infrastructure** of partner countries,
3. Give a substantial boost to **regional multilateral trade**,
4. Result in **financial integration** by the establishment of financial institutions (such as banks) and coordination in foreign exchange and monetary policies,
5. Boost people-to-people **cultural exchange** and social ties (BRI 2013).

In recent years, China has expanded the scope of BRI to include investments in a Digital Silk Road (connecting developing countries via optic fibers), Polar Silk Road (investments in the Arctic Circle); Health Silk Road (leadership in the health sector, especially in the context of COVID-19 pandemic); and the Space Silk Road (investments in satellites, ground support systems, and launching rockets, etc.).

This Working Paper concerns the latter and specifically aims to situate the Space Silk Road (SSR) within the larger BRI, while offering preliminary analysis vis-à-vis the economic and scientific benefits/developments of SSR to Sino-Pak cooperation in particular and the region in general.

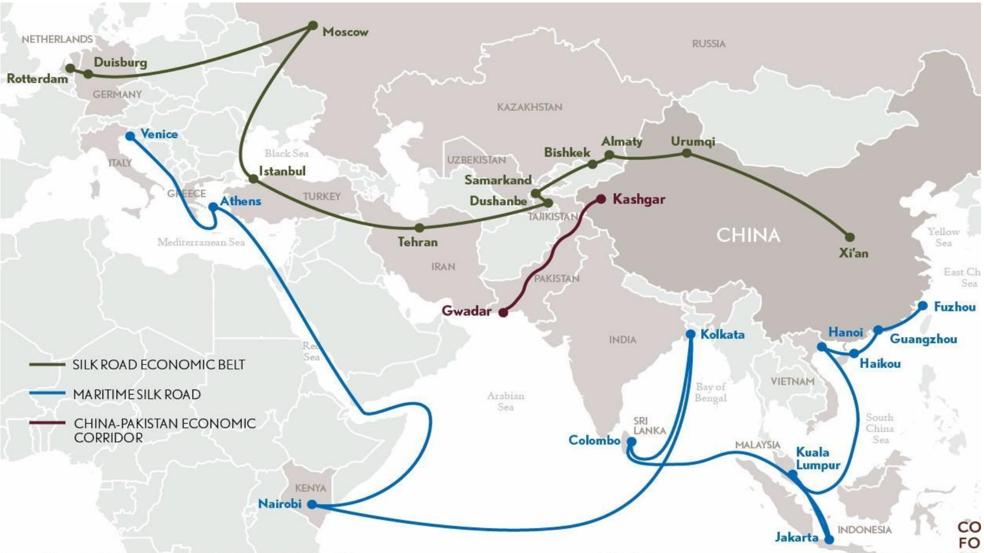
2. CHINA-PAKISTAN ECONOMIC CORRIDOR (CPEC)

The China-Pakistan Economic Corridor (CPEC) is a flagship project under the BRI. CPEC officially took off when Chinese President Xi Jinping visited Pakistan on his maiden trip in 2015, and on 20th April, he signed various Memoranda of Understanding (MoUs) with former Pakistani Prime Minister Nawaz Sharif worth a total of USD 46 billion. These included investments in infrastructure development, energy projects, and the development of Gwadar deep seaport (BBC 2015). However, since then, the investment value of various projects in CPEC has risen to approximately USD 62 billion (Siddiqui 2017).

For China, CPEC holds immense geostrategic and geo-economic importance as it forms a natural bridge between the terrestrial Silk Road and Maritime Silk Road (see Figure 2). Secondly, it connects the landlocked Western Chinese Xinjiang province with the Arabian Sea (via Gwadar Port), hence yielding substantial savings in costs of trade and transportation.

For investment-starved Pakistan, CPEC is nothing short of a 'game changer'—as it is popularly known in the press and media—with potential benefits spilling over in all facets of society besides the economy. Indeed, the project is connecting far-flung and hitherto unconnected areas of Pakistan (e.g., Balochistan, erstwhile Federally Administered Tribal Areas (FATA), Interior Sindh) with the country's core, which will spur development and improve the economic lot of the residents of these areas. This will also help mollify the sense of deprivation present in the inhabitants of Pakistan's peripheries, who feel that they have been neglected by the Centre and that sufficient funds are not allocated for their region's development and economic progress. Seen from this perspective, CPEC is an inclusive project that is uniting the Pakistani polity, thereby frustrating the designs of the country's enemies, who have deployed a consistent hybrid warfare on its territorial and ideological frontiers.

Figure 2: CPEC and the Larger BRI



Source: *Markey and West (2016).*

Besides acting as an engine of economic growth and sustainable (inclusive) development, CPEC shall also have a significant positive impact on bilateral and multilateral trade flows. In fact, a study conducted at the Pakistan Institute of

Development Economics (PIDE) found that the CPEC may increase regional trade flows by 119%, which roughly amounts to USD 49 billion, up from the current USD 23 billion trade (Mujtaba 2018, 2021).

In this context, then, it won't be an overstatement to say that CPEC is not merely an infrastructure and economic development project, but a cultural phenomenon that is further cementing the Sino-Pak brotherly bond and an alliance which is often referred to as 'higher than mountains, deeper than the ocean, stronger than steel and sweeter than honey' (The Nation 2010).

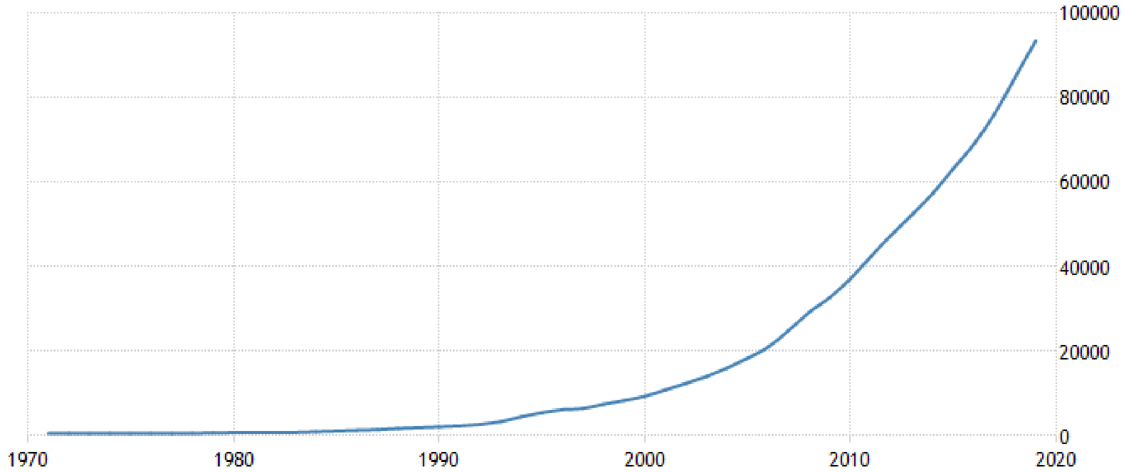
3. CHINA'S SPACE SECTOR IN THE CONTEXT OF CHINESE POLITICAL ECONOMY

Ever since Deng Xiaoping opened the Chinese economy in 1978 and undertook drastic market reforms, China has embarked on a path of continuous economic growth, industrial development, and poverty alleviation. The country started by harnessing the power of its large population and offered inexpensive labor to the world. In the following decades, China fully integrated into the global production value chains, attracted massive Foreign Direct Investment (particularly from the West), and became a hub of the world's manufacturing.

In the period between 1980 and 2015, Chinese real wages (i.e., wages after adjusting for inflation) have increased 14-fold (see Figure 3), and the country has successfully lifted approx. 800 million people out of abject poverty—the biggest anti-poverty campaign so far in the economic history of the world (Wei, Xie, and Zhang 2017; UN 2019). While this is indeed a miraculous achievement, the unprecedented rise in real wages is also causing other problems, which are best explained by the model of Nobel Prize winning economist Sir Arthur Lewis.

Lewis (1954) argued that in a typical developing economy, there are predominantly two main economic sectors — agriculture and the industrial sector. The agricultural sector often carries a surplus of cheap labor due to its low productivity. On the other hand, the industrial sector—which is crucial for the economy's growth and modernization—rapaciously draws cheap labor from the surplus pool of agricultural laborers, who are content with low wages on par with their rural lifestyles. This dynamic helps the industrial capitalist make windfall profits and generate savings that are reinvested back into industrial expansion. However, a point is reached in this happy scheme when the pool of surplus agricultural laborers is exhausted, and the cheap labor is no longer forthcoming. At this point, further industrial growth halts, and the economy is said to reach what economists call the ‘Lewis Turning Point (LTP)’ (Shah 2012).

Figure 3: China’s Real Wage Data (1971-2019) in Local Currency



Source: *Trading Economics (2019).*

In a 2013 paper, economists with the International Monetary Fund (IMF) predicted that the Chinese economy will reach LTP between 2020 and 2025 (Das and N’Diaye 2013). However, there is evidence to suggest that China crossed the frontiers of LTP even earlier, with its real wage levels at par with those of high-income countries like Greece and Portugal, and significantly higher than other emerging economies like Brazil, Mexico, and Argentina (Gao 2017; Johnson 2017). If this is true, then it means that China has reached an economic frontier beyond which further growth is not possible until and unless it fundamentally restructures its economy and embarks on a path of continuous innovation backed by groundbreaking scientific discoveries and cutting-edge research and development (R&D).

Many nations on reaching this coveted economic frontier also simultaneously converge towards what economists call a ‘middle-income trap.’ The ‘middle-income trap’ hypothesis suggests that a fast-growing, labor-intensive economy becomes non-competitive vis-à-vis other labor intensive economies owing to rising wages, but at the same time, it is not developed and sophisticated enough to compete with high value adding capital intensive or (in the modern case) knowledge economies. As a result, the country plateaus at the middle-income status (Paus 2017).

Some scholars have expressed fears about China getting trapped on a middle-income plateau and unable to add value or innovate at par with the capital intensive industrialized world (Ma 2016; OECD 2013). However, according to Wei, Xie, and Zhang (2017), local firms have shown remarkable dynamism in responding to the crisis created by wage increases and labor shortages, and the data on patents shows that Chinese innovation is satisfactory both from a quantitative and qualitative point of view.

Indeed, recent evidence shows that both the government and private sector in China are making earnest efforts to facilitate the transition to a high-value-adding and innovative economy. For instance, the Chinese government recently gave its private sector companies a generous ¥ 2 trillion or USD 286 billion exemption in taxes, which is expected to increase further or at least stay flat in the coming years. Moreover, foreign companies are also now welcome to invest in China and retain 100% ownership of their operations and proceeds from profits—the same as domestic Chinese firms (Blair 2019).

Even for creating fiscal stimulus (and other counter-cyclical policies), China is now investing in ‘new’ infrastructure projects such as 5G, industrial internet, Internet of Things (IoT), satellite systems, Artificial Intelligence (AI), and so on. In fact, in 2020, Chinese local governments invested a massive ¥34 trillion in these new infrastructure projects to countervail the economic depression caused by the COVID-19 pandemic (Tsui et al. 2020). It is this politico-economic context in which the space sector of China finds itself.

4. CHINA’S SPACE PROGRAM

China’s space program started in the 1950s, partly as a response to the United States (US) and former Soviet Union’s space race. At this stage, the country was more concerned about defense and security implications of the space program, and hence, its policy choice can be thought of as a strategic maneuver. As the Sino space program lacked a broader commercial, scientific, and research orientation, it stalled for the next couple of decades, only to be resumed around the turn of millennia. Specifically, the establishment of the China National Space Administration in 1988 and sending of a taikonaut to outer space in 2003 marked the resumption of activities in the stalled Chinese space program (Petersen 2018).

Until recently, the Chinese space sector consisted of only two public sector agencies, namely the China Aerospace Science & Industry Corporation Limited (CASIC) and the China Aerospace Science and Technology Corporation (CASC). This was because of the exorbitant costs of producing and launching space satellites, and also because China was still in an early phase of development, where it was exclusively focusing on low cost, low wage manufacturing and industrialization (Patel 2021). However, things changed when the costs of producing and launching satellites plummeted and when Xi Jinping became the President of China in 2013.

As part of his earnest efforts to modernize the Chinese economy and transform China into a hub of innovation and value addition, President Xi Jinping focused sharply on a few key emerging sectors. These included solar power, AI, 5G, industrial internet and IoT, and the space sector. Specifically for the latter's development, President Xi passed a paper called *'Document 60'*, which opened the sector for all types of investment, especially by the private sector (Ibid.). Since its approval, investment in the Chinese space sector has exceeded half a billion US dollars, and reports suggest that it will be close to USD 5 billion by 2025 (Waidelich 2021). Moreover, as of 2021, 78 firms are operating in the Chinese space sector, with more than half commissioned after 2014 (Patel 2021).

While it will be unfair to compare the fledgling Chinese space sector to the US and even the Russian space industry, it nevertheless has achieved some remarkable feats in its brief existence. For example, in 2020, despite the onslaught of the pandemic, the Chinese successfully landed a rover on Mars, brought home rock samples from the Moon, and developed a next-generation space vehicle that will take taikonauts to the outer orbit and perhaps to the Moon someday (Patel 2021).

Similarly, in November 2020, a Chinese private space company launched a new rocket called Ceres-1 with state-of-the-art technology that can deliver 770 pounds of payload into the Earth's lower orbit at a meager altitude of 62 feet. This is a remarkable development considering that this company is a new entrant in the market and was founded only three years ago (Patel 2021).

As of this writing (2021), China has launched the first component of its space station named *Tiangong* or 'Heavenly Palace' in outer space. The *Tiangong* is approx. 90 tonnes in weight and will hover at a distance of 400-450 km in the lower earth orbit. The Chinese space authorities will be launching 11 more components or modules, which are expected to be fully assembled and functional by 2022. Currently, the only space station in outer space is a collaboration of the US, Canada, Russia, Europe, and Japan which is set to retire by 2024. Thereafter, the Chinese Tiangong will become the only space station in Earth's outer space (AFP 2021).

The Chinese space sector includes both public and private sector ventures, with the public sector focusing on magnifying national prestige by taking on big projects such as building a space station and (potentially) sending taikonauts to Moon, while the private sector focuses on commercial viability such as manufacturing satellites, cost effectively launching them as well as competing with international space firms, thereby maximizing profits.

5. SPACE SILK ROAD (SSR)

Sino Space Ambitions

Ever since Xi Jinping came to power, he has set some bold and very ambitious programs for his country. One of them entails making China a fully developed and wealthy nation—at par with Western industrialized countries—and becoming a world leader in innovation and [economic] value addition. As per his vision, the Sino Space sector is all set to play a very crucial role in this future scheme of things—a timeline that matches with the centennial celebrations of the Chinese communist revolution, i.e., 2049 (Gracie 2017; Chi 2017; Wenderoth 2018).

It is interesting to note that Sino Space ambitions are markedly different from the US or any of its partners. The US space agency National Aeronautics and Space Administration (NASA) is more geared towards space exploration for research purposes and the advancement of science (NASA 2020). The Sino Space program, in contrast, is more focused on tapping the space economy to spearhead Chinese economic growth and national development (English.gov.cn. 2016). As of 2020, the space economy is worth USD 423.8 billion, and estimates suggest that it will grow to USD 2.7 trillion by 2040 (Sheetz 2017, 2020). In this context, then, China is particularly aiming to have a first-mover advantage in the lucrative space mining industry, which runs into several trillion dollars, and will be the *only* source of mineral exploitation, once humankind exhausts all natural resources inside the Earth. In fact, according to *Nature*, a 200-meter-long platinum-rich asteroid could be worth as much as USD 30 *trillion* (Elvis 2012).

In particular, China aims to establish a permanent research-based space station on the Moon by 2035 (Goswami 2019). This will yield many benefits to the country. ***First***, the space station will help China in mining asteroids, exploit mineral-rich resources and carry out deep space exploration. ***Second***, the space station will also serve as a cantonment for further space colonization. This is because the space station will help facilitate Chinese rovers to explore and drill lunar resources that can be used in launching future spacecraft to other planets. In fact, according to a study, space launches from the Moon require 22 times less energy than the Earth, owing to the former's lighter gravitational pulse. ***Lastly***, such a space station will also serve as a blueprint for futuristic human space settlement. Thus, establishing a lunar outpost is crucial for any nation if it wants to reap future benefits related to space economy, asteroid mining, and space settlement. All the existing signs indicate that China is recalcitrant in yielding this privilege to any other nation other than itself.

Moreover, China also plans to build a space solar power station 36,000 kilometers above the Earth's surface (Can 2016). The plan is to become entirely self-sufficient in energy using solar power, which will help ease the burden on the environment and meet energy needs simultaneously. This is also the need of the hour because, by 2052-60, fossil fuels are expected to start depleting, thereby creating a massive energy crisis (MAHB 2013). Therefore, harnessing solar (and other sources of) power using space technologies will become inevitable, and China is rightly planning for this longer-term horizon.

BeiDou Navigation Satellite System (BDS): An Integral Part of SSR

The Global Navigation Satellite System (GNSS) is a global geospatial satellite system that helps in locating, tracking, and positioning targets for all civil and military purposes. So far, only a handful of countries have an indigenous GNSS that includes the US with their Global Positioning System (GPS), the European Union with their Galileo, Russia with the *Globalnaya Navigazionnaya Sputnikovaya Sistema*

(GLONASS), India with the Indian Regional Navigation Satellite System (IRNSS), Japan with the Quasi-Zenith Satellite System (QZSS) and China with the BeiDou Navigation Satellite System (BeiDou) (US Space Force n.d.).

The idea of an indigenous Chinese GNSS was originally conceived in the 1980s, and the BDS was officially launched in 1994. As the BDS is a national-level project, including technical sophistication, it is of immense value to the Chinese Going Global Strategy and the overall BRI. The multibillion-dollar BRI has many projects, and the Space Silk Road (SSR) is one of them. The SSR is China's attempt to incorporate space as a third dimension of the BRI, besides terrestrial and the maritime. BDS is an integral part of this SSR, which also includes a full range of satellite/rocket launches, provision of ground support, deep space (asteroid) mining, sending astronauts in outer space, and so on.

BDS & the BRI

The BDS holds a central position in the Chinese plans for the SSR, which is alternatively but less frequently known as the BRI Space Information Corridor. According to the *Wall Street Journal*, the BDS is the glue that binds all the roads, railways, ports, telecommunication, and other infrastructure projects together—along the terrestrial Silk Road and Maritime Silk Road—and is crucial for the provision of satellite communications, navigation & earth monitoring, and weather tracking in the participating BRI countries (WSJ 2016). Currently, the BDS is available in 70 countries, of which 30 lie alongside the terrestrial or Maritime Silk Road, and is used by more than 5 million operating vehicles (Xiaoci 2020).

As noted above, the BDS was developed at the end of the 20th Century to provide nationwide coverage (i.e., in China) by the turn of the millennia. After achieving this feat, China focused on its Phase Two (also known as second generation BDS), intending to cover Asia-Pacific by 2012 (Yang et al. 2013). In Phase Three of BDS (or the third generation BDS), China set the explicit objective of providing global coverage by 2020 (Yang et al. 2018, 2019; Yang, Mao, and Sun 2020).

China successfully achieved this ambitious goal by launching the last of its 55 Geostationary Earth Orbit (GEO) satellites on 23 June 2020, thereby completing the constellation. With a total of 55 satellites, the BDS provides better, more accurate, and more reliable navigation & tracking services, satellite communication, and weather updates to all the global users. This is indicated by the fact that the BDS tracking accuracy—based on the GNSS—has become less than 1 meter, which is almost equivalent to the accuracy displayed by the GPS and the European Galileo. The Russian GLONASS, in contrast, has a tracking accuracy in the range of 2-6 meters. (Lu, Guo, and Su 2020).

A plethora of countries including Algeria, Arab States, Brunei, Cambodia, Egypt, Indonesia, Laos, Malaysia, Morocco, Myanmar, Nigeria, Pakistan, Thailand, Tunis, Saudi Arabia, Singapore, Sri Lanka, United Arab Emirates (UAE) have already started using and reaping the benefits of the third-generation technological sophistication of BDS and its related components.

6. GLOBAL RESPONSE TO SSR

The Chinese Space Silk Road (SSR) is an ambitious project, and the response of the global community, in particular the global powers such as the US, European Union (EU), and Russia, has been varied. For the countries participating in the BRI, this project is going to be a boon as it will result in many benefits such as transfer of technology, building of ICT infrastructure, better communication, amelioration of healthcare and education via online systems, innovation & research, precision farming, etc.

However, for established hegemonic powers, specifically the US, the SSR can prove to be an economic and security threat. This is because the US currently dominates the space sector. Approximately 30% of all the spacecraft currently in space belong to the US. The US space program took major leaps as early as 1958, and although it lost the so-called ‘Sputnik’ movement to Russia, it nevertheless caught up and currently boasts the most advanced space technologies, including communication & surveillance satellites, weather predicting mechanisms, missile detection, e-intelligence, and so on (ArcGIS n.d.).

With the rise of the Chinese space program and SSR in particular, the US is alarmed. It is already sharing its concern and blaming the Chinese state and military of intellectual property theft. It accuses the Chinese businesses of forming shell companies in the US to obtain cutting-edge technology, intellectual property, and other patented information (Strout 2019). It is also concerned that China is looking to dominate the space race in a zero-sum game, where the latter expels the former and all other nations to form a monopoly in space.

Other developed nations such as the EU and Japan are likely to take a similar stance as the US vis-à-vis SSR. Russia, however, is strongly expected to cooperate with China in SSR and form a partnership where the two regional powers share raw materials, equipment, personnel, and other technology required for successful space operations (Silk Road Briefing 2021; Bochkov 2021).

China should, however, address the concerns of the US, EU, and other developed countries regarding its space program. It should encourage Western powers to cooperate with it in building and expanding a space economy that can benefit all nations regardless of race, ethnicity, religion, or political orientation. The Chinese government should assure the developed world that it is not seeking zero-sum competition with them, rather it looks forward to cooperation and peaceful co-existence on Earth and in Space.

7. PAKISTAN'S SPACE PROGRAM

The period from 1958-69 is remembered as a period of rapid and proactive space development in Pakistan by many historians and economists, and coincided with the 'Decade of Development' (Hasan, Kemal, and Naseem 1997; Zaidi 2017). It was during this period that Pakistan's space program was given active attention, with SUPARCO (Space and Upper Atmosphere Research Commission) coming into existence in 1961. In contrast, the Indian space agency called ISRO, or Indian Space Research Organization, came into existence in 1969 (Jyoti 2017).

Shortly after its inception, Pakistan sent its first rocket into space named *Rehbar-1* in June 1962, becoming the third country in Asia—after Japan and Israel—and tenth in the world to have this distinguished honor. The primary purpose of this rocket was to study wind patterns in the upper atmosphere of the Earth and predict the weather or climatic conditions of the Arabian Sea. Rehbar-1 also led to the establishment of a tracking system with Doppler Radar technology (Iqbal 2020). Since the 'Decade of Development', however, Pakistan's Space Program has been on a downward trajectory. The Indian Space program, on the other hand, has made significant progress and is set to become a USD 11 trillion industry by 2040 (Mansoor 2018).

8. CHINA-PAKISTAN SPACE COOPERATION

For the last two decades, China has been playing a central role in the amelioration and modernization of Pakistan's Space Program and its related sectors. Beginning in 1991, China helped SUPARCO launched the *Badr program*, and in the following year, Pakistan launched its first locally produced satellite named *Badr-A* (Matignon 2019). At the turn of the millennium, Pakistan launched yet another satellite in the series named *Badr-B* (Earth Observation Portal n.d.). In 2012, both satellites completed their lifespan, and were subsequently decommissioned and replaced by the Remote Sensing Program (Bano 2021).

The Pakistan Remote Sensing Satellite or PRSS-1 was launched in 2018 from China with the help of Chinese engineers and other experts. The PRSS-1 is an earth-observation satellite with an optical design deployed to gather data from outer space and is currently being used for purposes as diverse as weather monitoring, geographic & urban planning, defense & intelligence gathering, mapping, and faster communication. The PRSS-1 is an integral part of the Chinese SSR as it provides remote sensing information to all countries included in the BRI. Currently, SUPARCO is also working with its Chinese counterparts to launch two more Remote Sensing (RS) satellites.

In addition to the RS satellite technology, China also helped SUPARCO launch an indigenously manufactured satellite named Pakistan Technology Evaluation Satellite (PakTES-1A) in July 2018 (SUPARCO n.d.). In the same year, Pakistan entered another joint venture with China for the production and operation of the PakSat Multi-Mission (PakSat-MM1) satellite with an equal 50-50 stake of both sides (Quwa 2018). The PakSat-MM1 is a communication satellite, and Pakistani authorities hope to improve communication services and the internet, especially in the Northern region and other remote areas of the country.

In 2019, at the second BRI Summit, the China National Space Administration (CNSA) and SUPARCO reached a historic agreement in which the former agreed to train Pakistani astronauts, conduct joint space exploration programs, as well as form a specialized committee for further enhancing the scope of Sino-Pak space cooperation. Furthermore, the Chinese body also agreed to send a Pakistani astronaut into outer space by 2022 (Sheldon 2019). These developments indicate that although progress in Pakistan's Space Program is slow, it nevertheless is moving in the right direction, and just like CPEC, the SSR is also proving to be a 'game changer' for the country's science, technology, communication, defense systems, and overall research.

9. BENEFITS OF SSR PAK-CHINA COOPERATION

While the benefits emanating from Pak-China space cooperation on the SSR cannot be delineated with perfect specificity at this early juncture, one may broadly discuss the direct and indirect effects of a strong bilateral space partnership (Table 1).

Table 1: Benefits of SSR to Pakistan & other BRI Participating Countries

Benefits of SSR to Pakistan & other BRI Participating Countries	
1.	Improvements in **innovation**, **productivity**, and **research & development (R&D)** in the space sector and its related industries.
2.	Amelioration of the general state of **science & technology** with directly benefit the internet & telecommunication sector, health & education sector, industry & manufacturing, transport and public safety.
3.	Significant **economic benefits** stemming from increased flow of Foreign Direct Investment (FDI), technology transfer, trade of capital goods (e.g., machinery, equipment) and job creation.
4.	Promotion of education & research in **Science, Technology, Engineering, & Mathematics (STEM)** fields.
5.	More **funding opportunities** available to the space sector from think tanks, universities, Non-Governmental Organizations (NGOs), and other enterprises in the private and public sector.
6.	General enrichment of **social, cultural**, and **intellectual** landscape of a country.

7.	Benefits to **precision farming** and better planning, organizing, cultivation, and harvesting of crops. Predictions about **weather & climate** made possible via satellites is also of great utility to farmers.
8.	Development of **Information & Communications Technology (ICT)** infrastructure. This will further cement the IT sector creating opportunities like freelance work, digital marketing, and consulting, besides promoting online education via Massive Online Open Courses (MOOCs) and tele-medicine.
9.	Further strengthen Pakistan's **defense** capabilities. The advanced systems and technology that are part of the SSR will significantly upgrade and improve the country's ability to monitor its borders, air defense system, terrain mapping, and detection of IEDs.

Source: *Authors' compilation.*

The ***first*** direct impact of the Pak-China partnership on SSR will be a boost to innovation, creativity, and productivity in the space domain of both countries. This is because the space sector is a very challenging and competitive area which requires constant upgradation, improvement, and advancements in technologies, systems, processes, and workflows. Moreover, it requires meticulous coordination and cooperation between humans and robots to achieve ambitious space goals, which also have spillover benefits, for example, in the healthcare sector (NASA 2013).

Second, Pak-China cooperation on SSR will result in a plethora of benefits for science and technology in both countries. The history of other space programs shows that space exploration has had direct positive consequences for areas such as telecommunications, internet, transport, health, consumer and industrial goods, public safety, and productivity. On a broader level, space exploration has played a key role in the amelioration of solar panel technology, biomedicine, implantable loop recorder for cardiac monitoring, anticancer photodynamic therapy, search & rescue (SAR) tools, modern smartphone cameras, alloys for airplanes, and compact water purifiers (Brisson and Rootes 2001; NASA 2018; Rainey 2015; Feuerbacher and Messerschmid 2011). The SSR will further consolidate these gains in science & technology and help Pakistan and other developing countries in getting access to it.

Third, the SSR cooperation between China and Pakistan will have significant economic benefits. The space economy is considered to be divided into three main categories viz., upstream, downstream, and derivative activities. The upstream space sector includes R&D, a satellite launch, and ground support. The downstream space sector, on the other hand, includes those services that make full use of the upstream sector's activities, for example, cell phone connectivity, internet coverage, map navigation, and so on. The third sector includes all those activities which are derivative of the upstream and downstream space sector but are not directly dependent upon them. This includes the spillover effects of the space industry on economic sectors such as health, education, engineering, automation, and so on (OECD 2020). As of now, Pakistan is lagging far behind in all the aforementioned sectors. Thus, SSR will give a significant boost to the country's space industry and will also help in capital upgradation in related industries, besides fostering a culture of innovation & research. In this regard, this paper also invites future researchers to conduct a general equilibrium analysis to gauge the effect of SSR on Pakistan's different economic sectors.

Fourth, visible cooperation in the space domain between Pakistan and China can motivate young people, especially children, to pursue education in fields related to Science, Technology, Engineering, and Mathematics (STEM). This is not a mere prognostication but backed by actual empirical evidence as well. For instance, in the US, the number of young people enrolling in STEM graduate programs (especially doctorates) increased dramatically after the launch of the Apollo Moon Exploration Program (Siegfried 2003). Besides, due to the positive impact on STEM education and the visible economic benefits that SSR is likely to create, the funding dilemma of Pakistan's space program is also likely to be at least partially resolved. This shall translate into more funds for space exploration, space cooperation, the setting up of new space companies, and specialized educational & training programs for the space sector.

Another subtle ***fifth*** benefit that the SSR may provide is a change in the culture and intellectual life of Pakistan. The SSR may inspire a new generation of children and young people to dream of becoming astronauts and scientists, thereby triggering an intellectual upswing in the country. It can also usher in a cultural change whereby people take science more seriously in all aspects of their lives and seek solutions to questions that have fascinated humans for millennia, such as: Where do we come from?, Where do we go? What lies beyond the Earth's atmosphere? Can we inhabit other planets? And again, this is not mere speculation, for history proves that Yuri Gagarin's ascent into space and Neil Armstrong's descent on the moon sparked a cultural revolution in their respective countries. Similarly, many scientists and researchers believe that the next major advancements in the space domain—for example, establishing a colony on Mars—may unleash forces that will alter the prevailing cultural norms, belief systems, and worldviews at par with the discoveries made by Nicolaus Copernicus (NASA 2013).

Sixth, the SSR will have immense benefits for Pakistan's agriculture and land cultivation. Agriculture is the backbone of Pakistan and comprises around 24% of the GDP, and employs approximately 50% of the country's labor force, especially in the rural areas (PBS 2020). The advanced satellite technology of the SSR—especially RS satellites—will help Pakistani agriculturalists in accurately monitoring soil patterns, snow cover (in the northern areas), development of crops, level of the water table, drought conditions, and so on. In addition, the ability of satellites to predict rainfalls and other weather changes will aid Pakistani farmers in the better planning of sowing, harvesting, and reaping of crops, besides preparing them for any exogenous shock. Finally, space technology may also be productively utilized for predicting the agricultural output of a region (for example, a province) as well as prepare for any contingency, such as famine, locust attack, or a food shortage (UNOOSA n.d.).

Seventh, cooperation in the space domain will have major benefits for the growth and development of the Information & Communication Technology (ICT) infrastructure, especially vis-à-vis the proliferation of cellphone technology and internet connectivity in Pakistan. This will be useful for connecting remote parts of the country with the mainstream, besides significantly contributing to the local economy. This economic contribution will come in two ways. First, the expansion of cellphone companies and Internet Service Providers (ISP) will directly provide jobs to the local people who will work in a company's franchise or other similar arrangements. Second, with better internet connectivity, local youth will have access to online work opportunities, such as freelancing, blog writing, digital marketing, online selling, etc. Moreover, better ICT infrastructure will also have a net positive effect on health, education, and other measures of the Human Development Index (HDI). For example, a high-speed internet connection can be utilized for distant learning, such as for taking Massive Online Open Courses (MOOC) and also for telemedicine. This will especially be useful for those far-flung regions of Pakistan which lack proper physical infrastructure in health and education.

Eighth, apart from the benefits of Sino-Pak space cooperation for science, technology, connectivity, agriculture, education, and healthcare, it will also revolutionize Pakistan's defense system giving it a competitive advantage over its regional adversaries. First, space technology can easily be deployed to monitor borders and foil any attempt by miscreants and insurgents to infiltrate porous areas along the border. This is especially true for Pakistan's western borders, which have witnessed innumerable infiltrations of militants and Indian-funded proxies. Secondly, using geosynchronous satellites, Pakistan Air Defense systems will be better able to detect and track the trajectory of an incoming missile and neutralize it in time. Third, the SSR satellite systems can also be effectively deployed to assist military personnel in advanced areas with coarse terrain. Using pocket devices, a band satellite can send maps and images of the terrain to soldiers, thus giving them a better understanding of their environment and how best to deal with the threats. Finally, hyperspectral imaging can also be added to SSR, which will help the Armed Forces and paramilitary to better detect land mines and Improvised Explosive Devices (IEDs). Such imaging is proven to detect even the best camouflaged mines using technology that is six times more powerful than the visible spectrum (Goel 2009).

10. HINDRANCES

This Working Paper has so far spelled out the details and benefits for China and Pakistan vis-à-vis the SSR. However, it must be noted that there are some roadblocks within the smooth execution of BRI in general and SSR in particular.

The ***first*** concerns the narrative doubts and ideological bickering about the BRI. Such doubts have usually been infused in the minds of people by Indian and Western elements such as media, think tanks, academics, and the like. The most common line of attack is that the BRI and its related components (such as CPEC) will create debt traps for participating countries (Lai et al. 2020). This shall make these countries (mostly located in the global South) economically dependent on China, thus amplifying Beijing's political and diplomatic clout (Brautigam 2020; Lai et al. 2020). Moreover, infrastructure and development plans of the BRI are also censured for polluting the environment by leaving a heavier carbon footprint while simultaneously damaging the green ecology of the participating countries (Rauf et al. 2018; Shakib et al. 2021). It is beyond the scope of this paper to address these accusations, but emergent literature offers ample refutation of such allegations (Lai et al. 2020; Brautigam 2020; Rauf et al. 2018).

The ***second*** hindrance in a potential Sino-Pakistan SSR cooperation involves the US' meddling and pressure of other Western powers. The US (and its Western allies) view the BRI and SSR with deep suspicion (Li and Wu 2021), owing to its perceived political dividends for Beijing and resultant scientific advancements that can outmatch the global prestige and standing of Western science and technology (Kim 2019; Zhang 2019). In this context, then, it comes as no surprise that in the recent past, many powerful (imperialist) countries have tried to dissuade Pakistan from joining CPEC (Aamir 2020), and a similar response is expected vis-à-vis SSR. However, Pakistan should tread a cautious path in this regard while balancing its ties with both China and the US. While Pakistan should further enhance its cooperation with China on CPEC and SSR, it should also assuage Western concerns about these projects and act as a mediator in resolving Sino-US outstanding disputes and clearing up the air similar to the 'Nixon in China' moment.

The ***third*** hindrance worth mentioning is the lack of a coherent National Space Policy and a weak space program (Waseem ud din et al. 2021). This is perhaps the biggest obstacle in the smooth execution of SSR-CPEC as Pakistan does not have adequate infrastructure to support the high-end activities of a thriving space partnership. Although this discrepancy can be attributed to various factors, continuous neglect of scientific education, quality research, and technological advancements is the main culprit holding back Pakistan's progress in this field. This is reflected in Pakistan's budget for education and scientific research, which has consistently remained below 3% of the GDP since the last five decades (World Bank 2020).

Therefore, to facilitate and complement SSR, the Government of Pakistan and policymakers need to develop a comprehensive National Space Policy (Waseem ud din et al. 2021) and revamp the existing space program, which is currently under the aegis of SUPARCO. Second, there is an urgent need to increase the budgetary allocation on higher education in general and STEM education in particular, not to mention earmarking for state-of-the-art research laboratories, satellite/rocket launches, space exploration programs, and so on.

11. POLICY RECOMMENDATIONS

Given the above discussion and analysis, the following recommendations are forwarded for the attention of relevant stakeholders and policy practitioners:

1. The Space Silk Road (SSR) should be made as visible and prominent as the Belt and Road Initiative (BRI) and China-Pakistan Economic Corridor (CPEC). One way to achieve this goal is by signing Memoranda of Understanding (MoUs) between various organizations that are directly and indirectly affiliated with the space domain in both countries; as well as information campaigns via print, electronic, and social media. Moreover, academia, university, and think tanks should also be encouraged to conduct scholarly research and disseminate relevant information among the masses.

2. The SSR should formally become a part of CPEC. While Pakistan is presently benefitting from Chinese space technologies such as the BeiDou Navigation Satellite System (BDS), Sino-Pakistan space cooperation needs to be formalized within the ambit of the Joint Cooperation Committee (JCC) and the long-term plan (LTP) of CPEC.

3. The Government of Pakistan should encourage the start-up of private space companies and pass relevant laws aimed at their growth and expansion. In other words, Pakistan needs its very own version of China's *'Document 60.'*

4. The private and public space organizations should work in unison to make SSR a resounding success.

5. The SSR should aim at fostering a 'critical path redundancy'. This means that if the space functions of a nation are down, then another partner SSR nation should fill in the gap and provide temporary support to it until it rejuvenates its space operations. This shall allow ceaseless human activity in space without interrupting the flow of normal space operations.

6. China should take the lead to encourage 'interoperability' in the SSR projects. Interoperability means the cooperation of private space companies of one country with those of a partner country but under the regulation of their respective governments. This is another possible way of fostering 'critical path redundancy.'

CONCLUSION

The Chinese Belt and Road Initiative (BRI) is a mega infrastructure and development project of the 21st Century through which China is simultaneously utilizing its excess capacity and uplifting the participating (underdeveloped and developing) countries while building its soft power throughout the region. Originally, the BRI consisted of the terrestrial and Maritime Silk Road, however, in line with its development at home, China has also expanded the scope of its ambitious project to include digital and space Silk Road. This paper analyzed the latter in some detail.

While China is undoubtedly a relatively late entrant into the space sector, it has nevertheless seen fast growth, thanks to the initiatives of the Chinese government, such as *'Document 60'*, which welcomes all types of investment in the space sector, and also encourages side-by-side work and cooperation of the public and private space entities. Unlike the space programs of the US and EU, the Chinese space program has a dual focus viz. building national prestige (by taking on projects such as sending taikonauts to the moon) and gaining economic benefits (such as mining asteroids).

The Space Silk Road (SSR) is an extension of both — the BRI and the indigenous Chinese space program. The starting point of SSR is the connectivity of all BRI participating countries via the BeiDou Navigation Satellite System (BDS), which is beneficial for a range of purposes such as telecommunication, internet connectivity, map navigation, weather prediction, etc. Moreover, the BDS is also being utilized for a full range of space activities such as satellite launch, ground support, asteroid mining, and deep space exploration. As of now, the BDS is already in use in 165 countries, posing a challenge to the hitherto hegemony of the US GPS (Tsunashima 2020).

In this context, then, this paper discusses and highlights the benefits of extending SSR to CPEC and future Sino-Pakistan space cooperation. While the list of potential benefits is aplenty, some of the immediate and more visible gains include the following: spinoffs from research & innovation, promotion of scientific education & a rational culture, connectivity of remote areas via cellular and internet services, precision farming, online education, tele-medicine, better defense systems (such as the enhanced ability to detect and foil missiles), to name a few.

The success of BRI and SSR is likely to ruffle some feathers, especially in the advanced industrialized Western nations. In particular, the US is already feeling threatened by the rise of China's space program as it alleges the Chinese military and businesses of stealing intellectual property, trade secrets, and other proprietary data (Li and Wu 2019; Kim 2019; Zhang 2019). The EU is likely to follow in the footsteps of the US vis-à-vis the SSR (Kim 2019), while Russia is likely to emerge as a partner of China in fulfilling its space ambitions and extending the SSR's network (Bochkov 2021).

In conclusion, the SSR is a golden opportunity or a historic 'catch' that Pakistan cannot afford to miss. While CPEC is already revolutionizing Pakistan's economy, industry, infrastructure, and ports, the SSR will galvanize the country's hitherto dilatory space program and provide the much-needed impetus to research, innovation, connectivity, and STEM education. So, while China and Pakistan share a brotherly bond, this fraternity should naturally be extended in the realm of outer space.

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