THE RELEVANCE OF 5G IN THE DIGITAL SILK ROAD

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I. INTRODUCTION

The first reference to the Digital Silk Road (DSR), named *Information Silk Road*, can be found in a white paper by the National Development and Reform Commission (NDRC), the Ministry of Foreign Affairs and the Ministry of Commerce over the vision of the Belt and Road Initiative (BRI). As part of the infrastructure needed to improve connectivity between BRI participants, Chinese authorities mentioned the improvement required in the capacity for information exchange, such as submarine optical cable and satellite communication (NDRC *et al.*, 2015). These proposals have been enriched by other technological services, such as data centers and critical technological developments within the digital economy in which China has shown its leadership, such as 5G cellular networks. As we will show in this chapter, 5G technology will become the circulatory system of this technological revolution.

The DSR essentially integrates two lines of initiatives. The first one is related to China's industrial policy and innovation efforts on various technological fronts, particularly those related to communication technologies. As we will see, although the State establishes the guiding principles, collaboration with the private sector is key to this area. The second has to do with China's internationalization and economic collaboration strategies through

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the BRI. As an open initiative, the BRI is a space for collaboration between governments of different countries. For these reasons, the DSR constitutes a sophisticated space of coordination between international, public and private, interests towards innovating within one of the most dynamic economic sectors of the XXI century.

The DSR adds a dimension to the terrestrial *Silk Road Economic Belt* and the maritime *Silk Road*. It is complemented with the former, because collaboration in a broader range of topics, such as development policies or culture, facilitates the understanding regarding the digital economy. We can find complementarities in both directions, with the geographical closeness revealing itself as a crucial factor concerning the integration of the real economy. Thus, the physical infrastructure necessary to integrate digital economies is more natural to be implemented under a broad collaboration scheme, such as that offered under the BRI platform. That may be the case of laying fiber optic, terrestrial and submarine cables. In the opposite direction, advances in the integration of digital economies would be complementary to other actions such as those aimed to facilitate international trade.

Cyber connectivity will offer a fundamental aspect to land and sea connectivity, which it enriches and complements. Logistics networks will require improved physical infrastructure, some of the aspects of which will be discussed in this chapter. But, in addition, optimal connectivity will critically depend on public policies, regulations, standards, and institutions. Possibly, digital connectivity is, among those in the BRI, the dimension that will be most affected by these factors. One of the fundamental aspects of the DSR, which reflects collaboration between countries, is the integration of standards in communication and information technologies. The digital inclusion favors the creation of integrated markets, facilitating international trade as well as the internationalization of the respective companies. Huawei, for instance, has been a front-line contributor in setting standards related to cutting edge communication technologies, promoting connectivity with physical infrastructure for the creation of information transmission capabilities. Notice that creating standards, in addition to benefiting the developing market, also places the participating firm at the vanguard of the competition.

The DBR is part of an initiative that has, among its objectives, the promotion of innovation. The scientific vision considers its integration into the industrial sector, and the digital economy is recognized as one of the technological revolutions of the 21st century. Collaboration is proposed in the areas that will constitute the leading sectors of the future: nanotechnology, artificial intelligence, or quantum computing. Notice how complementari-

ties among the multiple dimensions for international cooperation considered in the BRI reinforce economic integration. For example, cultural exchange, considered within the "people to people" axis, can improve mutual understanding and strengthen trade relations. Thus, the improvement in digital communication can arise in cultural exchanges and joint business opportunities. There would be network gains from collaboration on a broader range of issues, similar to how more users improve the consumer experience on a wide variety of digital products. Cooperation in these areas does not prevent competition in others but facilitates the delimitation of its most adverse effects.

II. Elements of the Digital Silk Road

As part of the BRI work plan, the *Belt & Road Digital Economy International Cooperation Initiative* has been signed with Egypt, Laos, Saudi Arabia, Serbia, Thailand, Turkey, and the United Arab Emirates. In August 2018, China and 49 other countries published the *Joint Statement on Pragmatic Cooperation in the Field Intellectual Property Among Countries Along the Belt & Road*. Although this document is only a letter of intent, it proposes actions and a framework to collaborate towards the protection of intellectual property, closely related to the development of new technologies in general and the role of communication technologies in the exchange of creative content. Even though China is among the world's technological powers and is proposing, accordingly, an intellectual protection regime, flexibility is offered on this matter, and the need for technology transfers is also being discussed. Cooperation agreements have been signed with Kyrgyzstan, Afghanistan, and Tajikistan. A letter of intent for international collaboration has also been signed with the International Telecommunication Union and 46 collaboration agreements in science and technology. Regarding infrastructure, international fiber optic cables have been built, such as China-Myanmar, China-Pakistan, China-Kyrgyzstan, and China-Russia (OLGPBRI, 2019).

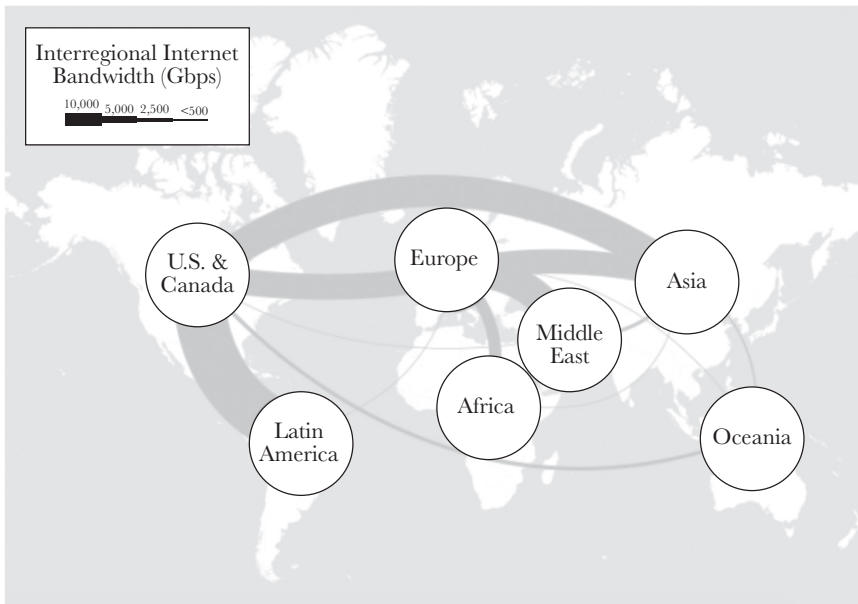
In 2016, the Digital Belt and Road Program was launched to promote cooperation in environmental monitoring with experts from 19 countries and 7 international organizations. The program provides information for the creation of the UN 2030 Sustainable Development Goals indexes. The enormous amount of data offered for this type of measurement (for example, the Sentinel 5P satellite of the European Space Agency alone makes 20 million observations daily on air pollution) requires greater computing capacity. Currently, this challenge has been faced with cloud computing solu-

tions; in the future, it is planned to be coped with quantum computing (Guo, 2018). Faced with these problems that affect all of humanity, international collaboration is necessary to share data, infrastructure, and, in general, coordinate efforts.

For the deployment of 5G networks, the implementation of physical infrastructure plays a fundamental role. In the context of the BRI in general and the DSR in particular, we are interested in looking at international connectivity, which in this regard materializes through fiber-optic networks. The placement of fiber optic networks follows the two axes of the BRI, the maritime through submarine fiber-optic networks and the terrestrial toward Central Asian countries that have no coast.

From 2015 to 2019, the global internet bandwidth has grown at a compound annual rate of 28% to 466 TBPS, with particularly strong growths in Africa (45%) and Asia (42%) (Mauldin, 2019). However, as it can be seen in Figure 1, interregional bandwidth is still weak between Asia, the Middle East, Africa and Oceania. On the other hand, Latin America lacks strong bandwidths independent of the USA and Canada.

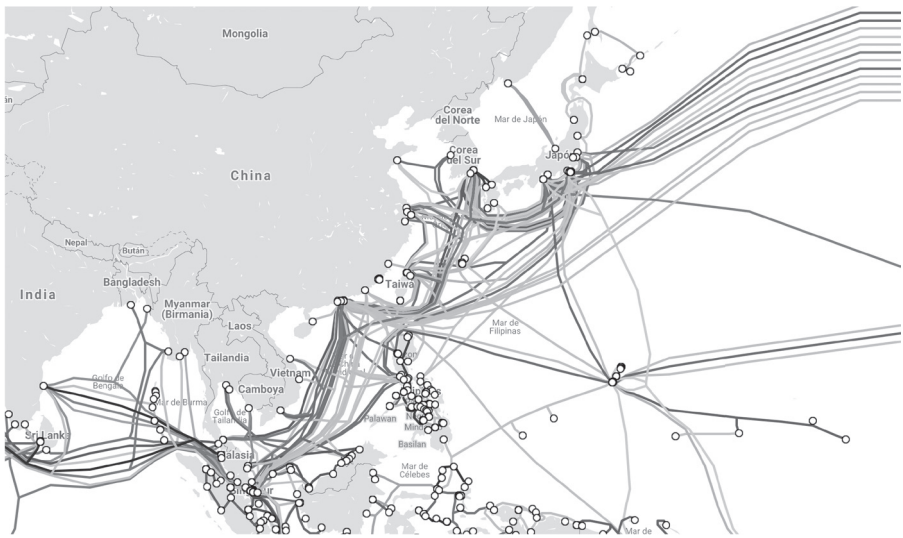
FIGURE 1. INTERNATIONAL INTERNET BANDWIDTH BETWEEN REGIONS (2019)



SOURCE: Mauldin (2019).

Also, a considerable part of the existing submarine cables has already been amortized. Notice that 40% of the submarine cables (as of 2018) were built before 2000, which placed them at the end of their useful life. After the crises of Internet companies in 2001, the construction of this type of infrastructure was significantly reduced. The submarine cables are very convenient since most of the countries have access to the sea. However, several countries in Central Asia do not. In fact, one of the two countries (along with Liechtenstein) that does not have direct access to the sea or borders a country that has one is located in this region: Uzbekistan. In terms of land connections, China has a system of 17 border stations with 12 countries with a bandwidth higher than 70 TBPS (CAICT). The geographical position of China, which shapes the BRI, also gives advantages in terms of providing a better communication network, through both land and sea, with countries in Africa, the Middle East, Central Asia, South Asia, Southeast Asia, and Oceania. Chinese companies have increasingly participated in the construction of these cables under international collaborations. Companies like Hengtong, ZTT, YOFC, and FiberHombe lead the manufacturing of fiber optic cables. Huawei Marine is one of the most advantageous global integrators for the delivery of submarine cables.

FIGURE 2. SUBMARINE FIBER-OPTIC CABLES FROM THE CHINESE COAST



SOURCE: TeleGeography.

We can expect that, in the coming years, the data that shape Figure 1 will change due to the intensification of communication around the DSR, whose irradiating nucleus is China. As we can see in Figure 2, China has intensified the construction of submarine fiber optic cables, increasing its density in recent years. The lines in gray represent fiber cables under construction, from which it can be deduced that this increase is in full expansion.

One of the most remarkable projects is PEACE (Pakistan East Africa Cable Express), which connects the port of Gwadar (Pakistan), the principal port of the China-Pakistan Economic Corridor, with Egypt, through the Mediterranean with France, south to Kenya and with a line that reaches Seychelles. In a second phase, the southern edge would reach South Africa. The PEACE cable is a reflection of how the Maritime Road relates to the DBR. It offers 16 Tbs per fiber pair system and was built and is being operated by a group of Chinese and local companies from the countries through which it runs: Hengtong, Huawei Marine, PCCW, Cybernet Pakistan, Djibouti Telecom and Hormuud Telecom, among others.

The development of the *China Pakistan Economic Corridor*, within the BRI, will constitute a mutual opportunity for economic and geostrategic development. For China, it implies a connection that allows it to access the Arabian Sea avoiding the Strait of Malacca. For Pakistan, the project will create many opportunities for economic development, due to the investments attracted and the improvement in infrastructure. As of May 2016, the China-Pakistan cable was launched as part of the Trans-European network, offering Pakistan an added loop to its submarine cable connections. In service since July 2018, the Special Communication Organization of Pakistan and China Telecom operate it jointly. The cable has a distance of 2,950 km and passes through a maximum height of 4,880 meters above sea level. The Pakistani part, of 820 km, has been jointly built by OSC and Huawei Technologies at the cost of $ 44 million, for which the EximBank of China provided a loan at 2% per year for 85% of the project. This is the seventh cable in Pakistan, but, above all, it gives it greater flexibility, since all the previous ones reached the port of Karachi. In contrast, this one does it by land and will be extended to the port of Gwadar, to also connect with the maritime road (Rauf, 2019).

The pursuit of internationalization by leading Chinese companies had favored the entry into new markets, even before the DSR strategy was conceptualized. For example, Zhongxing Telecommunication Equipment (ZTE), in collaboration with local companies, built the first fiber optic network in Afghanistan, with financing from the World Bank. This project was initiated in 2007. The investments made, in particular in the improvement

of communications infrastructure, have reached countries that are very short in this area, such as those in the African continent. As part of the BRI, data centers have been built and Smart City Initiatives have been carried out in countries such as Djibouti, Ethiopia, Kenya, Tanzania, Mozambique, Zimbabwe, Zambia, Angola, South Africa, Nigeria, Mali, Ghana, Algeria, Egypt, and Morocco. The three African countries that have received the most substantial amount of investment in BRI projects have been: Ethiopia ($ 2.4 billion), Nigeria, and Zimbabwe ($ 1.8 billion each). In these BRI projects, it has not been China the only investing country participating; for example, in Rwanda, South Korea has been leading the efforts to construct a 4G network (Deutsche Welle, 2019). In the face of the development of these communication infrastructure projects in Africa; Western countries have shown little interest.

Even though in some aspects, Russia prefers to opt for its technological developments, which give it independence from other powers, there has also been a meaningful collaboration with Chinese companies, which must be understood within the framework of the DBR. In September 2018, Alibaba established a joint venture with three Russian entities (Megafon, Mail.ru, and the state fund Russian Direct Investment Fund) for the development of a digital e-commerce platform linked to the consumers of the Alibaba platform. In December of that same year, Huawei and Union Pay created the first digital payment service in Russia. In June 2019, MTS, the Russian telephone operator, signed a contract with Huawei to develop 5G technologies jointly and to launch the first pilots in Moscow (Barisitz, 2020).

Since November 2017, the Malaysian government, in collaboration with Alibaba Group, promoted the first Digital Free Trade Zone (DFTZ). This initiative combines the classic design of an FTZ, offering incentives and exemptions to encourage a specific sector of the economy with high growth potential and offering job opportunities, with the particular requirements of the digital industry. Thus, DGTZ combines both physical and virtual spaces. To access these advantages, companies have to belong to one of the subsectors of the digital economy: Internet of Things, artificial intelligence, Fintech, creative media technology, among others. The DFTZ will also make international trade more dynamic because simplifying paperwork through electronic platforms for international trade will reduce the time it takes for physical goods to reach their destination. New digital technologies such as blockchain and 5G are being used to keep track of containers. Automation would reduce physical inspection and automatically pay customs. These technologies could reduce rail transport time, as several borders are crossed through the Belt corridors. In terms of delivery within the country,

the Chinese government has set 24-hour targets within 95% of the national territory, which will offer a large market with unprecedented agility (Min, 2018).

These projects require financing, so the links between the digital economy with the financial institutions that are promoting the BRI are also noteworthy. This commitment preceded the formalization of the digital bet within the framework of the DSR. Thus, on May 10th, 2010, the Ministry of Industry and Information Technology (MIIT) signed a memorandum of cooperation with China Export & Credit Insurance Corporation for the financing of various productive sectors, among which was the digital economy. Besides, institutions such as the Asian Infrastructure Development Bank, New Development Bank, Silk Road Fund, closely linked to the BRI, have continued this financing under the DSR.

III. The 5G connectivity: the circulatory system of the DSR

The introduction of 5G networks is going to be one of the great technological revolutions of the coming years. The improved connectivity will be fed back with the economic spills of the construction of necessary infrastructure. The exploitation of this technological advance will reposition countries on the international scene based on the competitiveness of their industry. As it is evident, the rapid adaptation of productive capacities to this set of technological possibilities will be a decisive factor in determining countries' competitiveness in the coming years.

The high traffic capacity, reliability, and low latency of 5G networks allow a qualitative leap that goes far beyond being able to stream high-quality videos. The number of units that can be connected to the network increases exponentially, with multiple communications that allow the application of the Internet of Things. Automated operations in the manufacturing sector are facilitated by the massive use of data, enabling the achievement of Industry 4.0 objectives. This is the type of communication that allows remote surgeries or autonomous vehicle control, with minimal latency requirements. It can receive massive data from millions of vehicles to improve the traffic of a city, or the movement of tens of millions of people to try to foresee the focus and progression of a contagious disease. Combined with big data and artificial intelligence solutions, which accelerate and automate decision-making, 5G connectivity lays the foundation for an industrial revolution.

The capacities of 5G communication networks are enormous, such as 20Gbps download speeds, 100 Mbps upload, high network stability, 1ms latency, and a capacity of one million connections per square kilometer. Different spectra need to be combined to offer these capabilities. Thus, ranges below 1GHz are used to achieve wider coverage. The bands in the 3.5 (3.3-3.8) GHz spectra are of higher frequency and therefore offer greater data transmission capacity. However, their disadvantage is that they have a shorter range, 400 meters for the 3.5 GHz medium spectrum. At the other extreme, frequencies above 24 GHz are focused on high-speed transmissions, which maximize the bandwidth characteristics and minimal latency. Its coverage is the most limited. The adaptability of the network to the needs of the users depends on an optical combination of the capabilities offered by the different ranges of spectra. The Global System for Mobile Communications Association (GSMA) recommends that 80-100 MHz of contiguous spectrum be provided to each operator in the mid-bands. Ranges close to 100 MHz can guarantee better service. Further international harmonization is also recommended, in particular, to minimize cross-border interference (GSMA, 2019). Here are two criteria that are taken into account in the DSR: international collaboration and collaboration between policymakers and private companies, particularly to agree on technical issues.

To be able to offer the previous capabilities, the cost of network infrastructure is going to increase, in particular, to exploit the complementarities between 5G macro layers, with broader coverage, and small cells, with higher capacity and better latency. McKinsey's estimations of the increased cost of infrastructure depend on the annual growth in data usage. They range from 60% peaks (for 25% annual growth in data usage) to 300% (for 50%). The relation between data usage growth and infrastructure cost is not linear because it depends on technological advances. Thus, a more substantial increase in the use of data would reach a peak in the cost of infrastructure earlier, which would later be reduced thanks to the technological improvement. In any case, policymakers must bear in mind that the increase in costs can significantly harm the implementation of this technology. Therefore, the maximum collaboration between countries and with operators and developers is necessary. Policymakers must prioritize the implementation of technology at competitive prices, over short-term collection approaches. Taking over commitments with the industry in this regard would offer more benefits for the country in the long term.

At the 5G World Convention that took place in Beijing in November 2019, it could be seen how several equipment manufacturers are already betting on this connectivity in their devices. The 5G connection is a real-

ity in equipment from Samsung, Huawei, Xiaomi, among others. At the same time, companies like Apple have not yet announced any models that include this capacity and do not have their own modems with this technology. The convention was not about potential applications, but about real ones. The MIIT offered the first non-experimental 5G licenses to China Telecom, China Mobile, China Unicom, and China Broadcasting Network. Zones, such as the downtown area of Beijing, already have 5G connectivity available (Lin, 2020).

The progress that Chinese companies show is not the result of chance. Faced with intense competition, in which the entry of Chinese latecomers has been fought with patent legal battles, Chinese companies bring the inertia of a more intense technological advance. Huawei began its 5G research in 2009 with a $ 600 million investment in R&D. By 2019, the company had disbursed four billion dollars in the development of this technology. This amount overpasses the investment of all producers in the USA and Europe in 5G together. Accordingly, up to June 2019, Huawei had already shipped more than 140,000 5G base stations. China Unicom and the Computer Network Information Center have created the 5G Technology Joint Lab to enhance collaboration in the development of standards and new technologies related to 5G. This is only a reference to the possibilities of collaboration between telecommunications companies and institutions. Over seven years (since 2018) China Mobile, China Unicom, and China Telecom, the three most important Chinese state-owned companies in the sector, have planned investments of 180 billion dollars (Rawat and Hao, 2018). Despite the leadership of Chinese companies, in today's competitive environment, it is impossible to think of a company going on itself. That is why it is common to find patent licenses among the main companies in the communications sector, such as Qualcomm, Nokia, Ericsson, Huawei, or Samsung (Huawei, 2019).

Although initially, but we can already observe some real applications of the capabilities of this type of communication. On March 16th, 2019, Ling Zhipei, chief of the Neurosurgery Department at the General Hospital of the People's Liberation Army, operated from Sanya (Hainan) in the extreme south of the country on a Parkinson's sick patient who was in Beijing (almost 3,000 kilometers away). He had implanted a brain pacemaker, using a network installed by China Mobile and Huawei. The delicacy of the operation reflects the achievements in reducing latency, of 30 microseconds in the mentioned operation (Lin, 2020).

Economic news media such as The Economist (2020) place Huawei at the forefront of the race in the development of 5G technology, followed by

Nokia-Ericsson and with American companies such as Qualcomm or Cisco without a great desire to provide a complete infrastructure in which they observe low-profit margins. The advantages that Huawei presents in the development of 5G technology comes from three aspects. First, it is the only provider that offers an integrated solution; that is, it covers all the necessary equipment. For example, the next alternative being developed combines Nokia and Erikson's products, which could lead to integration inefficiencies. Second, Huawei has been the first company to develop the technology, and since its research has not stopped, it can be expected to be in a more advanced position than that of its competitors. Third, Huawei has presented telecommunication equipment at low costs, in an apparent strategy of searching for volume and markets, compared to others with higher margins (Majerowicz, 2019). In the absence of the full development of other technology offerings, their prices are very likely to be more attractive to developing countries and, in general, to those with economic difficulties.

The difficulty of development in 5G base stations is that the scope of these results requires an unusual combination of new developments. Without being the object of this chapter geting into technical details, we can refer to: 5G Massive MIMO (Multiple Input, Multiple Output) 64T antennas that are not weighted; miniaturized filters that do not heat up; new cooling systems; development of new materials resistant to higher temperatures; specialized software. The ability of each party to solve the problem may depend critically on the other. For example, an optimal design of a cooling system appropriate to the size of the base station depends on the ability of the materials to operate at higher temperatures (Huawei, 2019).

The effective use of all this information depends on having a physical infrastructure for communication, which refers to 5G networks. It also depends on the development of skills to take advantage of this technology. Collaboration between the public and private sectors, at the national and international levels, through initiatives such as the DSR, can foster the development of these productive capacities. It should not be assumed that the optimization of the use of productive factors will occur spontaneously. This element, which could be included in the Total Factor Productivity, insofar as it is related to the efficiency in the use of the available productive factors, depends on the incorporation in the digital economy and the use of its capabilities. It is similar to how Western economies invested heavily in infrastructure and fostered an economy that relied heavily on the car. However, the automobile could not have offered its competitive advantages without roads, regulations, and transportation policies. It is intriguing to think about how an economy would look like if it had not taken the necessary measures

to develop an integrated economy regarding the advantages, opportunities, and dangers presented by the automobile industry. We should consider that the digital economy could reach similar disruptive levels. In that case, a country that does not develop adequate infrastructure, policies, and alliances to take advantage of technological opportunities will be condemned to the lack of material opportunities.

The improved connectivity is already affecting making a difference in the productive system. 5G technology allows a real-time connection between the company's machinery, which includes robots and software that participate in decision-making and even the customer and their product evaluation. The AI offers algorithms for taking advantage of that information for greater automation of decisions. This system has allowed progress towards the customization of the masses (Bianchi and Labory, 2018), a system that, through current technological solutions, seems to combine scale and scope economies. Communication networks allow the continuous collection of data on revealed preferences of consumers through their purchases, production decisions within the company, changes in prices and characteristics of inputs, product distribution, etc. As this is done massively, economies of scale are achieved without using a standardized product, but rather by standardizing flexibility to take advantage of the best margins of individualized attention.

IV. Industrial policy and alliances for technological change

The support that China offers to DBR is intrinsically related to the technological commitment of its industrial policy, particularly concerning communication technologies. In 2010, China published its "Strategic Emerging Industries Program", under which it has been given greater prominence to private initiative, which already had experience on the matter. This collaboration has been carried out under the leadership of the State, which has coordinated a complex set of policies such as education, regulation, standard-setting, financing, etc.

To analyze the complementarities between the DBR and Chinese industrial policy, it is interesting to observe the insertion of these issues in the respective five-year plan. In the 13th Five-Year Plan 2016-2020 (CCCPC, 2015), the DBR is mentioned as *Online Silk Road*, and related technologies play a major role in the document. In textual terms, it is stated that "innovation is the primary driving force for development", and concrete quan-

titative objectives are established, such as reaching 2.5% of GDP on R&D spending by 2020. Information networks are established as a strategic industry, together with quantum computing and the Internet of Things. There is a whole section dedicated to cyber economics, with various chapters. Chapter 25 affirms the need to build fiber-optic information networks throughout the country, in order to give access to households to connections of more than 100 Mbps in urban areas and more than 50 Mbps in rural areas. At the international level, the complementarity of this type of infrastructure is discussed through the *Online Silk Road* with the Arab countries and *China-Asean Information Harbor*. In addition to extending coverage and free access 4G technology spots, research targets are set for mobile networks and 5G network applications, quantum computing, and artificial intelligence. The development of this infrastructure is closely related to the industrial objectives of the subsequent chapters, where the development of New Internet Industries is analyzed, based on the Internet+plan (Chapter 26); implementation of the *National Big Data Strategy* (Chapter 27); and strengthening security in information networks (Chapter 28).

Although we should measure competitiveness in international markets, for which the BRI proposes a flexible opening agenda, there is prior learning at the national level with the intervention of the State. Following the industrial policy approach, the State has, for instance, promoted the construction of intelligent infrastructure in Chinese cities. This has accelerated the adoption of digital technology, and Chinese companies have acquired valuable experience, which makes them more competitive. It has also allowed solving some of the typical problems of cities, such as traffic, based on artificial intelligence and big data.

In November 2017, the Ministry of Science and Technology appointed Baidu, Alibaba, Tencent, and iFlytek to develop and run artificial intelligence platforms. In the following years, new companies were incorporated in the list. This recognition facilitates access to financing and participation in public projects, but also requires partially sharing their technology and qualified personnel with other companies that are potential competitors. For example, City Brain is Alibaba's artificial intelligence platform. Under this platform, a solution, using big data, has been offered to the city of Hangzhou, dramatically reducing traffic congestion and improving public services' response times, such as firefighters (Naughton, 2019).

China has also made advances in quantum computing. In 2016, it launched the first satellite that uses communication channels with quantum encryption and has built the longest quantum communication cable between Beijing and Shanghai (Segal, 2018). The Chinese government and

its producers have promoted the World Internet Conference, from which a global vision of the Chinese approach to the digital economy can be offered, to exercise international influence. The government itself collaborates with the private sector to exert influence on standards so that national companies can face competition from an advantageous situation.

There have been meaningful industry partnerships in the development of the BeiDou 3, a satellite navigation system made up of 30 satellites. On March 9th, 2020, China launched the 29th satellite of the project and it is intended to complete the system in May 2020 with the 30th unit. BRI countries have been offered to participate in the expansion of coverage offered by this satellite navigation system. The system has applications in the following areas: ground, river, marine, and air transportation, including autonomous navigation; geographic information for agriculture; establishment of unified time units for optimal electrical transmission; disaster prevention and communication; etc. The satellite system has been of assistance for the autonomous navigation of drones in the delivery of material during confinement and emergency constructions related to the Covid19 crisis (BeiDou, 2020). This system also targets public security objectives, such as police coordination. Accordingly, the Chinese motivation for an independent national defense has motivated to develop a satellite navigation system independent of the American GPS, the European Galileo, and the Russian GLONASS. Regarding this particular domain, there have been agreements with Thailand, Brunei, Laos, and Pakistan for the use of BeiDou by the respective governments and their military programs (Hong, 2018).

Analyzing the elements of the Chinese industrial approach is useful to understand the strength of the country's commitment to technological advances. Three areas of particularly powerful innovation concerning digital technologies can be identified in China (in brackets the most important companies of each area are presented): Shenzhen National Innovation Zone (Huawei, Tencent, DJI); Zhongguancun National Innovation Zone at Beijing (Xiaomi, Baidu, Didi, JD.com); and Hangzhou National Innovation Zone (Alibaba, Ant Financial). The dynamics between these places of innovation is related to their economic situation. If, in 2015, the average technological salary in Silicon Valley was seven times that of these Chinese areas, we can understand that there is not a transfer of technology via the attraction of a large number of workers. In the Chinese case, there has not been massive immigration of workers in search of higher wages, but of returnees who brought their experience and created their firms. The Shenzhen model has some peculiarities compared to other areas of technological innovation. A local adaptation of the products is sought. Thus, for example,

telephones with two SIM slots are built for migrant workers who want to avoid roaming between their work and their home. In the same way that the Special Economic Zones were areas of exploration, in Shenzhen it is usual to experience the reaction of the market with small quantities of product, and then scale up production in the event of a positive response. The intellectual property regime is flexible, which does not prevent innovation from seeking the benefits of market entry, but without an extreme restriction on copycats. Such an approach can be particularly interesting for developing countries. The flexibility of their companies and production systems allows them to adapt to rapid market changes. Its companies face a wide variety of market segments, from state-of-the-art products to lower price ranges, solutions that can be better tailored to the situation of developing markets (Fung *et al.*, 2018).

From the many differences with the American approach, we can point out one which is essential regarding the cultural diversity of the BRI. The Americans have been historically very successful in expanding the market for their products. One of its fundamental tools has been marketing. There may have been slight adaptations, but as with Coca-Cola, Hollywood movies, or Starbucks (iconic products of the model), digital products such as Windows, iPhone, or Facebook have been homogeneous. The recipient market would adopt them in imitation of American consumption patterns. Chinese companies, on the other hand, are offering a greater variety of products, showing greater adaptability to change. Faced to a cultural reality that was very different from the Western one, Chinese companies learned flexibility. It is observable that more cultural diversity is a fact along countries belonging to the BRI. Then, the Chinese approach with more variability and adaptability could work better than the extension of western consumption patterns.

Chinese companies are at the forefront of technology, as the consequence of years of large investments. For example, Huawei invests at least 10% of its income in R&D as part of its policy. Consequently, it has accumulated 73 billion dollars of investment from 2008 to 2018. At the end of 2018, it had 87,805 patents granted, of which 11,152 were in the USA. In other indicators, the company publishes annually between 100 and 200 academic papers and has made more than 60,000 contributions to International Standards Organizations (Huawei, 2019). The above data reflects the image of a company that bets on its technology, like other leading Chinese companies. The image of Chinese companies as copycats, although it may have been valid a few years ago, no longer reflects the essence of Chinese competitiveness.

The larger size of Chinese companies, as a result of being victorious in the vast local market, and their shareholding structure have allowed them to adopt different and longer-term strategies, similar to what has been done by the Chinese State itself. Long-term thinking is essential in the face of a developing market in which specific segments emerge and disappear. Companies such as eBay tried to obtain too much profitability rates from their market shares too soon in response to their shareholders' requirements. Against this model, Alibaba provided a free basic services scheme with premium paid services. Its punctual profitability was lower, but it could be done with a bigger market. Alibaba's business model did not go unnoticed by eBay and was rejected with condescendence. However, Alibaba was victorious and eBay currently does not represent a comparable competition (Lee, 2018, pp. 34-36). This episode reflects a lesson in the capabilities of Chinese companies to capture broader markets based on lower margins.

A clear example of the government's commitment to new complementary technologies with 5G advances is that of AI. Thus, between 2017 and 2020, more than 450 million dollar financing had been programmed to promote the Nanjing Economic and Technological Development Zone. This is related to grants to attract talent, funding for research projects, creation of an AI center, and associated government purchases: training, autonomous robots, simplification of administrative procedures and face recognition technology, among others (Lee, 2018, pp. 98-100). On the one hand, the previous industrial policy elements are the typical ones, so that it is clear that for China the classical industrial policy approach remains valid. On the other hand, note that this Economic and Technological Zone was created in 1992, so there is also a willingness to keep it updated. This technology area is still specialized in optical display, equipment, and biopharmacy. The preceding reflects a continuous approach to renewal and technological commitment, based on which the industrial policy approach does not refer to a particular moment in the economic development of a country.

V. China expands its technological leadership through the DSR

China's digital economy is growing at enormous rates. In 2016 it represented almost a third of the economy (30.3%), and it is showing superior growth: that same year, for example, while the rest of the economy grew at 6.7%, the digital economy did so at 18.9% (Min, 2018).

One of the aspects of the digital economy is fintech, which is growing steadily in China. Internet payments have grown a lot in the country with systems like Alipay (from Ant Financial), WeChat Wallet, and Huawei Pay, among others. In 2016, when the USA had 74 billion US $ in mobile payments, China already reached 790 billion. In other words, an economy with a similar total GDP (lower if we did not take into account the purchasing power parity adjustment) and with four times more population (a more penetrating technological insertion could be expected in communities with higher GDP per capita) multiplied by ten the nominal amount of mobile payments of the former (Fung *et al.*, 2018). Alipay, for example, has more than 300 million users, with more than 45 million daily operations to 2018. The experience that these companies bring when they go to the international market is that of a market that has matured rapidly and is very competitive. In addition to online payments, services such as P2P loans, online microfinance, crowdfunding, or mutual funds and insurance have been strengthened. The Chinese government's approach, despite its speed in openness, maintains elements of stability. For example, the growth of Fintech must motivate the growth of the real economy. This approach can help avoid future financial bubbles (Min, 2018).

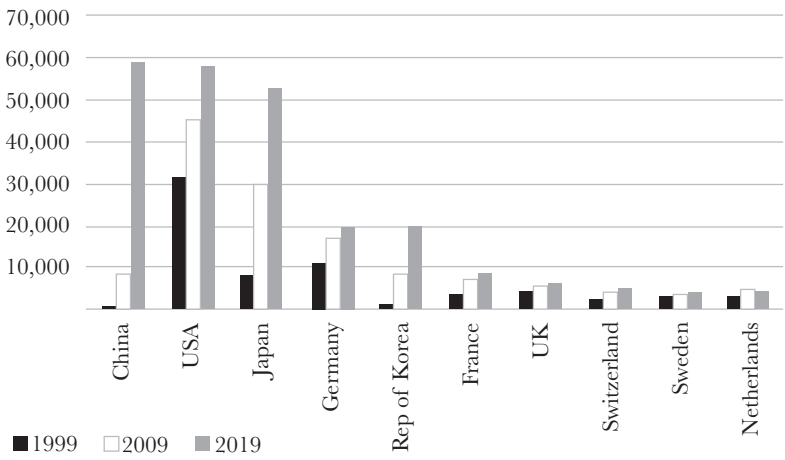
The lack of development in some technologies (or their lack of expansion) can facilitate the adoption of new ones by reducing the cost of transformation, which also has network effects. Thus, the lack of insertion of credit cards in China may have facilitated the adoption of new payment technologies through cell phones (to which a vast majority of the population had access). The great extension in the use of the WeChat super application and its WeChat Wallet payment system has enabled, for example, bidirectionality in the O2O (online-to-offline) scheme. This scheme reflected the ability to request online the distribution of services offline. The best-known cases, due to their rapid extension, might be the services of shopping, home delivery, or transportation. Payments through cell phones using QR codes, which have notoriously extended in China, offers a novelty of attraction towards the digital economy of interactions that occur in other areas and whose payment is made online.

With the same ease as technology allows a money transfer between two people, the digital money technology offers payment for goods and services at affordable rates. Thus, for example, in WeChat, this service is free for users with very few sales. For more qualified users, the charges remain low, from 0.1% of the value of the transaction with marginal additions based on accumulated amounts. These costs are exiguous compared to that of credit cards, which explains the null interest of financial institutions in Western

countries to move towards a similar model. These solutions, however, would be beneficial for Latin American countries in general and Mexico in particular. Due to its low barriers to entry, it would be effortless for the informal economy to move to mobile payment schemes. It would have positive effects on security and, above all, on the increase in the tax base, offering an outline of a higher collection with equal or lower margins. In addition, the elimination or reduction of cash would reduce the scope for criminal activities. Regarding this technology, it will be very interesting for Latin America what happens in the countries linked to the BRI in the coming years. Some of these countries may present similar elements concerning low bank penetration and a large informal economy. The contributions of technology in terms of financial inclusion, formality, and tax collection must be observed by countries such as Mexico.

The DSR strategy will boost China's position as a superpower of electronic commerce by strengthening its digital economy and through international collaboration. China is at the forefront in this matter, ranking second in the Global Ecommerce Market Ranking 2019, only behind the United States and ranking first in several aspects: the greatest number of online consumers (1 billion), the greatest number of cross-border consumers (149.4 million), and the largest market by revenue (639.1 million in 2018). Besides, the countries of Southeast Asia, one of the geographic areas aimed by the BRI, are among those for which the greatest market growth is expected in relative terms. (EShopWorld, 2018).

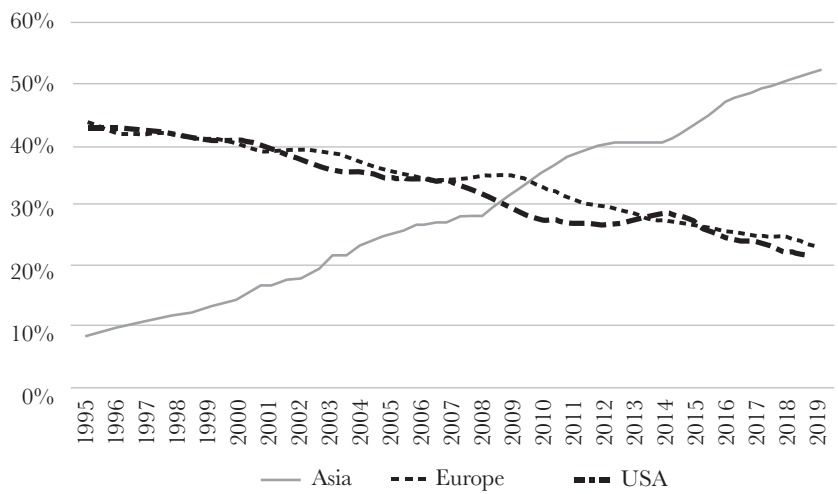
GRAPH 1. INTERNATIONAL PATENT (PTC) APPLICATIONS BY ORIGIN



SOURCE: Own elaboration with data from World Intellectual Property Organization.

As we have seen, the DSR constitutes a new region for collaboration in intellectual property protection. That is of significant relevance, due to the changes that are taking place regarding global technological leadership. In Figure 3, we can see the change that has occurred in the last two decades in international patent applications of the ten countries with the highest number of applications in 2019. It reflects the change in technological leadership that is taking place and will affect the geopolitical equilibrium. All countries, except the Netherlands during the last decade, have increased the number of international patent applications, reflecting the greater internationalization of companies, intensification of innovation, and the intellectual protection system. However, from all the promotions, China is the highest one. While this country only had 276 patent applications in 1999, a figure that would not enter this select group of ten leading countries, in 2009 it already had 7,900 applications, which placed it behind Korea. By 2019, it was leading the ranking with 59,005 patents requested internationally. In third place, and comparable to China and the USA, it is located Japan, with 52,665 applications. Germany and Korea are in a second group, with slightly less than 20,000 international applications. The rest of the countries are below 8,000 applications.

GRAPH 2. INTERNATIONAL PATENT (PTC) APPLICATIONS BY ORIGIN (%)



SOURCE: Own elaboration with data from World Intellectual Property Organization.

As it can be seen from the rise of China in Figure 4, but from a more geopolitical perspective that makes sense for the analysis of the DSR, the tendencies are not the reflection of the rise of a country, but a change in the regional geopolitics of technology. On the one hand, it is the consequence of China's growth in a region on which it has a great influence, due to its civilizing character. But also, the increases of the three East Asian powers have been relatively more substantial than that of their Western counterparts, showing the higher innovative power of the Asian development model. Japan has increased the number of international patent applications by 5.86% annually equivalent during the last decade; 14.84% considering its growth over the last two decades. In the case of Korea, the annual equivalent growths have been 9.03% for the last decade and 24.90%, considering the previous decade. To take as a reference, the USA and Germany increased their international patent applications by 2.37% and 1.42%, respectively, during the last decade and 3.86% and 4.79% during the last 20 years. Of course, China offers a spectacular growth of 22.27% and 39.85% averages, respectively, for each of the two periods. This leaves us with the innovation core change presented in Figure 4. In 1999, Europe and the USA were sharing, practically, the total of the international applications, with almost 45% each and Asia barely reached 8%. Currently, the picture is different. Asia already accounts for half of the international applications, while Europe and the USA share the remaining. No less surprising is the fact that the exhaustion of this dynamic is not yet observed, due to the differential growth of recent years, so we still cannot know how far Asian technological dominance will reach.

VI. Acceleration of the digital economy due to Covid19 and necessity of 5G connectivity

To protect themselves from the Covid19 pandemic, many countries recommended confinement during 2020, depending on the evolution of the epidemic in the respective country. This generated an unprecedented growth in the digital economy. Thus, for example, in February 2020, the average daily online time in China increased by 36.4% compared to 2019, and the number of people who teleworked multiplied by more than ten times. Data traffic in Italy increased by 70% in that same month. The reduction of human contact has led to the use of 5G robots and drones, temperature image processing in airports, analysis of the movement of people and contacts to delimit sources of contagion. Also, the use of video communication platforms with multiple

participants or online games require more data usage. In China, policies for the use of technologies in combating the epidemic were promoted, such as the *Fully Leveraging Artificial Intelligence to Fight Covid19* of the MIIT or the *Notice on Organizing Efforts to Implement New Infrastructure Projects (Broadband Network and 5G) in 2020*. In countries such as Germany, the United Kingdom, Switzerland, or France, measures were taken to manage traffic, revealing the inability of current networks to absorb the increase. As a timely intervention, it is worth highlighting the effort of China Telecom and Huawei to improve communication in various hospitals and a 5G network at Wuhan Union Hospital. This allowed the use of robots, sharing images and diagnoses with other hospitals to accelerate joint learning, as well as offering consultations by videoconferences to those who were at home. Notice that a large bandwidth is necessary to transmit High Resolution Computed Tomography scans that have a size of 200 Mb to 1 Gb. Last but not least, videoconference communication allows offering accompaniment to patients who had to remain isolated (Huawei, 2020).

Tracking applications, which are based on a high number of connections and usage of big data, have been created in several countries. They have been helpful to reduce sources of infection such as Self-Quarantine Safety Protection (South Korea), Trace Together (Singapore), or Health Check (China). The acceptance of these applications is an example of how a more open vision when sharing data can be acceptable to citizens, depending on the efficiency of the intervention with said data.

The greater closeness and the intensification of commercial relations and other types of exchanges will bring more challenges. For example, it would not be strange that the expansion of the Covid19 is superior in cities, which are most intensely connected with the rest of the world. Likewise, the arrival of the black plague to Europe was linked to the greater commercial integration facilitated by the Mongol empire. Similarly, the greater connectivity of computer equipment makes them more vulnerable to security attacks. More connectivity implies greater vulnerability, which requires better governance. International governance that exceeds and respects different forms of national and cultural government is needed. It is evident that there are differences in the understanding of the world, and it mutates between East and West. An initiative like the BRI, open to collaboration under the mutual respect of different forms of government, is a necessary mean of communication in the face of common challenges. In the same way that a pandemic is a global challenge, the governance of the digital economy is necessary to deal with technologies with the ability to cross physical borders.

The pandemic has given us a test, an experiment that implies an acceleration of the digital economy. Surely, when the confinement ends, many activities will be recovered in person. However, some activities will be found to be more convenient or convenient to do through apps, such as shopping. To that extent, digital change may accelerate permanently. Therefore, what happens during confinement regarding the digital economy must inform a discussion of what we want the digital economy of the future to be. Those countries that have found themselves in need of better connectivity should face its improvement in the near future to overcome the challenges of the new digital economy.

VII. On the spread of 5G and geopolitical tensions

Understanding the technological leadership of Chinese companies in 5G networks, notably Huawei, is essential to assess the repercussions of the US ban. The US has blocked China Mobile from offering communication services and Huawei and ZTE from selling equipment in its territory, as well as it has put pressure on other countries to imitate them. The ban has generated notable costs, which have driven its delay. Beyond determining if the American companies will finally be able to materialize the intended substitution, the truth is that it can only be done at a high cost. In this line, on March 13th, 2020, US President Donald Trump enacted the law offering a billion dollars in aid to replace equipment from ZTE and Huawei. Note that the approval of these grants has not avoided postponing the dates for the end of the collaborations. It seems evident that the Chinese advantage is too much to be overcome by a legislative change.

According to an estimate by the GSMA, which incorporates 750 mobile operators, a ban on Chinese providers would make it more expensive to create a 5G network in Europe by $ 62 billion and delay technology by 18 months (GSMA, 2019). Such delay would have an aggregate effect on the European economy that would increase the productivity gap between this region and the United States.

Faced with the conflict between the USA and China and the tensions between the USA and Europe, and taking into account that the European productive fabric is not alien to the needs of technological development posed by Industry 4.0, the European strategic alliances may be rethought toward flexible schemes. The call for the US ban on the use of Huawei technology does not appear to have received the intended European response. The European approach to the digital economy can be analyzed from the

Digital Single Market and *Digital 4 Development* strategies. These underline efforts to improve accessibility and establish a level competition environment for all participants (Okano-Heijmans, 2019). Under this scheme, it would be strange if the prohibition of important participants was adopted. From the European side, there is some concern with regarding compliance of the *General Data Protection Regulations*, from a more protectionist perspective of personal data compared to that adopted by Asian countries. This barrier is not insurmountable and does not bring Europe closer to the USA since the latter's data marketing approaches have also been rejected.

It seems clear that neither the European Union nor the United Kingdom will yield to US pressures denying entry to its market to any specific participant, in the absence of conclusive evidence. While there may be security concerns, these will be addressed with all participants. The 5G security criteria have been detailed in the Network and Information Security (NIS) Cooperation Group report *EU coordinated risk assessment of the cybersecurity of 5G networks.* It states the will of international cooperation for the establishment of standards through the 3rd Generation Partnership Project in which they participate, in addition to Europe: USA, China, Japan, Korea, and India. In particular, the European vision of becoming a dynamic technological power, also vis-à-vis the USA, makes it look for the best infrastructure, looking for partners in the USA, in China or other countries, at its convenience.

One of the concerns that have arisen from the Western media (Halpern, 2019) is that the close collaboration between private companies and the Chinese State may jeopardize clients' data. In particular, this concern has to do with their data being used for surveillance contrary to their legitimate interests. It is complex to establish a clear border regarding this type of surveillance. On the one hand, Western citizens value greater protection of their privacy. On the other hand, several examples can be mentioned in which Western countries themselves have carried out surveillance to reduce exposure to common problems such as terrorism or those in which Eastern countries have done better, such as monitoring the movements of people to combat the contagion of the Covid19. The greater collaboration in Asian countries between the State and private companies to share this type of information may generate suspicions in the West, but that should not prevent the agreements from being of a different nature in each region. In any case, it must be remembered that the market is not immune to the dangers of sharing this type of information, as it happened with Cambridge Analytica. In general, we should agree that the commercialization of this data and collaboration agreements with public authorities are issues that must

be treated with transparency and understanding that different societies will reach unalike agreements.

The security concerns should be constant and addressed to all distributors in all countries because perverse incentives for the inappropriate use of data could be found anywhere. It would seem that it is the first time that Chinese manufacturers participate in the installation of equipment on the cellular telephone network. However, the participation of, for example, Huawei in this matter comes from several years ago. Its 3G distributed base stations reduced the costs of this type of installation, and the SingleRan allowed 2G, 3G, and 4G to share infrastructure. These solutions constitute the technological advantages under which Huawei has become a strong player in the market of communications.

VIII. Conclusion

First, the present chapter does not offer a strict definition of the DSR. Like the BRI itself, into which it is inserted, the DSR is flexible. This flexibility is necessary insofar as the participating subjects are very diverse. On the one hand, the BRI participating countries come from different traditions, based on which they have built very different societies. As it has been observed during the development of the BRI, from the experiences of international collaborations that incorporate a considerable number of countries, particularly when these countries have different philosophical roots, a rigid structure can discourage the participation of some agents. A flexible perspective, which China has understood through facing and solving the difficulties of adapting to the internationalization schemes that the West has dictated, can more successfully incorporate countries that belong to a region which, very gradually, bring the West and the East closer.

One of the dimensions that are structured through the DSR is the collaboration between the State and the private initiative, made up of the company and civil organizations aimed at research. China has reinterpreted a collaboration model under the leadership of the State that, based on its past success, promotes a continuous productive transformation along with current and potential technological progress, making it real. The alignment of divergent interests is complex and does not always offer the same results under similar schemes. Industrial policy, a classic benchmark for this type of cooperation, must always be subject to evaluation and change. For this reason, an approach to transforming the digital economy must be flexible, depending on its results.

Furthermore, the digital economy is constantly changing due to the acceleration of technology itself and how it may be affecting the economy as a whole. The transformation towards the digital economy may be one of the fastest productive changes that many societies have ever faced. For this reason, the possibilities, benefits, and dangers of technological advances are still not fully understood. Similarly, Chinese companies themselves are leading flexible production models to cater to rapidly changing mass consumption.

The initiative needs to be flexible since many social realities are trying to adapt to a changing technological circumstance that will transform our societies. The DSR, integrated into the BRI, complements the productive leap with a geopolitical change that surpasses that of a particular shift in leadership, such as when, for example, the USA replaced the United Kingdom after WWI. The shift from West to East will require new visions to be combined with the technological revolution. This technological revolution is a matter of the present. The Covid19 epidemic has, by forcing us into confinement, given a boost to the advancement of the digital economy and a vision of what the near future will look like.

Digital connectivity is an essential infrastructure for this productive and social transformation. Therefore, the installation of 5G networks that, as we have seen, enables many of the necessary technical elements of this productive transformation is a crucial element. China leads this model of technological change with public features, such as industrial policy, as well as private, with the leadership of the companies that have been winners in this enormous market. For anyone who wants to keep pace with this productive transformation, collaboration with these actors is inevitable, and learning from their experience would be desirable.

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