Scientific Collaboration along the Silk Road

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ABSTRACT

The Belt and Road Initiative (BRI) is an immense development program announced by the Chinese government in late 2013, which knitted around trade routes. Since scientific and technological cooperation is an integral part of BRI, the Alliance of International Science Organizations (ANSO) was established in 2018 as a non-governmental organization. In this work, conditions for effective cooperation in science and technology among countries are discussed first. Then, the research ecosystem's current situation is analyzed in terms of the number of scientific articles and trends while some results from the literature on international collaboration patterns are reviewed. Considering the current situation, scientific cooperation mechanisms are reviewed, and it is argued that ANSO can serve as a networking tool or seed for a future organization and that an inter-governmental body is necessary for the long run. After a short comparison with the Framework Programmes of the European Union, basic principles on which such a body should be established are discussed. A "fair return" principle, availability of flexible contribution options and, simplified bureaucratic procedures are proposed. Mechanisms to avoid the creation of a dominant core that can cause a brain drain in the long term are also recommended following the balanced and inclusive spirit of BRI. Then, a set of criteria is proposed for the choice of cooperation areas, and the research areas suggested in the literature are discussed under the light of these criteria.

Keywords: Belt and Road Initiative, innovation, inter-governmental organizations, science policy, scientific collaboration

Introduction

Belt and Road Initiative at a Glance

The Belt and Road Initiative, or BRI for short, is an immense development program announced by the Chinese government in late 2013. The program is knitted around trade routes, including the historic Silk Road, that are generally aligned in an East-West direction, and includes investment in the construction of railways, highways, and ports. As stated by Chin and He (2016), the original 65 countries envisioned by China's International Trade Institute have more than 62% of the world's population, 30% of the world's GDP, and 38.5% of the land area. Considering that 140 countries signed a Memorandum of Understanding (MoU) with China within the framework of BRI, the project's impact is even more far-reaching. It is announced not only as an infrastructure investment and trade network project but also an open, inclusive, and balanced joint development model that would boost economic growth in the whole region.

The Science Component of BRI

The historic Silk Road, trade routes between the East and the West of Eurasia, was active from the 2nd Century BCE. Not only trade goods but also ideas, religions, art, and techniques were exchanged. Many Chinese inventions like the compass and irrigation techniques reached Europe via the Silk Road and catalyzed the development of Western Civilization, while China imported techniques from the World as well, mostly through the same route. BRI is a huge collaborative effort covering a much larger area. Naturally, science and technology are also an essential dimension of this program. With its broader definition today, the Silk Road may again be a circulatory system for the spread of science and technology.

International scientific collaboration increases the overall efficiency of the innovation system either through better use of resources through optimal allocation or increasing the impact of the conducted research. It also helps with cultural and economic integration. To discuss how scientific and technical cooperation can be facilitated among the BRI countries, the "First International Science Forum of National Scientific Organizations on the Belt and Road Initiative" was organized in 2016. The "Alliance of International Science Organizations," ANSO, founded by 37 institutions including the Chinese Academy of Sciences (CAS), was inaugurated in 2018 as a non-governmental organization for international cooperation in science and technology.

The current mechanism of ANSO for collaboration are a) master of science and PhD. scholarships in China sponsored by CAS, b) awards, c) short training courses hosted by Chinese institutions, d) collaborative research activities, and e) associations for joint activities on chosen subjects related to the environment, development and human well-being (ANSO, 2021a).

There are also several other international organizations that promote scientific and technical cooperation, such as the academic networks of the University Alliance of the Silk Road and the University Alliance of Belt and Road.

Contribution of This Work

Although everyone agrees on the necessity of scientific and technical cooperation as part of BRI, the mechanisms to promote the cooperation have only recently started to emerge. In this paper, after the conditions of effective international cooperation in science, technology, and innovation are briefly discussed, the big picture is drawn on three axes: First, the current level of the innovation ecosystem and its trends are analyzed through an elementary bibliometric analysis. Secondly, the results from the study of Gui, Liu and Du (2019) are summarized to depict existing collaboration patterns and their trends. Thirdly, the language problem is briefly visited.

Considering the current situation, possible cooperation mechanisms are discussed. The role of ANSO is crucial in initiating multilateral research and providing a platform to discuss the future of the "BRI Research Area," but it is argued that an inter-governmental umbrella organization is necessary for the long run. Comparisons with various institutions are also provided, and the basic principles of such an organization are discussed. Hopefully, this paper can initiate more discussions about the future of the joint innovation system and contribute to the creation of a long-term vision for the scientific collaboration dimension of BRI.

Current Situation of BRI Countries

Conditions for Effective International Scientific Cooperation

It is important to understand which factors inhibit effective scientific and technical cooperation among countries and which ones facilitate them to be able to propose realistic cooperation schemes. Gui, Liu and Du (2019) summarized the factors that determine the possibility of collaboration in science with a vector of proximities, namely, geographical, cognitive, social, organizational, and institutional proximities, as well as with the existence of a common language, earlier relationships even in the form of colonialism, size of the economies, the capacity for innovation, networks of the partners, and administrative issues.

A common language is an accelerating factor in international technological collaboration. The common language can be the native language or a second language taught in the education system.

Ge, Dollar and Yu (2020) stated that "improved regulatory quality, political stability, government effectiveness, and rule of law" are indicators for institutional quality, which facilitates the companies' participation into global value chains in the BRI countries. These factors probably encourage scientific and technical cooperation as well.

First of all, the existing research ecosystem in a country determines its ability to take part in international activities to a large extent. Powerful scientific institutions well-integrated with industry that creates products and services via research and development activities ensure the creation of added value through cooperation.

Another important factor is the geographical proximity of candidate partners. However, its importance is getting weaker with recent developments in Information and Communications Technology (ICT), which accelerated considerably with the COVID-19 pandemic. On the other hand, the ICT connectivity in Central Asia is insufficient (Kunavut, Okuda and Lee 2018). Hence it can be a limiting factor for this area located in the geographical center of BRI.

As pointed out by Montobbio and Sterzi (2013), a common language is an accelerating factor in international technological collaboration. The common language can be the native language or a second language taught in the education system.

Political stability is also a very important factor for international cooperation. Conflicts reduce capacity in multiple ways, and recovery may take a very long time after the end of the conflict. Diversity in culture, economic and scientific development levels, languages, etc. may also be roadblocks, but it is possible to overcome such difficulties and, in certain cases, they can even be used as an advantage.

Current Situation

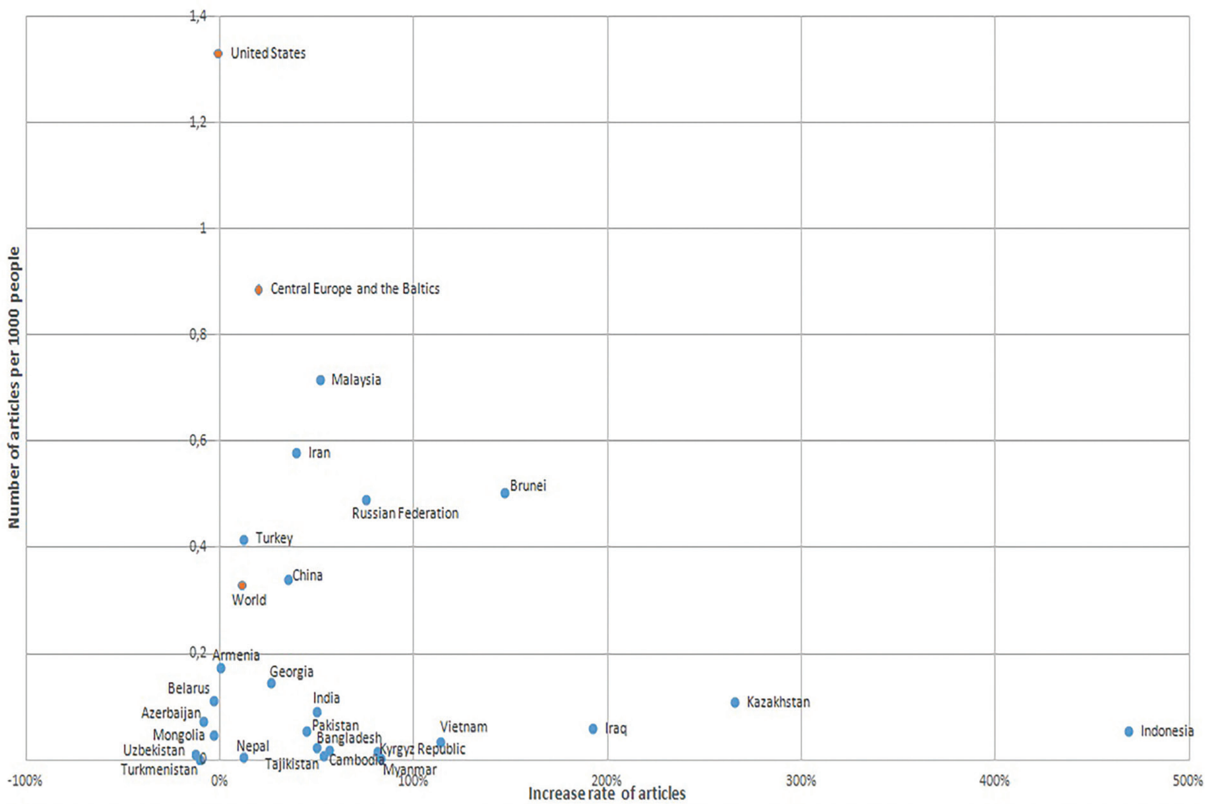
In this sub-section, only the current research capacities of chosen countries, existing collaboration patterns, and the situation with languages will be briefly visited. Firstly, the level of current research capacity is measured for some BRI countries. The number of articles from the "Scientific and technical journal articles" database of the World Bank (World Bank, 2021) is used as an indicator of the research capacity for convenience, although a composite metric derived from a larger set of indicators is necessary for a detailed analysis. Even though 140 countries signed MoU with China, and hence joined the BRI Initiative in some sense, we limit this analysis with chosen countries in Asia and over major roads on the east-west axis, that is, Armenia, Azerbaijan, Bangladesh, Belarus, Brunei, Cambodia, China, Georgia, India, Indonesia, Iran, Iraq, Kazakhstan, Kyrgyzstan, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Russia, Tajikistan, Thailand, Turkey, Turkmenistan, Uzbekistan, and Vietnam. Central Europe and the Baltics, the United States, and the World categories from the database are also included for comparison purposes.

For the chosen countries, two parameters are calculated. The first one is the number of articles per 1,000 people for 2018 that shows the current research capacity. The second parameter is the percentage increase in the number of articles, from the 2009-2013 average to the 2014-2018 average, which shows the trend. A scatter plot of the parameters is shown in Figure 1. Figure 2 shows the same data, but the axes are changed so that the cluster near the origin can be seen clearly.

The first observation in Figure 1 is that the average number of articles per 1,000 people is much lower when compared to the US or Central Europe and the Baltics. However, the rate of increase tells a different story because some countries are rising quite fast while the US and Europe look like they have reached a plateau.

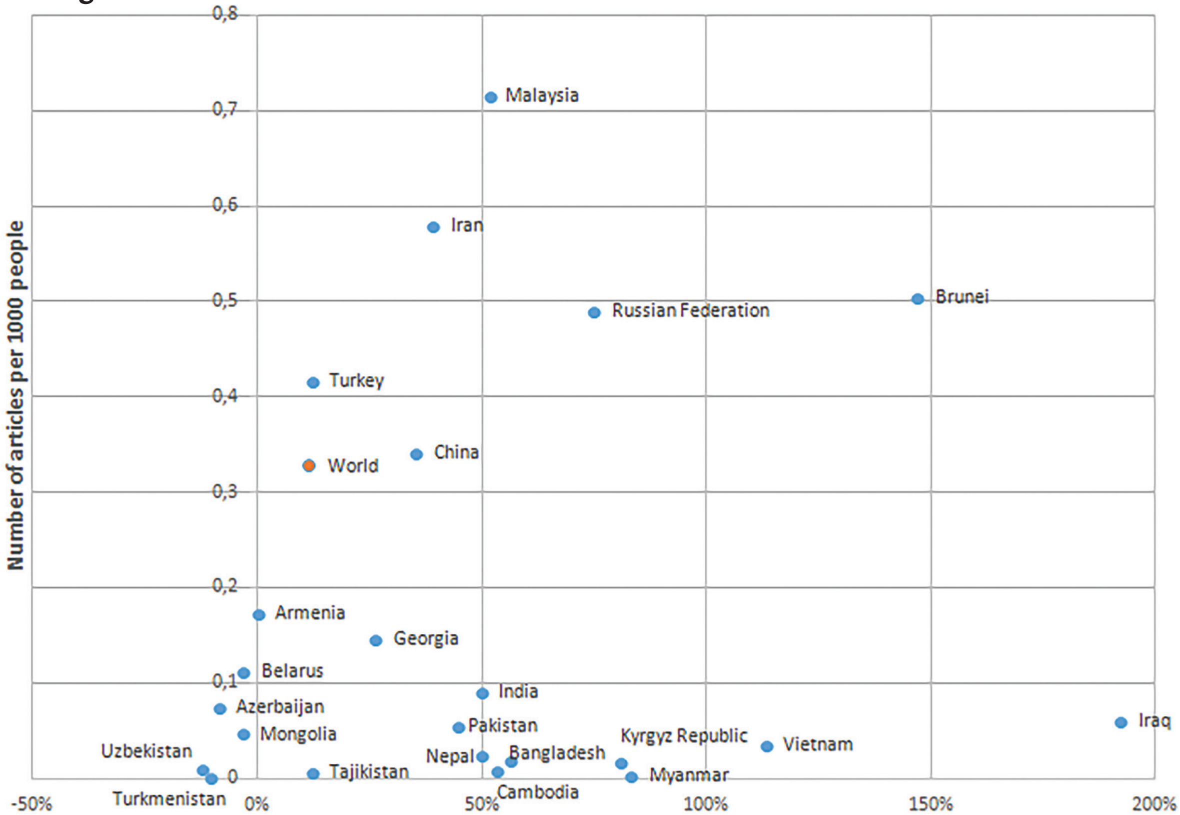
In Figure 2, a cluster around the origin is observed. This group with a low number of articles and small and sometimes negative trends will probably require special cooperation mechanisms. There is also another group with an increasing number of articles, although current levels are low. This group naturally has good potential for increasing their international collaboration.

Figure 1. **Publication Performance of Chosen Countries**



Note: Scatter plot of chosen countries or country groups as a function of the number of articles per 1,000 people and the rate of increase of the number of articles.

Figure 2. Publication Performance of Chosen Countries



Note: It shows the central part of Figure 1.

Finally, a cluster around the World average or slightly higher can be identified that are composed of relatively large countries, i.e., China, Iran, Malaysia, Russia, and Turkey. This group can serve as engines of scientific cooperation by playing the role of local hubs.

In the elaborate study of Gui, Liu and Du (2019), a detailed bibliographic analysis is performed for the 65 BRI countries using internationally co-authored articles. Firstly, they show that the cooperation among these countries has increased significantly from 2000 to 2018, and the network is significantly decentralized. Secondly, the topology structure shows that Russia, Poland, and China are core countries with star-shaped links, that is, connections with a large number of countries. However, China is taking over the main center status from Russia. Collaborations of Turkey, Iran, and Poland are also increasing. When the spatial distance is examined, they discover collaborations between countries with large separation are sparse, and most collaborations are between neighboring countries, but long-distance collaborations are increasing. The core-periphery analysis of Gui, Liu and Du (2019) reveals that there is a de-centralization trend and the core countries are China, Czechia, Hungary, Poland, Russia, and Turkey in 2018. Analysis of the networks also shows that China replaces Russia as the center of the largest sub-network while two other sub-networks emerge. One is an Eastern Europe network around Poland, and the other is an Arab network around the Saudi Arabia-Egypt axis.

A common language is an accelerating factor in international technological collaboration. (CGTN, 2018)

The language diversity among the BRI countries can be an important roadblock. One large cluster in the area is the former Soviet countries group in which Russian was the lingua franca, and higher education was mostly in Russian. Although Russian is still spoken by most of the educated people, the number of Russian speakers is decreasing in non-Russian countries (Pavlenko 2008). China is promoting Mandarin Chinese via scholarships in China and other mechanisms. For example, Masood (2019) explains how Mandarin becomes an optional language choice in Pakistan. However, Chinese is very far from being the lingua franca of BRI. The obvious choice is English for cooperation programs for the foreseeable future. Although the existence of former British colonies in the region like India and Pakistan is facilitating this option, the proportion of English speakers as a second language is very low in most of the area, including Central Asian countries.

Possible Mechanisms for Effective Scientific Cooperation

We can classify the cooperation mechanisms as bilateral or multilateral according to the number of parties involved. It is also possible to classify mechanisms as symmetric or asymmetric based on the nature of the cooperation. In some cases, there is a dominant party of cooperation, and in other cases, the relation is more balanced. How the cooperation is funded can also characterize the cooperation. Most bilateral scientific collaboration agreements are project-based, and each party covers its own expenses. In multilateral cooperation, the parties can form a pool from which the joint projects are funded based on merit, or a "fair return" principle can be adopted. This kind of cooperation, which requires strong commitments from the governments, is established through inter-governmental agreements.

For the case of the fair return, the European Space Agency can be a good example. Each member country contributes to the pool with a certain percentage of its gross domestic production (GDP), and there are complicated mechanisms to ensure that each country receives benefits proportional to its contribution in the long run.

For the other kind of cooperation, The Framework Programmes for Research and Technological Development of the European Union can be considered as a good example. It can also be a good template for future cooperation among BRI countries because it is one of the largest regional cooperation programs, if not the largest, with its budget of 188 billion Euros from 1984 to end of 2020, excluding the upcoming Horizon Europe programme (Reillon 2015). There is no explicit rule to ensure that the returns from the program match the contribution of a country, and the funds are distributed based on competition.

When we consider current cooperation mechanisms among BRI countries, the most significant ones are implemented by ANSO, whose members are very heterogeneous, including universities, science academies, research funds, and centers. According to the 2019 Annual Report of ANSO, the 2019 budget was around 0.5 million USD. This structure is very convenient for networking and as a platform to discuss how to create more structured inter-governmental bodies that can fund larger-scale projects and other collaborative actions. Over time, the core started by ANSO should evolve to a program similar to European Framework Programmes. However, the circumstances of BRI countries should be considered to be able to have an efficient and working mechanism.

First of all, a "fair return" policy is necessary to avoid friction due to the possible unfair distribution of the funds.

The European countries have a long list of factors that make scientific collaboration among them easier. Existing economic and political integration process under the umbrella of European Union, sharing the same geographical area and cultural background, high economic development level, being well-connected both digitally and physically, speaking mostly languages from the same language family are only some of them.

In the BRI area, some economic, political, or security alliances are forming (like the Association of Southeast Asian Nations or Shanghai Cooperation Organisation), but they cover only part of the area. Geographically as well as culturally, some BRI countries are very far from others. Most of the BRI countries are developing economies. Physical connections through the motorway, railroad, and maritime road networks are being established along with the Digital Belt and Road, but the construction is in its early phase. A large variety of languages are spoken with radically different writing systems.

Despite these difficulties, it is possible to establish a mechanism similar to EU Framework Programmes if some principles are adopted. First of all, a "fair return" policy is necessary to avoid friction due to the possible unfair distribution of the funds. Secondly, instead of forcing contributors to allocate a certain percentage of their GDP, they should be allowed to start with small contributions. The main idea is to create win-win situations that will encourage governments to contribute more funds to be able to get more from the created value. In the beginning, this should be even easier because the projects will focus on "low-hanging fruits" first if a competitive environment among projects can be established. The "BRI Research Area" will probably start with a fraction of the countries involved in BRI; hence the rules for new members should be clear from the very beginning. There might be an overlap between "European Research Area" and "BRI Research Area", which will be an opportunity for a group of countries who will be able to benefit from both Worlds.

Of course, the selection of projects with competition and the "fair return" principle might be conflicting and may require complicated operation rules. Additional rules are necessary to encourage cooperation from distant countries, to avoid local clustering, and help better integration. Also, the number of participants to joint projects should be forced to be large because, as indicated by Guerrero Bote, Olmeda-Gómez and de Moya-Anegón (2013), the gain in impact increases with the number of countries involved. The emergence of a dominant core should also be avoided because, first of all, the main idea is to have an inclusive and balanced model. A dominant core may even lead to brain drain in the long run. Masood (2019) gives an example of how China tries to prevent brain drain into China. However, preventing brain drain should be a primary concern for the whole design of the mechanisms because losing very scarce human resources would be detrimental to the development goals of many small nations.

In multilateral cooperation, the parties can form a pool from which the joint projects are funded based on merit, or a "fair return" principle can be adopted. (Chinadaily, 2021)

On the other hand, as another conflicting requirement, the funding mechanisms should be kept simple. In the Eight Framework Programme, the European Commission simplified the administrative procedures based on the preceding Framework Programmes' experience. Wang, Chen and Guo (2018) also point out the difficulty of project management in such multinational cooperation schemes and emphasizes the necessity of supervision mechanisms so that the system operates efficiently while ensuring optimum use of resources and increasing overall cooperation gain.

The choice of the research areas is paramount for the success of collaboration mechanisms. The principles and decision procedures for the research areas should be fixed at the beginning but the major areas and sub-fields should be updated every several years, similar to the Framework Programmes. Due to the self-organizing nature of collaboration (Wagner and Leydesdorff 2005), scientists and other shareholders will maximize the impact of the research within each sub-field. Details of research areas are discussed in the following sub-section.

The involvement of the private sector and specifically small business in the research and development projects deserves special attention since the private sector is an important driver of economic growth and job creation. The instruments designed within the Framework Programmes can again be a good template, but they will need to be tailored for the much more complicated BRI landscape.

The Asia-Pacific Space Cooperation Organization (APSCO), established in 2005 as an inter-governmental organization (Yan 2021), may serve as an example, and conclusions can be drawn from the experience. It was not established in the context of BRI, but it is still relevant as an example, and the definition of the geographic extend overlaps considerably with the BRI countries. The working principle of APSCO is similar to that of ESA. The contribution of a country is calculated according to its economic development level and GDP per capita using a formula, and a fair return principle is adopted. Nevertheless, Yan (2021) states the problems in the implementation of that principle and underlines that organizational development is still necessary. Nie (2019) also emphasizes the difficulty of implementation of the fair return principle and discusses the legal difficulties of integrating APSCO into the BRI paradigm. We can infer from the discussions by Nie (2019) and Yan (2021) that the organization should have the flexibility to adapt to the changing circumstances.

Cooperation Areas

Before determining possible cooperation areas within the BRI framework, we need to decide on the criteria for evaluation of the candidate areas:

- Problems related to phenomena covering large geographical areas require international cooperation; hence research addressing such problems should be preferred.
- Research that has a large potential to turn into commercial activities or sustainable services should be preferred to support development.
- Areas in which the contributing countries have human resources or other resources should be preferred.
- Research that will help mitigating problems created or aggravated by the implementation of BRI should have priority.

ANSO describes the special focus areas of collaborative research as follows: "Scientific Research Orientations: Climate Change and Adaptation, Natural Disaster, Water Resource and Water Security, Air Pollution and Human Health, Ecosystem and Biodiversity, Combating Desertification, Energy Security, S&T Policy and Strategy on Sustainable Development, and Big Data." and "Human Well-being Orientations: Agriculture and Food Security, Public Health, Poverty Alleviation, Disaster reduction, and Technology Transfer." (ANSO, 2021b).

Research on the environment and climate change stands out as an important and indispensable research area as the World faces a deepening crisis right now, and the BRI area is not immune to it.

In the global context, Yang, et al. (2016) suggested scientific work on "smart cities, industrial transformation, pollution control, oceanic resources exploitation … (and) clean energy". They also recommended better use of remote sensing for monitoring natural resources. On the other hand, Barakos and Mischo (2018) suggested scientific and industrial collaboration in rare earth elements in the framework of BRI. Liu (2015) proposed several research subjects in the domain of geography, like geopolitical studies or foreign direct investment theories.

Research on the environment and climate change stands out as an important and indispensable research area as the World faces a deepening crisis right now, and the BRI area is not immune to it. On the contrary, most of the area is arid and semi-arid and hence more vulnerable to climate change (Li et al., 2015). Also, the consequences of the implementation of BRI may worsen the existing environmental problems (Ascensão et al., 2018; Hughes et al., 2020).

Energy is another indispensable research area, which is closely coupled to the environmental problem. The BRI is a development program, and development without energy is not possible. Hence, research on clean energy is essential.

Water and agriculture are also critical problems that require research and development efforts. Binlei (2020) showed empirically that cooperation in agriculture creates substantial benefits through spill-over effects. The scientific component will enhance these effects.

Earth observation and remote sensing is a cross-cutting area that serves environmental, climate change, water and agriculture-related research among others. Digital Belt and Road (DBAR) (Guo et al., 2017) is a structure that serves this purpose and can be integrated into the higher-level organization in the future. ICT is a cross-cutting area as well. Especially, big data, artificial intelligence, and robotics research will catalyze all the research areas mentioned above. Digital Silk Road (Guo et al., 2018), which is a part of the BRI, will facilitate the research in this area.

The above items are not exhaustive and more areas can be identified. Although social sciences are beyond the scope of this study, it is clear that collaboration in social sciences, specifically history, archeology, linguistics, anthropology, geography, economics and international law, will serve the goals of the BRI program.

Conclusions

In this paper, a vision for the future of the BRI innovation system is proposed. After visiting the conditions of effective international scientific and technical cooperation and briefly analyzing the current situation, the mechanisms for fostering collaboration are discussed. The main conclusion is that ANSO and similar organizations should evolve into an intergovernmental organization that will create the "BRI Research Area." For such an organization, the following principles are proposed:

- A "fair return" principle should be adopted.
- In the selection of projects, a competitive mechanism should be used.
- Flexible contribution options that will allow the countries to increase their contribution over time should be available.
- The rules for acceptance of new members should be designed to facilitate the organization to grow.
- The emergence of a dominant core should be avoided.
- The administrative procedures should be kept as simple as possible.
- The involvement of the private sector, and especially that of small businesses, should be encouraged.
- Some of the important research areas are environment and climate change, energy, water, and agriculture. Earth observation, big data, artificial intelligence, and robotics are cross-cutting areas.

However, the subject is very large and cannot be covered in the volume of a single paper. Hence, more discussion is necessary on various platforms, and each element should be analyzed in detail from different perspectives.

References

ANSO. (2021a). *ANSO Programmes.* Retrieved from http://www.anso.org.cn/programmes/

ANSO. (2021b). *ANSO Collaborative Research.* Retrieved from http://www.anso.org.cn/programmes/flagshipProject/research/

Ascensão, F., Fahrig, L., Clevenger, A. P., Corlett, R. T., Jaeger, J. A., Laurance, W. F., & Pereira, H.

M. (2018). Environmental challenges for the Belt and Road Initiative. *Nature Sustainability,* 1(15), 206-209.

Barakos, G., & Mischo, H. (2018). The potentials of scientific and industrial collaborations in the field of REE through China's Belt and Road Initiative. *International Journal of Georesources and Environment,* 4(3), 86-91.

Binlei, G. (2020). Pathways for expediting joint agricultural development of China and BRI countries. *China Economist,* 15(5), 15-29.

Chin, H., & He, W. (2016). *The Belt and Road Initiative: 65 countries and beyond.* Hong Kong: Fung Business Intelligence Center.

Ge, Y., Dollar, D., & Yu, X. (2020). Institutions and participation in global value chains: Evidence from Belt and Road Initiative. *China Economic Review,* 61.

Guerrero Bote, V. P., Olmeda-Gómez, C., & Moya-Anegón, F. (2013). Quantifying the benefits of international scientific collaboration. *Journal of the American Society for Information Science and Technology,* 64(2), 392-404.

Gui, Q., Liu, C., & Du, D. (2019). The structure and dynamic of scientific collaboration network among countries along the Belt and Road. *Sustainability,* 11(19), 5187.

Guo, H., Liu, J., Qiu, Y., Menenti, M., Chen, F., Uhlir, P.F., Zhang, L., et al. (2018). The Digital Belt and Road program in support of regional sustainability. *International Journal of Digital Earth,* 11(7), 657-669.

Guo, Huadon, Liu, J., Qiu, Y., Menenti, M., Chen, F., Zhang, L., Genderen John van, Ishwaran, N., et al. (2017). DBAR: International Science Program for Sustainable Development of the Belt and Road Region Using Big Earth Data. (Bulletin of Chinese , Academy of Sciences).

Hughes, A. C., Lechner, A. M., Chitov, A., Horstmann, A., Hinsley, A., Tritto, A., & Douglas, W.Y. (2020). Horizon scan of the Belt and Road Initiative. *Trends in Ecology & Evolution,* 35(7), 583-593.

Kunavut, K., Okuda, A. & Lee, D. (2018). Belt and road initiative (BRI): Enhancing ICT connectivity in China-Central Asia corridor. *Journal of Infrastructure, Policy and Development,* 2(1), 116-141.

Li, P., Qian, H., Howard, W. F., & Wu, J. (2015). Building a new and sustainable "Silk Road economic belt". *Environmental Earth Sciences,* 74(10), 7267-7270.

Liu, W. (2015). Scientific understanding of the Belt and Road Initiative of China and related research themes. *Progress in Geography,* 34(5), 538-544.

Masood, E. (2019). All roads lead to China. *Nature,* 569(2).

Montobbio, F., & Sterzi, V. (2013). The globalization of technology in emerging markets: a gravity model on the determinants of international patent collaborations. *World development,* 44, 281-299.

Nie, M. (2019). Asian Space Cooperation and Asia-Pacific Space Cooperation Organization: An appraisal of critical legal challenges in the Belt and Road Space Initiative context, 47. *Space Policy,* 47, 224-231.

Pavlenko, A. (2008). Russian in post-Soviet countries. *Russian linguistics,* 32(1), 59-80.

Reillon, V. (2015). *Horizon 2020 budget and implementation. A guide to the structure of the programme.* Brussels: European Parliamentary Research Service.

Wagner, C. S., & Leydesdorff, L. (2005). Network structure, self-organization, and the growth of international collaboration in science. *Research policy,* 34(10), 1608-1618.

Wang, Y. C., Chen, C.X., & Guo, X.F. (2018). A study on the cooperation game between china and southeast asian nations under the "The Belt and Road". *2018 Chinese Control And Decision Conference (CCDC).* IEEE, 3155-3159.

World Bank. (2021). *Scientific and technical journal articles.* Retrieved from https://data.worldbank.org/indicator/IP.JRN.ARTC.SC.

Yan, Y. (2021). Capacity building in regional space cooperation: Asia-pacific space cooperation organization. *Advances in Space Research,* 67(1), 597-616.

Yang, D., Cai, J., Hull, V., Wang, K., Tsang, Y. & Liu, J. (2016). New road for telecoupling global prosperity and ecological sustainability. *Ecosystem Health and Sustainability,* 2(10), e01242.