

POLICY NOTE

Flourishing through Societal Change



India Japan STI Forum

December 1, 2023



Centre
For
Society
And
Policy

Keio University



Authors

Dr. Satish Kumar Yawale¹, Mr. Abhishek Choudhary², Prof. Anjula Gurtoo³, Prof. Rajib Shaw⁴

1. Project Scientist-II, Centre for Society and Policy, Indian Institute of Science (IISc), India
2. PhD Scholar, Keio University, Japan
3. Professor and Head, Centre for Society and Policy, Indian Institute of Science (IISc), India
4. Professor, Keio University, Japan

Acknowledgements

Indian Institute of Science, Bangalore and Keio University, Japan would like to thank MS Ramaiah University of Applied Sciences, Indo-Japan Business Council, Rakuten India, Yokogawa India, PADECO India and IUDX for their support.

CONTENTS

Foreword	3
Executive Summary	4
Review of the India-Japan Collaboration	5
Economic Collaboration.....	5
Demographic Synergy and Innovation.....	6
Driving Technological Innovation.....	7
Environmental Concerns and Public Health	8
Infrastructure Development and Economic Growth	8
Hydrogen Sector and Bioeconomy.....	9
India-Japan collaboration through the societal change	10
Small and Medium Enterprises (SMEs):.....	10
Energy	11
Societal Innovation	12
Sustainability	13
Challenges ahead.....	15
Recommendations for STI collaboration for societal transformation	17
References	19

Foreword

India and Japan are two of the world's leading economies and scientific powers. Their collaboration in science technology and innovation (STI) has the potential to make significant contributions to societal transformation based on a sustainability framework. In recent years, both the countries have elevated cooperation to a strategic level with a focus on developing and deploying innovative solutions to address common challenges, such as climate change, energy security, and sustainable development.

This policy note aims to provide a comprehensive overview of India-Japan cooperation, with a particular focus on its potential to contribute to **societal transformation based on science, technology and innovation**. The note will identify key areas of collaboration, review existing initiatives, and provide recommendations for further strengthening India-Japan collaboration in the years to come.

Executive Summary

The comprehensive policy note, “Flourishing through Societal Change India Japan Science Technology Innovations”, delves into the dynamic collaboration between these two Asian powerhouses, India and Japan, with a keen focus on the immense potential for societal transformation through the lens of science, technology and innovation.

The India-Japan partnership is characterized by multifaceted cooperation, extending across diverse sectors such as healthcare, education, disaster management, sustainable energy, and recommendations drawn from our extensive analysis to shed light on the transformative possibilities inherent in this strategic relationship.

India and Japan`s partnership in science and technology is poised to address critical global challenges, including climate change, resource security, and sustainable development. This collaboration is anchored in their shared values and interests, encompassing clean energy, environmental protection, and socioeconomic development. The collaborative initiatives aim to harness the power of innovation for the betterment of their societies, as emphasized by numerous research studies. The partnership is not limited to bilateral gains; it holds the promise of benefiting the broader Asian region by fostering economic growth and nurturing innovation.

The India-Japan collaboration is exemplified by pivotal initiatives, such as the India-Japan Digital Partnership (IJDP), the supply chain resilience initiative, and the India Japan Fund (IJF). These initiatives champion cooperation in science, technology, and innovation, facilitating sustainability and resilience in the Indo-Pacific region. Our analysis brings to the forefront the importance of these initiatives in forgoing a more interconnected and resilient future.

The policy note delves into various aspects of India Japan collaboration, for example, economic expansion, demographic profiles, technology sharing, Environmental concerns, and urge of Infrastructure development. While the collaboration between India and Japan holds immense promise, our analysis identifies key barriers and challenges that needs to be address. To overcome limitation, we propose recommendations that focus on enhancing inter-governmental cooperation, streamlining regulations, and facilitating the disclosure of essential data for cost visualization.

Review of the India-Japan Collaboration

India and Japan have fostered a robust partnership marked by technological collaboration across various domains. This partnership is underpinned by shared interests encompassing trade and investment promotion, energy resource security, environmental protection, climate change mitigation, and other critical areas. Recognizing the vast potential inherent in their collaboration, both countries are poised to further bolster their trade and investment ties. Beyond bilateral gains, this strategic relationship holds the promise of benefiting the broader Asian region, fostering economic growth, and nurturing innovation.

Collaborative efforts in science and technology are poised to address pressing global challenges. Climate change, resource security, and sustainable development are at the forefront of the agenda. Research by Choudhury (2017) underscores the transformative potential this partnership, while Bhatt [2021] highlights the concerted efforts of India and Japan in harnessing innovation for the betterment of their societies.

Furthermore, this dynamic alliance is exemplified by several pivotal initiatives. The India-Japan Digital Partnership (IJDP) and associated startup hub, launched in 2018, champion cooperation in science, technology, and innovation to support sustainability. Concurrently, the supply chain resilience initiative, in 2020 with the participation of India, Japan and Australia, is aimed at diversifying supply chains and sharing best practices to enhance resilience in the Indo-Pacific region.

Economic Collaboration

The economic dimension of the India-Japan partnership is a crucial aspect that merits careful review. A comprehensive study conducted by Bhattacharyay and Mukhopadhyay (2015) employed Computable General Equilibrium (CGE) analysis to scrutinize the economic-wide impact of the Comprehensive Economic Partnership Agreement (CEPA). The findings suggest that India's exports to Japan are likely to surpass those in the opposite direction, while yielding positive net welfare gains for both nations. The analysis by Kalirajan and Battacharya (2008), revealed that India has achieved on average, only 60% of its export potential, while Japan stands at 64% across ten sectors or commodity groups.

In recent years, the economic relationship between two countries has undergone significant expansion and deepening. Alongside consistent growth in bilateral trade, where India ranked as Japan's 18th largest trading partner and reciprocally, Japan became India's 13th largest trading partner in 2021, direct investment from Japan into India has notably surged. Furthermore, the flow of direct investment from Japan into India has seen a substantial increase, with Japan securing its position as India's 5th largest investor during

the fiscal year 2021. Notably, the private sector in Japan has displayed an increasing interest in Indian market dynamics, exemplified by the presence of approximately 1440 Japanese companies with branches operating in India as of 2021. This robust economic partnership is further complemented by the recent launch of the \$600 million India Japan Fund (IJF) which is nearly INR 50 thousand, jointly initiated by the National Investment and Infrastructure Fund (NIIF) and the Japan Bank of International Cooperation (JBIC) [MoF, 2023], underscoring the shared commitment of both nations to addressing climate and environmental challenges, thus positioning India and Japan as global leaders in tackling crucial global issues.

The India-Japan Free Trade Agreement (FTA) has been a topic of interest, with several studies offering insights into its potential economic impact. Ahmed (2010) analyzes the FTA's effects on trade in goods, revealing its potential for boosting economic growth in both countries. Bhattacharya and Bhattacharyay (2007) assess the gains and losses of India-China trade cooperation and provide valuable lessons for the India-Japan partnership. These findings underline the importance of continued economic cooperation to drive innovation and growth. Kalirajan and Bhattacharya (2008) examined the constraints to an FTA between India and Japan. Their work underscored the importance of addressing impediments to trade, both tariff and non-tariff, to maximize the benefits of economic cooperation. A report by the Government of India [GOI, 2008] reported on trade talks between India and Japan, focusing on market access and addressing unresolved issues. Such government communications provide insights into the negotiation process and policy intentions. Similarly, the Ministry of Foreign Affairs Government of Japan [MOFA GOJ, 2006] reported academic collaboration outlining the potential areas of cooperation and the rationale behind strengthening economic ties between the two countries.

Foreign direct investment (FDI) and collaborative projects between Indian and Japanese companies are integral components of economic cooperation. Japanese companies have invested significantly in India, contributing to the growth of Indian industries [OECD, 2008b]. Additionally, joint industrial projects have been instrumental in technology transfer and innovation. Collaboration in sectors like automotive manufacturing and electronics has boosted economic growth in both countries (Wright, Emele, Fukumoto, Velaga, & Nelson, 2014).

Demographic Synergy and Innovation

The demographic profile of India and Japan present a unique opportunity for mutual collaboration in the realm of science, technology, and innovation. While Japan grapples with a rapidly aging and dwindling population, India faces the challenge of accommodating its ever-expanding workforce. Japan's need for skilled IT professionals and engineers aligns with India's abundance of highly skilled talent in these fields. Leveraging this

demographic complementarity, India can fill the critical gaps in Japan's labor market. Conversely, India's pursuit of innovation and employment growth finds a promising avenue in Japan's technology-centric landscape. To bridge the language barriers, collaborative efforts are essential, and the evolving social norms in Japanese cities indicate a growing openness to diverse workforces (Hui & Hussain, 2020). Academic research by Curtis et al. (2017) examines the relationship between demographics and household savings, shedding light on the importance of addressing demographic challenges for long-term growth. Lee and Mason (2012) discussed the impact of population aging on economic growth and intergenerational transfers, emphasizing the need for innovative solutions to mitigate demographic challenges. Ogawa et al. (2010) report that Japan is experiencing an unprecedented aging process. Its population is aging rapidly, and birth rates are declining. India, on the other hand, boasts a youthful population. The demographic dividend, as highlighted by (Bloom, Canning, & Sevilla, 2003), presents an opportunity for economic growth. However, realizing this potential requires investments in education, healthcare, and employment opportunities.

Household savings and investment are central to economic growth. As documented by Jangili (2011), India has a high saving rate. The high savings, when channeled effectively, can fuel economic growth. Whereas Japanese citizens have a tradition of saving for their retirement and have accumulated substantial savings over the years (Ogawa, Mason, Chawla, & Matsukura, 2010). India-Japan collaborations are instrumental in addressing demographic challenges and promoting innovation (Maly, Vahanvati, & Sararit, 2022).

Driving Technological Innovation

Technology is a key driver of economic growth, and global value chains play a significant role in the discussion of innovation. Dedrick, Kraemer, and Linden (2009) explore who benefits from innovation in global value chains, with a specific focus on the case of Apple's iPod. This analysis highlights the importance of technological innovation to enhance competitiveness and economic development. In the context of trade and technological innovation, the work of Wright et al. (2014) explores the design, management, and operation of flexible sheds light on innovation in transportation and logistics impacting trade and economic development. The research by Lee and Chiu (2012) delves into the development of a biohydrogen economy in the United States, China, Japan, and India. This study is particularly relevant as it underscores the significance of innovation in the transition to sustainable energy sources and collaborative efforts in innovation sectors. Policy notes from the governments of India and Japan are instrumental in providing a strategic direction for enhancing technological innovation within the trade context (MOFA GOJ, 2006).

Environmental Concerns and Public Health

Environmental concerns and public health are shared priorities for both India and Japan. Hu et al. (2021) provide insights into air pollution during and after COVID-19 lockdowns in various Asian countries, including India and Japan, emphasizing the need for sustainable and clean technologies. Izumi and Shaw (2022) offer a comparative analysis of the impact of COVID-19 and natural hazards highlighting the importance of disaster management and climate resilience in the context of trade relations. Additionally, studies by Maly et al. (2022) and Tam et al. (2023) explore the impact of natural hazards and climate change, making a compelling case for collaborative efforts in disaster management and climate resilience. Academic research by Basnyat, Pokhrel and Cohen (2000) emphasize the need for travel vaccinations for Japanese travelers whereas Hamada and Fukushima (2015) examine the present situation and challenges of vaccinations for overseas travelers from Japan to India. Saveyn et al. (2012) focus on healthcare infrastructure and the development of health-care related industries with collaborative initiatives between the Indian and Japanese governments.

The significance of environmental education and awareness as fundamental pillars of a sustainable future is underscored by the work of Laiphrakpam et al. (2019). India and Japan, with their distinct culture and education landscapes, recognize the significance of nurturing a new generation of environmentally conscious citizens. Though collaborative efforts in science, technology, and innovation, both nations can contribute to the dissemination of knowledge and the development of sustainable solutions that transcend borders.

Infrastructure Development and Economic Growth

Infrastructure development is integral to trade, affecting the efficiency of goods movement, connectivity and economic growth. Infrastructure development encompassing energy, transport, telecommunications, water and sanitation. Bhattacharyay (2010) estimates the demand for infrastructure in energy, offering an analytical perspective on energy infrastructure development influences economic growth. Wright et al. (2014) provided insights into the design, management, and operation of flexible transport systems offering a perspective on innovation in transportation and logistics that directly affects trade and economic development.

India and Japan have jointly initiated remarkable infrastructure projects that exemplify their commitment to mutual development. These projects include the construction of the Patna Metro Rail in March 2023, the Delhi-Mumbai Industrial Corridor Project, the Chennai-Bangalore Industrial Corridor, the Dedicated Freight Corridor Project, and the Mumbai-Ahmedabad High-speed Railway. The Delhi-Mumbai Industrial Corridor Project

considered transport, telecommunications, water, and sanitation in the context of Asia Bhattacharyay (2010). These projects aim to address growing traffic congestion, improve urban conditions, foster economic development and contribute to climate change mitigation efforts.

Hydrogen Sector and Bioeconomy

The hydrogen sector and the bioeconomy represent areas of significant collaboration between India and Japan. This is because it is a pivotal resource for curbing carbon emissions and enhancing energy security. India and Japan are actively engaged in harnessing the potential of hydrogen. Research by Lee and Chiu (2012) and Lee (2016) discuss the development of bio-based industries in various Asian countries including India and Japan, highlighting the potential for sustainable economic growth through innovative technologies. Japan's "Basic Hydrogen Strategy", established in 2017, has spurred the development of numerous hydrogen related technologies (TCMREH, 2017). In August 2021, India's Prime Minister, unveiled a national hydrogen mission, marking a significant commitment to hydrogen-related technologies (MNRE, 2022). Recognizing the shared importance of this endeavor, the Prime Ministers of both countries solidified the "India-Japan Clean Energy Partnership" in March 2022; this commitment to bolster cooperation in the energy sector, particularly in hydrogen-related initiatives (EOJ, 2022). This collaboration is especially noteworthy due to India's robust potential for green hydrogen production and Japan's advanced demonstration research in sectors aligned with India's hydrogen facility priorities (Otaki & Shaw, 2023).

Moreover, their commitment to a stable business environment is further underscored by the advance pricing agreement scheme in the financial year 2022-23. This scheme aims to provide certainty and consistency in transfer pricing matters for multinational companies, reducing legal disputes and offering a favorable atmosphere for businesses. This holistic approach to collaboration, spanning technology, industry, finance, and taxation, encapsulates the multifaceted nature of India-Japan partnership and its role in promoting innovation, sustainability, and economic growth.

India-Japan collaboration through the societal change

In the backdrop of the deepening economic collaboration between India and Japan, it is crucial to analyze this partnership through a human security and sustainability framework. Such an examination not only sheds light on the progress achieved but also underscores the areas that require further attention and action. India has a huge market made up of approximately 1.3 billion people as well as a large and high-quality labor force. On the other hand, Japan has advantages in terms of capital, technological skills, and product development. In addition, with the strong purchasing power of middle-class people, India is an emerging market. The rapidly growing information technology (IT) industry of India hopes to see the Japanese companies. This comprehensive exploration delves into four thematic areas: Small and Medium Enterprises (SMEs), Energy, Societal Innovation, and Sustainability. By analyzing these thematic areas, we can identify the addressed and unaddressed aspects, role of technology, industry, and government.

Small and Medium Enterprises (SMEs):

India and Japan have actively promoted cooperation in the SME sector, recognizing its vital role in economic development and job creation. Collaborative efforts, such as joint ventures, technology transfers, and knowledge sharing have been employed to boost the growth of SMEs in both countries. Bilateral trade between the two nations has experienced consistent growth, with India ranking as Japan's 18th largest trading partner, and Japan reciprocating as India's 13th largest trading partner in 2021 (MOFA GOJ, 2010). Furthermore, the flow of direct investment from Japan into India has seen a substantial increase, with Japan securing its position as India's 5th largest investor during the fiscal year 2021. Notably, the private sector in Japan has displayed an increasing interest in India's market dynamics, exemplified by the presence of approximately 1439 Japanese companies with branches operating in India as of 2021. The current status of SMEs in India highlights their significant engagement in various types of innovations, with approximately 35.2% of SMEs actively involved in innovation activities (Pachouri & Sharma, 2016).

Both governments have actively supported SMEs through policies and incentives, while industry associations have fostered partnerships and knowledge exchange. Government-supported initiatives such as the India-Japan SME Forum have acted as catalysts for collaboration. The Indian government's, for instance, "Make in India" and "Startup India" campaigns aim to promote entrepreneurship and boost the growth of SMEs. In Japan, the Ministry of Economy, Trade and Industry (METI) has implemented the "Japan Revitalization Strategy" to support SMEs expansion and innovation. Governments also support cultural and people-to-people exchanges, including initiatives to enhance mutual understanding and promote tourism, education, and cultural cooperation. Government-led

infrastructure development projects, as discussed in previous section, are key components of the collaborations. These projects aim to create the necessary infrastructure for industrial growth and connectivity.

Technology plays a pivotal role in SME collaboration, enabling the adoption of efficient production processes, quality control, and market expansion. The utilization of digital platforms and e-commerce has facilitated cross-border trade and improved market access for SMEs. India's "Make in India" initiative and Japan's "Society 5.0" vision share the goal of technological self-reliance and innovation-driven growth. Both the governments encourage and facilitate technology collaboration between the two countries. This includes supporting research and development partnerships, joint ventures, and initiatives in science and technology sector [Basrur Kutty, 2021]. In addition, both the governments playing important role on climate-resilient infrastructure, renewable energy projects, and other initiatives, in alignment with their climate goals. Food and agriculture are becoming an active area of collaboration between Indian and Japanese companies. A program for promoting Japanese investment in Indian agriculture and fisheries was established in 2018 (MOFA GOJ, 2010). Climate smart agriculture, food processing, logistics and cold chain, and food packaging are important areas where Indian companies can adapt Japanese technologies. Health care, clean water and sanitation, waste recycling are other important areas. Indian small companies in information technology-based service sector is also actively seeking opportunities in the Japan market. Japan International Cooperation Agency (JICA) is actively involved in projects to improve irrigation, forest management, and livelihoods in different states, further enhancing bilateral cooperation.

Despite significant progress, challenges remain in access to finance, skill development, and market entry for SMEs. More concerted efforts are needed to address these gaps and ensure equitable growth.

Regulatory challenges, such as simplifying export-import procedures and customs clearance, need attention. Moreover, ensuring SMEs have access to affordable financing remains a challenge. Further collaboration is needed to enhance credit availability. Access to technology for Indian SMEs remains an important area of concern.

Energy

India-Japan collaboration in the energy sector has centered on renewable energy, nuclear cooperation, and efficient energy utilization. Joint ventures in renewable projects and technology sharing have been key highlights. Harnessing clean energy needs smart technologies based on renewables. Advanced solar technology, nuclear energy expertise, and energy-efficient appliances have been exchanged to promote sustainable energy practices. In this context both the countries' strategy is to rapidly adopt new energy

technologies, energy efficiency improvements and the widespread integration of solar and wind power. Electrification and energy efficiency upgrades in various sectors are underway.

In India, the total consumption of coal by industry has increased from 462.35 MT during 2006–07 to 832.46 MT during 2015–16, while the consumption of petroleum sources, especially oil and gas increased from 146.55 MMT during 2006–07 to 232.87 MMT during 2015–16' (MoSPI, 2017). This has also led to a corresponding increase in greenhouse gas emissions and has made way for direct as well as indirect damage to the environment as well as to human beings.

India has been equally concerned about reducing fossil fuel consumption, primarily because of the dependence of the key energy-consuming sector on these fuels. Industry and transportation heavily depend on fossil fuel usage, which is also critical in meeting the overall national economic targets.

Both governments have fostered a conducive environment for energy collaboration, with policies promoting renewable energy adoption. Industry players have actively engaged in research and investment in renewable projects. While the transition to clean energy is promising, challenges persist. These encompass grid integration, energy storage solutions, and ensuring sustainable energy access for marginalized communities. India's "National Solar Mission" and Japan's "Renewable Energy Promotion" initiatives aim to foster cooperation in the renewable energy sector. These initiatives encourage the adoption of clean energy technologies, benefiting not only large energy corporations but also SMEs engaged in energy-related businesses.

Addressing these gaps necessitates a concerted effort involving both government intervention and focused research to harness the full potential of renewable energy sources. A more robust approach to grid modernization and storage solutions is necessary to bridge these gaps.

In the hydrogen sector, key points of discussion included the need for cost reduction and improved performance in fuel cells and hydrogen storage, the pursuit of viable green hydrogen production processes, and the necessity of substantial investments in research infrastructure and commercialization support (MoST, 2021).

Societal Innovation

Collaborations in societal innovation have seen joint research projects, knowledge exchange in healthcare and education, and innovative solutions for societal challenges. Technology has been instrumental in addressing societal issues, including healthcare accessibility, education quality, and disaster management. Innovations such as telemedicine, e-learning platforms, and data analytics have been deployed.

Both governments have actively promoted societal innovation through initiatives like the “India-Japan Industrial competitiveness Partnership.” Industry leaders have engaged in research and development to address pressing societal challenges. Despite progress in societal innovation, there is a need for broader access to healthcare and quality education, especially in rural areas. Collaborative efforts must continue to bridge these disparities and promote inclusivity.

Sustainability

Sustainability is a multifaced concept that goes beyond environmental preventions and extends to encompass the broader notion of well-being, both for present and future generations. It is deeply intertwined with the LIFE (Lifestyle for Environment) principles, which emphasize responsible living practices that reduce our ecological footprint. These principles encourage mindful consumption, waste reduction, and the promotion of eco-friendly lifestyles. By adopting LIFE principles, individuals can make daily choices that have a positive impact on the environment, such as reducing single-use plastics, conserving energy, and supporting sustainable products and businesses.

Resilience building is another critical aspect of sustainability. It entails the capacity to withstand and recover from shocks and stressors, whether they are environmental, economic, or social in nature. In the context of sustainability, resilience is about creating systems and communities that can adapt and thrive in the face of challenges, including climate change and resource scarcity. Sustainable practices and policies that promote local food production, clean energy adoption, and disaster preparedness are vital components of resilience building. By enhancing resilience, societies can better protect their environment, economies, and the well-being of their citizens, ensuring a more sustainable future.

The India-Japan collaboration on sustainability, guided by the incorporation of LIFE principles and resilience building, extends beyond just environmental conservation. It represents a comprehensive approach to improving the quality of life for citizens in both nations. By striking a balance between societal needs and ecological limits, these collaboration aims to foster a harmonious relationship between people and the environment. Sustainable policies and practices will enable both countries to navigate the challenges of a rapidly changing world and build a more resilient, sustainable future for their respective populations and the global community.

India-Japan collaborative potential

To meet the NDC targets, electrification and energy efficiency upgradation requires large-scale systemic changes. For example, solar energy in grid transition must be prioritized with efforts to minimize energy loss at the decentralized level. Energy security is crucial, with efficient battery storage being a key enabler.

As discussed above, industrial collaboration contributes to societal transformation, as it fuels economic growth, job creation and innovation. India and Japan have engaged in a symbiotic relationship where Japanese companies invest in India markets, thereby fostering employment and skill development. Simultaneously, India provides opportunities for Japanese companies to leverage its growing consumer base, contributing to their economic growth. This collaboration is not just about trade and investment; it's above that for shaping the economic landscape, driving technological advancements, and addressing shared global challenges such as climate change (Bhattacharyay & Mukhopadhyay, 2015).

The electric vehicle (EV) initiative is gaining momentum, with incentives for adoption in both countries. However, advancements in EV technology and efficiency are still needed. Developing more efficient and durable batteries is vital for EV infrastructure. Expanding charging infrastructure is equally crucial, depending on technology enhancements and supportive policies (Hema & Venkatarangan, 2022; Kumar, Panda, Naayagi, Thakur, & Panda, 2023). The collaborative efforts between India and Japan particularly in the realm of green technologies and EV development, have the potential to pave the way for a societal transformation (Tarei, Chand, & Gupta, 2021). By harnessing the power of innovation, joint research and development, and sustainable practices, these two nations can propel the adoption of cleaner and more efficient transportation options. Their partnership signifies not only a commitment to economic growth but also a shared dedication to environmental protection and a sustainable, interconnected future, transcending the barriers that hinder the broader acceptance of electric vehicles and contributing to a greener and more prosperous society.

To improve the innovation performance of SMEs, it is very important to understand the key barriers in the innovation ecosystem. There are six categories of barriers to innovation classified.

People and Skills: The need for specialized skills is required for both R&D and marketing innovations. Unavailability of skilled workers as a barrier to innovation, making it one of the foremost challenges in SEM innovation.

Finance: The cost of innovation is a key barrier for more than 75% of the innovative small and medium firms. This clearly shows that financial constraints remain one of the biggest

barriers to SME innovation.

Regulatory Hurdles: Bhattacharyay and Mukhopadhyay (2015) have emphasized the regulatory challenges including complex bureaucratic procedures and legal frameworks, were significant impediments to trade and investment. Streamlining regulations and enhancing the ease of doing business was identified as a crucial area for improvement.

It is worth mentioning that Japan's exports constituted 2.31 percent of India's total imports, and India's exports to Japan represented 1.21 percent of India's overall exports. These figures indicate that there remains significant untapped potential in bilateral trade relations (Bhardwaj, 2023).

By jointly investing in cutting-edge technologies and sustainable practices, India and Japan are taking a pivotal step towards societal transformation. Their collaboration serves as a beacon of hope in addressing the global challenge of climate change while nurturing economic growth.

Challenges ahead

Lack of Infrastructure development: Availability and access to infrastructure is crucial. Bhattacharyay and Mukhopadhyay (2015) highlights the need for significant improvements in infrastructure, specifically transportation, logistics and power supply, to facilitate the efficient movement of goods and services. Insufficient infrastructure was recognized as a bottleneck for expanding economic cooperation between India and Japan. Hiroyuki et al. (2022) emphasizes the regional disparities within India, encompassing variations in infrastructure, labor availability, and economic development across different states. It is imperative to acknowledge that these disparities significantly influence the activities of Japanese manufacturing multinationals in India.

India-Japan collaboration on the hydrogen sector faces several significant challenges. First, there is a need to address the issues related to cost visualization, particularly the transportation costs associated with hydrogen. Second, harmonizing regulations between the two countries is essential. Third, there is a need for alignment in the promotional measures taken by both nations. Fourth, a clear and shared definition of green hydrogen needs to be established. Fifth, intellectual property protection poses another challenge. To overcome these limitations and realize successful joint hydrogen projects, it is imperative to facilitate the disclosure of essential data for cost visualization of hydrogen transportation and enhance inter-governmental cooperation between India and Japan. Hydrogen energy mission in both the countries poised to expedite technology deployment and supply network development.

In the context of India-Japan collaboration, it is crucial to acknowledge the profound demographic differences between these two nations. Both countries have undergone

significant demographic transitions, shifting from relatively young populations to relatively older ones (Curtis, Lugauer, & Mark, 2017). However, these transitions have unfolded at distinct times and on varying scales. Japan, often regarded as the world's oldest country, currently has a significant elderly population, with over 28 percent of its population aged 63 and above. In contrast, India boasts a much younger population, with only 6 percent in the elderly age group. These demographic distinctions have far-reaching implications for collaboration, especially in sectors like healthcare, technology, and social services, as the two nations navigate the challenges and opportunities presented by their differing demographic profiles.

Both governments have recognized the importance of bilateral trade and technology collaboration, emphasizing cooperation in technology, clean energy, and infrastructure development, among other sectors, to strengthen their partnership. While Japan has largely supported India's transport sector, there is immense untapped potential for collaboration in clean energy and energy efficiency. To unlock the full potential of technology collaboration, India and Japan must overcome barriers and enhance their collaborative efforts to benefit both nations.

One major limitation is the cost competitiveness of Japanese technologies. Indian SMEs often find these technologies expensive, which hinders their adoption, despite their energy-saving potential and durability. Literature identifies compatibility of advanced technology remains a significant hurdle to collaborate as the technology may not always align with local conditions and domestic demand in India, making it less attractive to potential users.

Recommendations for Science Technology and Innovation collaboration for societal transformation

The undeniable fact is that India and Japan's collaboration in science, technology, and innovation has experienced remarkable growth, signifying a depth of commitment to addressing contemporary global challenges. Regardless, this partnership offers a clean pathway to societal transformation, not just within the Indo-Pacific but with far-reaching implications for the international community.

To harness the full potential of science technology and innovation, India and Japan should strengthen their bilateral collaboration in research and development. This can be achieved by fostering partnerships between research institutions, universities, and industries. Additionally, promoting joint initiatives in emerging fields such as artificial intelligence, biotechnology, and renewable energy can drive innovation and societal transformation.

In order to promote India-collaboration on societal transformation and sustainability, the following policy recommendations are proposed:

1. Establish a joint India-Japan working group on climate change and sustainability: this working group could be responsible for identifying and coordinating opportunities between the two countries.
2. Develop a joint India-Japan roadmap for sustainable development, focusing on LIFE (Lifestyle for Environment) principles and resilience building: this roadmap could outline the specific areas of collaboration and the targets that the two countries aim to achieve.
3. Provide financial and technical support for India-Japan collaboration projects: The governments of India and Japan could provide financial and technical support for projects that promote the adoption of low-carbon technologies and practices in both countries.
4. Encourage private sector participation in India-Japan collaboration: The governments of India and Japan could encourage private sector companies in both countries to collaborate on the development and deployment of low-carbon technologies and practices.
5. Establish collaborative innovation platforms that bring together young minds from both nations. Encourage competitions and innovation challenges to address sustainability issues, such as clean energy, waste management, and sustainable agriculture.
6. Strengthen academic collaborations and research exchanges between universities and institutions in India and Japan, with a specific focus on sustainability and

resilience studies. Establish research centers and laboratories, ensuring that higher education equips students with the knowledge and skills needed to drive sustainable development.

Japanese companies and Indian policymakers should work together to make Japanese technologies more cost-competitive. This could involve exploring economies of scale, localized production, or subsidies to bridge the cost gap. These companies should update the technologies to suit the local conditions and demands of the Indian market. Collaborative research and development projects between the two countries to ensure compatibility of existing infrastructure. In addition, promote awareness and provide training in Indian SMEs on the benefits and usage of Japanese technologies.

The role of multinational enterprises in India extends beyond mere investments, they are vital contributors to the local economy, job creation and industrial growth. Policymaker can utilize this knowledge to develop targeted policies that attract foreign investments and reduce regional disparities [Hiroyuki, Azusa, Takahiro, 2022].

Co-innovation can play a key role. India can co-innovate with Japanese players and produce the equipment and machinery domestically. Co-innovation is defined as a collaborative and iterative approach to jointly innovate, manufacture and scale-up technologies (Janardhanan, Ikeda, Zusman, & Tamura, 2020).

It is essential for both countries to collaborate on societal transformation and sustainability to achieve their climate change and sustainable development goals. In addition, India and Japan can collaborate on capacity building programs to train and educate the workforce on low-carbon technologies and practices; Japan can support the transfer of low-carbon technologies to India; Collaboration on public awareness campaigns to promote the adoption of low-carbon lifestyles. By working together, in these important key areas, India and Japan can make a significant contribution to global efforts to mitigate climate change and achieve sustainable development.

References

- Ahmed, S. (2010). India-Japan FTA in goods: a partial and general equilibrium analysis. *Goods: A Partial and General Equilibrium Analysis (April 15, 2010)*.
- Basnyat, B., Pokhrel, G., & Cohen, Y. (2000). The Japanese need travel vaccinations. *Journal of Travel Medicine*, 7, 37–37.
- Basrur, R., & Kutty, S. N. (2021). Modi's India and Japan: nested strategic partnerships. *Springer NAture*, 59, 67-89. doi:<https://doi.org/10.1057/s41311-021-00288-2>
- Bhardwaj, N. (2023, 10 10). *India Briefing*. Retrieved from India-Japan Economic Partnership: Bilateral Trade, Infrastructure Projects, and Semiconductor Collaboration: <https://www.india-briefing.com/news/india-japan-trade-investment-data-fy2023-new-frontier-areas-cooperation-29096.html/>
- Bhatt, P. (2021). Emerging pillars of India-Japan relations in the Indo-Pacific. *Indian Foreign Affairs Journal*, 134-152. Retrieved from <https://www.jstor.org/stable/10.2307/48720486>
- Bhattacharya, S. K., & Bhattacharyay, B. N. (2007). Gains and losses of India-China trade cooperation-A gravity model impact analysis.
- Bhattacharyay, B. (2010). Estimating demand for infrastructure in energy, transport, telecommunications, water, and sanitation in Asia and the Pacific: 2010-2020.
- Bhattacharyay, B. N., & Mukhopadhyay, K. (2015). A comprehensive economic partnership between India and Japan: Impact, prospects and challenges. *Journal of Asian Economics*, 39, 94-107. doi:<https://doi.org/10.1016/j.asieco.2015.06.006>
- Bloom, D., Canning, D., & Sevilla, J. (2003). *The demographic dividend: A new perspective on the economic consequences of population change*. Rand Corporation.
- Choudhury, S. R. (2017). India–Japan Relations: Economic Cooperation Enabling Strategic Partnership. *International Studies*, 54, 106-126. doi:[10.1177/0020881718791404](https://doi.org/10.1177/0020881718791404)
- Curtis, C. C., Lugauer, S., & Mark, N. C. (2017). Demographics and aggregate household saving in Japan, China, and India. *Journal of Macroeconomics*, 51, 175-191. doi:<https://doi.org/10.1016/j.jmacro.2017.01.002>

- Dedrick, J., Kraemer, K. L., & Linden, G. (2009, June). Who profits from innovation in global value chains?: a study of the iPod and notebook PCs. *Industrial and Corporate Change*, 19, 81-116. doi:10.1093/icc/dtp032
- EOJ. (2022). *India-Japan Clean Energy Partnership*. New Delhi: Embassy of Japan in India.
- GOI. (2008). *India-Japan Clean Energy Partnership*. Retrieved from Government of India.
- Hamada, A., & Fukushima, S. (2015). Present situation and challenges of vaccinations for overseas travelers from Japan. *Journal of Infection and Chemotherapy*, 21, 405-409. doi:https://doi.org/10.1016/j.jiac.2015.03.006
- Hema, R., & Venkatarangan, M. J. (2022). Adoption of EV: Landscape of EV and opportunities for India. *Measurement: Sensors*, 24, 100596. doi:https://doi.org/10.1016/j.measen.2022.100596
- Hiroyuki, N., Azusa, F., & Takahiro, S. (2022). Regional disparities, firm heterogeneity, and the activity of Japanese manufacturing multinationals in India. *Pacific Economic Review*, 462-488.
- Hu, M., Chen, Z., Cui, H., Wang, T., Zhang, C., & Yun, K. (2021). Air pollution and critical air pollutant assessment during and after COVID-19 lockdowns: Evidence from pandemic hotspots in China, the Republic of Korea, Japan, and India. *Atmospheric Pollution Research*, 12, 316-329. doi:https://doi.org/10.1016/j.apr.2020.11.013
- Hui, T. M., & Hussain, N. (2020). Japan-India: An Indigenous Indo-Pacific Axis. *The Diplomat* 18.
- Izumi, T., & Shaw, R. (2022). A multi-country comparative analysis of the impact of COVID-19 and natural hazards in India, Japan, the Philippines, and USA. *International Journal of Disaster Risk Reduction*, 73, 102899. doi:https://doi.org/10.1016/j.ijdr.2022.102899
- Janardhanan, N., Ikeda, E., Zusman, E., & Tamura, K. (2020). *Co-innovation for low carbon technologies: the case of Japan-India collaboration*. JSTOR.
- Jangili, R. (2011). Causal relationship between saving, investment and economic growth for India—what does the relation imply?
- Kalirajan, K., & Bhattacharya, S. (2008). Analysis of Constraints to Free Trade Agreement between India and Japan. *Draft, National Graduate Institute for Policy Studies, Tokyo, and the Indian Institute of Public Administration, New Delhi*.
- Kumar, M., Panda, K. P., Naayagi, R. T., Thakur, R., & Panda, G. (2023).

Comprehensive Review of Electric Vehicle Technology and Its Impacts: Detailed Investigation of Charging Infrastructure, Power Management, and Control Techniques. *Applied Sciences*, 13, 8919.

- Laiphrakpam, M., Aroonsrimorakot, S., & Shanker, A. R. (2019). Environmental education and awareness among students in India, Japan and Thailand for sustainable development. *Interdisciplinary Research Review*, 14, 48–53.
- Lee, D.-H. (2016). Bio-based economies in Asia: Economic analysis of development of bio-based industry in China, India, Japan, Korea, Malaysia and Taiwan. *International Journal of Hydrogen Energy*, 41, 4333-4346. doi:<https://doi.org/10.1016/j.ijhydene.2015.10.048>
- Lee, D.-H., & Chiu, L.-H. (2012). Development of a biohydrogen economy in the United States, China, Japan, and India: With discussion of a chicken-and-egg debate. *International Journal of Hydrogen Energy*, 37, 15736-15745. doi:<https://doi.org/10.1016/j.ijhydene.2012.02.152>
- Maly, E., Vahanvati, M., & Sararit, T. (2022). People-centered disaster recovery: A comparison of long-term outcomes of housing reconstruction in Thailand, India, and Japan. *International Journal of Disaster Risk Reduction*, 81, 103234. doi:<https://doi.org/10.1016/j.ijdrr.2022.103234>
- MNRE. (2022). *Increase in the use of Green Hydrogen*. New Delhi: Ministry of New and Renewable Energy of India (MNRE), Press Information Bureau of India.
- MoF. (2023). *India Japan Fund (IJF)*. Retrieved from <https://pib.gov.in/PressReleasePage.aspx?PRID=1963922>
- MOFA GOJ. (2006). *Report of the India-Japan Joint Study Group*. Tokyo: Ministry of Foreign Affairs of Japan.
- MOFA GOJ. (2010). *Joint declaration between the leaders of Japan and the republic of India on the conclusion of the comprehensive economic partnership agreement between Japan and the Republic of India*. Tokyo: Ministry of Foreign Affairs of Japan.
- MoSPI. (2017). *Energy Statistics*. New Delhi: Ministry of Statistics Programme and Implementation.
- MoST. (2021, 04 20). Retrieved from India and Japan collaborations for innovations on Hydrogen based technologies: <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1712893>
- OECD. (2008b). *OECD Statistics*.
- Ogawa, N., Mason, A., Chawla, A., & Matsukura, R. (2010). Japan's

- unprecedented aging and changing intergenerational transfers. In *The economic consequences of demographic change in East Asia* (pp. 131–160). University of Chicago Press.
- Otaki, T., & Shaw, R. (2023). The Potential of Collaboration between India and Japan in the Hydrogen Sector. *Energies*, *16*, 3596.
- Pachouri, A., & Sharma, S. (2016). Barriers to innovation in Indian small and medium-sized enterprises.
- Saveyn, B., Paroussos, L., & Ciscar, J.-C. (2012). Economic analysis of a low carbon path to 2050: A case for China, India and Japan. *Energy Economics*, *34*, S451-S458. doi:<https://doi.org/10.1016/j.eneco.2012.04.010>
- Tam, K.-P., Chan, H.-W., & Clayton, S. (2023). Climate change anxiety in China, India, Japan, and the United States. *Journal of Environmental Psychology*, *87*, 101991. doi:<https://doi.org/10.1016/j.jenvp.2023.101991>
- Tarei, P. K., Chand, P., & Gupta, H. (2021). Barriers to the adoption of electric vehicles: Evidence from India. *Journal of Cleaner Production*, *291*, 125847. doi:<https://doi.org/10.1016/j.jclepro.2021.125847>
- TCMREH. (2017). *Basic Hydrogen Strategy*. The Council of Ministers on Renewable Energy and Hydrogen (TCMREH).
- Wright, S., Emele, C. D., Fukumoto, M., Velaga, N. R., & Nelson, J. D. (2014). The design, management and operation of flexible transport systems: Comparison of experience between UK, Japan and India. *Research in Transportation Economics*, *48*, 330-338. doi:<https://doi.org/10.1016/j.retrec.2014.09.060>

@ INDIAN INSTITUTE OF SCIENCE, BANGALORE, 560012