CHAPTER 2

Leveraging Co-innovation Model for Energy Transition: Examining India's Engagement with Japan and China

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2.1 Introduction

The growing dependence on fossil fuels and inefficient energy usage together led to a significant increase in greenhouse gas emissions across the world. No country alone is capable of addressing the complex threats of climate change in the present-day world. To address the growing emissions and climate impacts, integration of better technologies across various energy-producing as well as energy-consuming sectors is necessary. Addressing trans-border impacts of greenhouse gas emissions, complex technical needs of mitigation and adaptation initiatives, demand for scientific knowledge and innovation capability, and so on requires greater interdependence among the countries. To meet the domestic demand for cleaner energy and for transitioning from fossil fuel-based to a clean-energy-based economy, technology remains critical for the developing countries. As the lack of availability of advanced technologies has been a

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critical impediment, developing countries often turn to overseas players for technological support. Global initiatives of climate mitigation under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) also stipulate that financial resources and technology transfer to developing economies are critical in their fight against climate change.

However, the existing predominant models of technology collaboration are often limited to the sale of finished products from technology supplier to the recipient country. This makes the recipient economies merely the market for the source country's products. Despite being the customers of imported products, many recipient economies face three critical challenges with regard to access to advanced technologies—'Affordability', 'Adaptability' and 'Market threat'.

First, with regard to affordability, one may note that the cost of the imported product always hindered the popularisation of a specific technology, thus limiting its access where it is necessary. The suppliers are keen to sell at a premium in the available markets. As there is a lack of advanced technology to meet the growing domestic needs, developing country customers end up paying a premium to access the technology supplied by the source countries. Even with regard to the technologies that are 'appropriate' (Wicklein 1998) in terms of efficiency and have the potential to play a significant role in emissions reduction, affordability remains a critical barrier. Second, in many developing economies, adapting to the advanced technology and its acceptability among consumers are other important challenges. The integration of imported technologies without adequate customisation will limit the recipient country in making full use of the imported technology. Even for those technologies, which are important in terms of environmental benefits, factors such as lack of continuous support, lack of adequate capacity in operations, and lack of adequate customisation to local conditions place serious limitations on their popularisation. Third, the supply of finished products to meet the technology needs in a developing country also adversely affects the recipient country's domestic industries. This has often pushed the domestic manufacturers out of the market or turn them into mere suppliers and resellers of the imported technology or products. On certain occasions, overseas players have been seen as *predatory* by certain domestic industries as the former's cheaper and more efficient technologies systematically oust the latter in markets where both compete. One example is the heavy dependence of India on Chinese players to meet the domestic demand for renewable equipment, especially in the solar power sector. Due to the cheaper supply of solar panels and modules from China, it has been observed that (Parliament of India 2018) India's domestic industries have been reduced to mere suppliers or resellers of Chinese products in recent years.

This chapter introduces co-innovation as a potential solution to address these multiple challenges faced by developing countries against the backdrop of their energy transition initiatives, and their efforts towards building a more sustainable society. As the chapter discusses co-innovation in the case of developing countries, it takes the example of India to explain the experiences of technology transfer and the associated opportunities and challenges. The next section focuses on the need for advanced technology in India against the backdrop of the energy transition and climate mitigation initiatives. Then the chapter discusses the collaboration between India and Japan on the low-carbon technology front. The following section discusses Indian industries losing out to overseas competition, especially to Chinese companies. In order to examine this, the chapter looks at India's dependence on Chinese equipment imports for the renewables sector and how India's players have been losing out to Chinese companies in the domestic energy market. The following section focuses on the role of co-innovation in facilitating better technology collaboration. The chapter then concludes by highlighting the role of co-innovation in the context of developing countries and the advantages it has in giving impetus to energy transition.

2.2 Role of Technology in Energy Transition

The role of technology has been highlighted as a critical element in addressing climate mitigation, originally by the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/FCC), which was established in 1990. The committee has further recognised that Technology Transfer (ToT) is a significant step considering the 'common but differentiated responsibilities' of developed and developing countries (UNFCCC 1990). The fact that the lack of adequate technology in developing economies would continue to be a critical impediment in addressing climate change has further strengthened this perception. However, while the convention emphasises the importance of ToT and collaboration in Paragraphs 1 and 5 of Article 4 as well as in Article 10 (UNFCCC 2016), these have only resulted in shaping various market mechanisms which are yet to make any significant impacts in addressing the technology gaps in the developing countries.

The International Energy Agency's analysis shows that energy-related CO_2 emissions need to be 52% below the current level by 2040 to be on track with the Paris Agreement (IEA 2019). With regard to strengthening the energy transition in developing countries, advanced technology can undeniably play a critical role. The energy transition involves the accelerated deployment of renewable energy technologies and energy efficiency, which requires systemic change, matching and leveraging synergies in innovations across all sectors and components of the system, and involving multiple actors (IRENA 2020). This is critical for the developing economies as there is a need for an enormous change in the way these countries use environmentally damaging fuel sources to meet domestic economic growth. Facilitating the transition from fossil fuel-based to cleaner fuel-based mobility, minimising the usage of coal and fossil fuels in the industrial sector, integrating advanced systems to reduce consumption in all energy-consuming sectors, and so on require upgrades to existing technologies.

2.2.1 *India's Dependence on Imported Technology*

The country's renewable energy expansion plans have benefited from the cheap supply of equipment and machinery from other countries, mainly China. However, it is often noted that the over-dependency on China has also led to the vulnerability of India's renewable energy supplies, as disruptions in supply have adversely affected the growth of the sector. In order to develop alternative supply lines of equipment and machinery from within the country, the industry will need to integrate advanced technology which can facilitate cheaper and more efficient production competitive with the imports. Improving industrial energy efficiency, achieving electric mobility, and strengthening the energy efficiency in the residential and urban building sector are critical targets in order to further meet the energy transition plans of the country.

India also seeks technological assistance in controlling carbon emissions and in limiting environmental damage, using the climate negotiation platforms as well. The alarming growth of carbon emissions in the country also demands urgent action. 'Even though India has one of the lowest per capita energy consumption in comparison to other major emitting countries, the total CO_2 emissions increased by 71.4% between 2007 and 2017 and reached almost 2.3 Gt in 2018, with an annual growth of 4.9% from 2017' (IEA 2019). For India, reducing greenhouse gas emissions and increasing the renewable installed capacity demand integration of advanced technology across the sectors. However, the efficacy of technology collaboration initiatives between India and potential technology source countries faces critical hurdles. The suitability of overseas technology in Indian domestic conditions, concerns regarding royalties, legal issues related to use of a specific technology, lack of adequate customisation adaptive to local conditions, lack of adequate post-sales support and intellectual property rights, and so on are often major hurdles for strengthening technology collaboration. Hence, 'ToT' or 'collaboration' is often reduced to the sale of finished product or equipment to India from the source country which has mature technologies.

An assessment of the technology gaps in addressing climate mitigation highlights that several energy-producing and energy-consuming sectors have been facing a lack of access to efficient technologies in a sustained manner. India's Biennial Update Report also indicates that 'transfer and grounding of appropriate technologies and know-how is the key to enhancing adaptation and mitigation measures' (MoEFCC 2018). The report also presents an array of technologies that are critical for the country to meet its climate and energy goals, the most critical of which are the needs in the transport, industry, power and building sectors. The report states that by 'learning from the collective wisdom of innovators elsewhere, India can complement its efforts and fast-track the development of environmentally friendly technologies appropriate to its national circumstances and requirements' (MoEFCC 2018). However, to put this into practice, India needs to encourage alternative approaches to technology collaboration.

2.2.2 Key Sectors and Technology Need in India

The industrial sector especially plays a significant role in India's GDP. It is also a major contributor to the Gross Value Added (GVA2), which in 2016–17 accounted for 31% of the total. Among industries, the micro, small, and medium enterprises (MSMEs) play a significant role, not only for their contribution to the GDP but also for the fact that a significant share of the industrial workforce is employed in this particular sector.

> The Ministry of MSME, of the Indian government estimates that around 100 million jobs are generated through over 46 million units situated through-

> out the geographical expanse of the country. With 38% contribution to the nation's GDP and 40% and 45% share of the overall exports and manufacturing output, respectively, it is easy to comprehend the salience of the role they play in the social and economic restructuring of India. (Kapuria 2015)

For a country like India, the numerous industrial activities and the energy required to run these industries need to be complementary to the emissions reduction plans that have been given utmost importance over the past few years. The past 10 years indicate that a significant increase in the consumption of fossil fuels has taken place in India. 'The total consumption of raw 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.

On the other hand, 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. However, balancing the energy-economy-environmental targets is crucial for the long-term sustained economic development of the country. To achieve this, the transition to non-fossil fuels is being prioritised by the government with the aim that India's emissions intensity will be substantially reduced in the years ahead. A combination of measures that include supply-side as well as demand-side measures driven by advanced technology is needed in this regard.

The fact that India has massive energy-saving potential is another critical reason for integrating advanced technology in the major energy-consuming sectors. Here, industry, especially MSMEs, emerges as a natural choice with its immense energy-saving potential. India also has been aiming to promote the widespread use of electric vehicles for public transportation. Though there are existing technologies for electric mobility, their exorbitant cost has been adversely affecting their popularisation in India. In addition, the lack of efficient technologies for advanced battery storage and charging facilities and lack of vehicle designs that suit the needs of the Indian consumer also limit the popularisation of existing electric vehicle technologies.

2.3 India's Energy Transition and Technology Needs: Role of Japan and China

Japan and China have been playing an important role in advanced technology-based equipment and machinery in India. While Japan has been India's long-term partner for several decades, China's growing presence in the global equipment and machinery supply chain has benefited India's energy transition initiatives.

2.3.1 India—Japan Technology Collaboration

The progress Japan has achieved on the energy efficiency and energy conservation front is a remarkable learning opportunity for other less developed economies. The governments of Japan and India have been giving great importance to bilateral trade and technology collaboration. The two countries have 'underlined the need to intensify cooperation in technology, space, clean energy and energy sector development, infrastructure and smart cities, biotechnology, pharmaceuticals, ICT, as well as education and skills development to strengthen and deepen their Special Strategic and Global Partnership' (MoFA 2016). They have been collaborating on the technology front for several decades. Japanese technologies have gained widespread recognition as reliable and state-of-the-art technology solutions for diverse sectors. Japan's International Cooperation Agency's role in India in promoting advanced technology for heavy industry as well as various notable national projects have been some of the examples. Japanese—Indian joint efforts to develop Maruti Udyog Limited, metro rail projects that are operational in Indian cities, and the multi-city transport corridor projects are some of the examples of the use of Japanese technologies in India. In the industry sector, too, Japanese technologies play a major role both in heavy industries and the micro, small, and medium enterprises (MSMEs). India's domestic initiatives to improve energy efficiency in the industry and the key energy-consuming sectors will undoubtedly benefit from technology collaboration with Japan.

India has been the largest recipient of Japanese Official Development Assistance loans in past decades (Ministry of Foreign Affairs, Japan 2020). However, most of the technology collaboration and financial assistance to India from Japan has been directed towards supporting the transportation sector, especially metro rail projects. This is despite the fact that there is a high demand for Japanese technology and equipment in the Indian market that has a direct bearing on clean energy generation and energy efficiency. The Japanese private sector's interest in India is rising, and currently approximately 1305 Japanese companies are representing various industries that have branches in India. However, it should be noted that the actual potential of collaboration between India and Japan can be several times greater than what is happening currently.

Market options such as the Clean Development Mechanism, which spearheaded ToT in the past, have not only witnessed a fall in the rate of implementation but also faced limitations in terms of narrow geographical and sectoral coverage (Chatterjee 2011). On the other hand, bilateral mechanisms focusing on the transfer of technology in the form of subsidised sales of finished products also did not hold much appeal for the developing country stakeholders due to economic and technical factors and concerns regarding accessibility, availability, and affordability. Japan's push for a joint crediting mechanism, which also could potentially facilitate technology transfer, has not convinced the Indian policymakers of any notable advantages. Concerns regarding the operationalisation of such an agreement and the lack of information available to the stakeholders pose a critical challenge to concluding the agreement.

Despite the strong bilateral relations India and Japan enjoy, India's bilateral engagement in terms of overall trade or the sale of equipment or finished products required for the industry is remarkably low compared to that with China. To achieve the full potential of enhancing technology collaboration, the countries need to work together and eliminate all possible hurdles that limit collaboration on the technology front.

2.3.1.1 Limitations in Strengthening Technology Collaboration with Japan

Several key factors adversely affect the technology transfer or the collaboration for sharing know-how on advanced technology from Japan to India. Three main factors are listed in this chapter: cost competitiveness, compatibility, and business practices.

Indian customers in the MSME industry sector have often noted that Japanese technologies, despite their advantage in terms of energy-saving potential and durability, are not preferred especially due to their high cost. Similarly, the compatibility of advanced technology remains a key hurdle in technology collaboration. Interactions with industry experts have also highlighted that lack of acceptability of technologies from Japan to India is also because the equipment and machinery supplied in the market do not always take into account the domestic demand and local conditions that influence usage. Hence, the perception of the complexity of a particularly advanced technology/finished product limits its adoption and diffusion in the Indian market.

Technology use in industries is often influenced by regional, geographic, and climatic factors, as well as the practices of maintenance and operation. There is a clear demand for integrating local solutions to these hurdles. Necessary modifications in the equipment to fit the climatic changes, usage and load patterns, placing of equipment in the industry premises, and operation and maintenance will be critical in ensuring the adaptability of the equipment. In addition, flexibility in modifying or refurbishing the equipment is also critical in many developing country contexts. For example, some of the pilot installations of Japanese technology experts (Interviewee-A 2016) revealed that Japanese machinery and equipment are complex in design and do not allow for easy replacement of spare parts, eventually limiting their acceptability in the Indian market. For a product manufactured abroad but sold for local industries in a technology-recipient country, flexibility concerns regarding the designs remains critical. The location of the manufacturing facility, availability of spare parts, availability of locally accessible technical expertise, and so on are also key factors that are critical for successfully promoting technology collaboration.

Another major concern with regard to technology transfer is the perception of a lack of timely post-sales support. Many of the Japanese players are unable to maintain a reasonable ratio of servicing personnel to equipment installations (Interviewee-A 2016). Only in exceptional cases can Japanese players create an adequate presence in post-sales servicing. With regard to industrial refrigeration, an interviewee noted that very few overseas companies which have a long-term presence in India can meet the post-sales service requirement. For example, specifically in the refrigeration sector only one Japanese company maintains the installation to service personnel ratio at 1:20, while the rest of the other leading industry players from Japan can maintain only approximately a 1:100 ratio for installation to service personnel (Interviewee-B 2016). As Japan has achieved substantial improvement in energy-efficient technologies it has received much attention from the Indian industry players. However, the integration of these technologies in India faces serious challenges due to concerns regarding the initial capital cost (Interviewee-C 2017). These concerns continue to be critical challenges in strengthening collaboration between India and Japan.

2.3.2 *China's Export of Equipment and Machinery to India: Politics vs. Technology*

It is interesting to note that the Indian industry and consumers resort to the usage of cheaper equipment options, often received through imports from China. While China continues to be the major source of exports of renewable energy equipment to India, this has also adversely affected the latter's domestic industry production to a significant degree. Though the Indian industry is concerned about over-dependence on equipment supplies from Chinese manufacturers, the clean energy development targets in India have been forcing India to continue its dependence on China. In the case of the renewable energy industry, India imported (Chandrasekaran 2017) almost 87% of the total solar panels required to meet its domestic demand in 2017, of which the majority were imported from China. Recent years have witnessed a substantial increase in energy equipment imports from China. During the fiscal years 2017, 2018, and 2019, India's solar sector imports from China stood at $2817.34 million, $3418.96 million, and $1694.04 million, respectively, which is far higher than India ever imported from any other country (ETEnergyWorld 2020). Though there have been domestic manufacturers involved in solar equipment production in the past, the high influx of cheap equipment from China eventually turned the domestic manufacturer into a retailer of Chinese goods.

It can be noted that India does not consider import dependency on China as a long-term plan; rather it is to meet the immediate demand due to the domestic energy transition targets. However, one of the critical questions raised by many concerns whether or not India can build its domestic industrial production capacity if it continues to depend on imports. This points to the need to increase domestic industrial capacity and improve domestic supply lines of key equipment and machinery.

As per the Paris Agreement, India has also planned to achieve a 40% non-fossil fuel-based supply in the electricity mix. India's renewable energy targets of 175 GW by 2022 and 450 GW by 2030 demand an uninterrupted supply of key equipment and machinery to the renewable energy sector. This further adds pressure on the country to enhance renewable energy production, which inevitably leads to the demand for imported renewable energy equipment from China. However, considering the fact that domestic industry production is insufficient to meet the clean energy targets, the dependence on Chinese products has been growing substantially.

As Chinese exports to India have benefited the domestic energy transition plans, it should be noted that two main concerns have been adversely affecting the collaboration: first, China's exports of cheaper goods to the Indian market; and second, the concerns regarding Beijing's larger strategy to dominate Indian markets. The first is the domestic concern about the dumping of cheap equipment in India and thereby flushing out the domestic industries. It should also be noted that 'Chinese enterprises benefit from preferential policies that lead to subsidized overcapacity in China's domestic market, which then depresses world prices and pushes foreign rivals out of the global market' (White House 2018). While India's trade deficit with China has been widening, imports of Chinese equipment for use in the industrial sector have significantly damaged the MSME. The government has estimated that the dumping of Chinese solar panels in India has resulted in nearly 2,00,000 lost jobs in the MSME sector (TNN 2018) in the energy equipment production arena.

The second concern involves the apparent geopolitical strategy of China (Freeman 2017; Janardhanan 2017) to indirectly weaken India's domestic energy industry and make it heavily dependent on Chinese supplies. It is often noted that 'the Chinese government is implementing a comprehensive, long-term industrial strategy to ensure its global dominance. Beijing's ultimate goal is for domestic companies to replace foreign companies as designers and manufacturers of key technology and products first at home, then abroad' (US-China Economic and Security Commission 2017). It has also come to light that China uses a *predatory* 'debt trap' (White House 2018) model of economic development and finance that proffers substantial financing to developing countries in exchange for an encumbrance on their natural resources and access to markets. Even in India, some observers have noted that China has been pursuing a similar strategy which can be termed predatory. India, out of concern for over-dependency on imports, has imposed a '25% safeguard duty on solar imports from China' (Lal 2018). However, it should be noted that products made in China are often rerouted through neighbouring countries and then to the final destination: Indian markets. The 'Indian Parliamentary Committee report in 2018 found that Chinese manufacturers were also re-routing their products through the markets of other countries that India has Free Trade Agreements (FTA) with. Straddling South East Asia, underdeveloped members of ASEAN have served as hubs for Chinese exporters to circumvent anti-dumping and countervailing duties' (Waghmare and Chakraborty 2018). It is often understood that once dependency is developed on overseas supplies, conventional trade barriers will not be effective.

2.4 Strengthening India's Energy Transition Through Co-innovation

Energy transition in India is a technology-intensive process, as the existing fossil fuel-oriented energy production and consumption infrastructure will need to undergo a drastic change. Fossil fuel-based electricity-generating facilities, internal combustion-based transportation modes, hydrocarbon-based industrial activities, and so on will need to undergo changes for the country to make significant progress in energy transition. As of 2017 accounts, renewables, primarily wind and solar together, have accounted for only 1% of Total Primary Energy Supply (TPES), while coal and oil constitute roughly 44% and 25% (IEA 2020) respectively. In order to significantly improve the share of renewable energy in the TPES, innovation in energy generation is critical. This should not be limited to the technology front but must also involve information technology, policy frameworks, market design, business models, finance instruments, and enabling infrastructure (IRENA 2020). The country also needs accelerated deployment of technologies for renewable energy generation and energy efficiency. Collaboration with Japan and China can contribute to the development of technologies in India; however, the country needs to address the inherent concerns regarding collaboration with these two countries. Here, co-innovation can play a key role. India can co-innovate with Japanese players and produce the equipment and machinery domestically. The domestic policy environment supporting industrial production will also help strengthen the *business-to-business* engagement between these two countries. With regard to China, concerns pertaining to the influx of cheap Chinese goods and Indian industry losing out to its Chinese counterparts have already been adversely affecting trade relations. Co-innovation can help strengthen trade relations and build mutually beneficial collaboration pathways between the two. The subsequent sections discuss co-innovation and the approaches for operationalising this.

2.4.1 Co-innovation: A Conceptual Understanding

Co-innovation is defined as *a collaborative and iterative approach to jointly innovate, manufacture and scale-up technologies* (Janardhanan et al. 2020). While it is a relatively newer approach for discussing technology collaboration between Asian countries, it has been widely used in the context of the IT sector. It is also referred to as 'a shared work of generating innovative and exceptional design conducted by various actors from firms, customers, and collaborating partners' (Saragih and Tan 2018). Along with this concept, two other approaches are also often discussed in the context of joint production and manufacturing: 'co-creation' and 'co-development'. These terms are widely discussed in industry circles when referring to two or more stakeholders coming together to develop equipment or better technology. However, there are two prominent limitations to these concepts. First, these terminologies are used to denote collaboration without any purposive or directional aspects. However, co-innovation is discussed in the context of developing advanced technologies to achieve sustainability transition. In addition, co-creation and co-development often have limitations in recognising the innovative inputs given by various actors and stakeholders outside the product development arena. On the other hand, co-innovation highlights the contributions of various actors and stakeholders involved in the innovation stage. Co-innovation also reflects the continuous exchange of knowledge among all the stakeholders, including scientists, manufacturers, and the end-users of technology. It thereby efficiently captures the efforts of all the stakeholders in comparison to the co-creation and co-development frameworks, which only emphasise the creation and development stages, rather than the innovation stage. While 'co-development or co-creation are the economic model based on maximising the returns on design investments through product sales, co-innovation aims to generate knowledge and incorporate the same for continuous technology improvement, and thereby help the product remain competitive in markets that are constantly being redefined. Hence co-innovation is an approach that requires profound changes in the industrial world's operating rules' (Maniak and Midler 2008). In addition, Maniak and Milder point out that, 'while co-development usually involves a smaller group of partners, co-innovation indicates the cooperation of a wider set of partners outside the traditional channels'.

Another critical question concerns the relevance of co-innovation while stakeholders can depend on the conventional markets or other market-based approaches to sell advanced technology equipment. There are several factors that make co-innovation relevant. First, in the context of conventional technology transfer, the source country can often be ill-equipped to understand the demand conditions specific to the recipient country markets. These include various key factors such as cost sensitivities of the domestic market, climatic conditions under which the equipment needs to operate, and design needs of the consumers. A product or

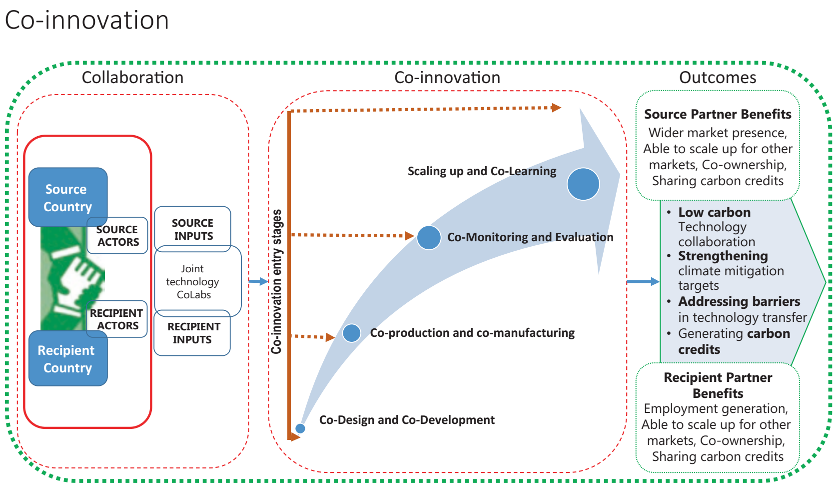

Fig. 2.1 Co-innovation: Schematic Representation. (Source: Janardhanan et al. 2021)

machine that incorporates the knowledge of the local market, consumer expectations, and the requirement by policy as well as the legal environment can perform better in the recipient market. Second, a product that is jointly developed by pooling financial and knowledge resources and by fine-tuning the innovation is likely to have a far better output than a finished product or piece of equipment imported straight from an overseas partner. These factors make co-innovation a valuable approach in redefining the traditional technology collaboration between source and recipient countries. Figure 2.1 shows the process of co-innovation.

2.4.2 *Operationalising Co-innovation*

Co-innovation is intended to promote sustainability transition. Hence, the resultant product or technology developed is expected not only to be technologically advanced, cost-effective, and adaptive to local conditions but also environmentally suitable. Co-innovation may involve multiple stakeholders, including government agencies, the private sector, business organisations, higher institutions, and financial institutions.

Flexibility remains the key to engagement in the co-innovation process. The process of co-innovation can roughly involve three stages: Collaboration, Co-innovation, and Outcome. As indicated in Fig. 2.1 in the first phase of 'Collaboration', both partners recognise the importance of jointly working together and agree on the type and depth of engagement they can have. Both the source and recipient partner can develop technology collaboration laboratories (CoLabs) or joint production facilities with the support of these institutional stakeholders or agencies. This CoLab platform will help partners exchange ideas and develop or refine the concept. With regard to the inputs, both the recipient and source country have their respective domains of expertise, which include technical knowledge that acts as the basic concept. While the key inputs from the source country are initial technical expertise as well as production and manufacturing guidance, the value added to the basic technology and the customisation is undertaken with the inputs of the recipient country. These include local knowledge, understanding the industry needs, demand conditions in the specific geography, information on the market trends, and raw materials. The recipient and the source countries also pool their financial resources at this stage.

The second stage—'Co-innovation'—remains the core segment in the process where multiple phases of collaboration can occur. These include *Co-Design and Co-Development*, *Co-production and co-manufacturing, Co-Monitoring and Evaluation*, and *Scaling-up and Co-Learning*. These phases are indicative of a possible collaboration trajectory under which the partners can work together. The first phase, 'co-design and co-development', focuses on the design and development of technological solutions for addressing local needs and societal challenges. In the second phase, 'co-production and co-manufacturing', the partners develop or manufacture products based on joint technological initiatives/solutions. The 'co-monitoring and evaluation' phase focuses on progress, outcomes, and problem detection, and eventually ensuring the sustainability of the technology solutions. In the last phase, the partners focus on scaling up the products to new markets.

The third stage highlights the 'Outcome' of the collaboration. As the concepts are developed and products are launched to the markets, these joint platforms can aim to expand their product lines and reach out to new markets. The key advantages for the source country are better market presence, the opportunity for jointly scaling up for other markets, cost-effective production, co-ownership of products, and above all sharing of carbon credits in the case where the technology or product can offset carbon emissions in its respective field. Specific advantages for the recipient country include employment generation, the opportunity for jointly scaling up production in newer markets, co-ownership, and sharing the carbon credits. Overall, the process of co-innovation offers climate, health, economic, and environmental co-benefits.

While highlighting the importance of co-innovation the chapter does not undermine the potential challenges in operationalising these. Aligning the interest of the source country and recipients, the capacity of the recipient in manufacturing and production, setting up adequate institutional mechanisms, securing financial resources, legal aspects, and so on will be key hurdles for operationalising co-innovation. In terms of energy transition and addressing greenhouse gas emissions or even minimising air pollution in developing countries, co-innovation can help enhance technology collaboration.

2.4.3 Role of Co-innovation in Facilitating Technology Collaboration

Energy transition is undeniably a technology-intensive process. Whether for the energy-consuming sectors or the energy-producing sectors, improving the efficiency of the equipment used will be of critical importance. As in the cases discussed above, collaboration with Japan is of significant importance for India. The challenges for traditional ToT can be addressed by facilitating policy and legal provisions to enable co-innovation, where overseas partners and Indian industry can jointly develop, fine-tune, and produce advanced technology solutions for addressing energy transition needs in the developing countries.

Unlike the conventional understanding of ToT, where technologies from one country to another are facilitated through business-to-business interactions, it is important to find options for a more sustainable approach. The issues pertaining to energy transition are dynamic and continue to evolve based on the changing economic activities, energy consumption patterns, and so on. Hence, it is important to continuously upgrade and integrate the local concerns in fine-tuning the technological solution. Co-innovation typically helps in achieving the desired targets in a specific local context and helps to make the solutions economically viable even for a larger market. In the case of views with regard to Chinese equipment supplies pushing out domestic market players and China pursuing a long-term 'predatory' strategy to capture the domestic market, one may consider revisiting these debates. Despite the historical perception of China as an aggressor preying on India, one should note that India's collaboration with the former can play an undeniably positive role in the current situation. By promoting opportunities to co-innovate within India, the domestic industry and energy equipment manufacturers also gain the opportunity to develop and learn. However, to what extent co-innovation as a business model will be appealing to China will depend on the policy tools and financial mechanisms India can roll out in support of this. Co-innovation would not only help the external players in pooling resources to produce more efficiently but will also give the source and recipient partners opportunities to explore the market in other economies using their diplomatic and economic ties.

2.5 Conclusion

Taking India's case as an example, this chapter describes collaboration with two countries. First, Japanese clean energy technology companies have not been able to make substantial inroads into the Indian market, despite the two countries enjoying one of the healthiest bilateral relationships in the region. Even though Japanese technologies could potentially support India in its low-carbon development plans, they remain a relatively low-key partner compared to the Chinese companies in India. The high capital cost of technologies and the differences in business practices often pose additional hurdles for Japanese companies reaching out to Indian end-users. Co-innovation is proposed here as a way to bring together the Japanese and Indian industry players to jointly develop technologies and manufacturing in India. It can also provide multiple benefits for Japanese industry, in terms of gaining access to a wider consumer network in India and being able to reach out to other developing country markets. Availability of skilled manpower, natural resources, and the existing policy mechanisms such as Make in India also open up opportunities for building joint manufacturing facilities in India. Indian customers in turn can access world-class technology and equipment and locally adaptive technologies.

The second case discussed in the chapter concerns India's China engagement in the energy technology front. For the past several decades India—China engagement has witnessed political differences taking the driver's seat. The conventional energy sector has also witnessed India and China competing to secure overseas oil and gas assets, which has often paved the way for geopolitical frictions. However, India's over-dependency on China to meet the domestic demand for renewable energy equipment to cater to the energy transition targets has been a concern. With the influx of cheap Chinese equipment and products for the renewable energy sector, Indian producers have faced a serious threat to their survival. As the renewable energy industry is highly dependent on Chinese supplies, policy circles as well as industry are concerned about Chinese players dominating the domestic market. The chapter proposes co-innovation as a possible way for building collaboration in this context. As Chinese companies offer strong advantages in terms of cost-effective products and advanced technologies, Indian companies collaborating with them to manufacture in India will be a win-win situation for both.

Co-innovation offers an opportunity to explore the alternative pathways for strengthening technology collaboration between the source country and the recipient country. It provides opportunities for long-term development, piloting, and commercialisation of technology from the concept to marketable product with the joint efforts of supplier and recipient partners. The chapter highlights that co-innovation will not only help develop locally adaptive technologies but also help strengthen the domestic industry. Technology collaboration or transfer of technology from one country to another is not a new phenomenon. The objective of this chapter is not to reinvent the wheel but to examine the feasibility of technology collaboration in a manner that enhances the long-term partnership between the players. In this sense, the objective of this chapter is to present a potential new platform to supplement the technology collaborations to address climate change impacts.

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