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Green Technological Opportunities for India's Industrial Transformation

This policy brief is based on a Policy Roundtable on "Opening Green Windows: Technological Opportunities for a Low Carbon World - Implications for India" organized by ISID on April 27, 2023. **Dr Clovis Freire *Jr*** of UNCTAD shared the key highlights of UNCTAD's *Technology and Innovation Report 2023* from an Indian perspective. The presentation was followed by discussions by panellists, **Prof Suma Athreye** of the Indian Institute of Technology, Delhi and Visiting Professor, ISID; **Dr Rasmus Lema** of UNU-MERIT, Maastricht, the Netherlands; and **Dr Easwaran Narassimhan** of Centre for Policy Research, New Delhi and Tufts University. **Prof Nagesh Kumar** moderated the roundtable which was followed up by a rich open discussion with an audience that included **Prof Thomas Pogge** of Yale University. The YouTube video of the policy roundtable is avaialble here.

A green and clean transition of economies, is the need of the hour as "business as usual" is not an option for sustainable development. We need an active policy to harness green technologies, particularly for countries like India that are trying to accelerate a clean energy transition with solar, photovoltaic (PV) solar, and other types of green energy sources. The opportunities presented by Green Windows or a Green Revolution, as UNCTAD's *Technology and Innovation Report 2023* calls it, can help not only in clean transition and climate action but also accelerate economic and technological development. The market size of these technologies is projected to go up to $9.5 trillion by the end of the decade, that is, about three times the current size of the Indian economy. What could be the catch-up trajectories for the Global South in general, and for India in particular?

The Early Mover's Advantage

History is witness to the fact that if countries miss an early stage of technological revolution, it creates gaps that are hard to close later and creates a great divide between the per capita incomes of developed and developing countries. The literature on technological revolution shows that countries that were able to catch up, did so at the early stage, at the beginning of the technological revolution -- the installation phase itself -- and not in the mature phase. At the beginning of a new technological wave, every country is more or less in the same position. Early adopters move ahead quicker and then create advantages that others struggle to catch up with later. Thus, it the imperative for developing countries to strongly respond to take advantage of the green windows of opportunity that encompass government policies as well as private sector initiatives.

There are great opportunities in the development of green technologies and frontier technologies. The UNCTAD report discusses a comprehensive picture of 17 green and frontier technologies. These include artificial intelligence, the Internet of Things (IoT), green hydrogen, electric vehicles, and many others. The report analyzes aspects related to market size, the potential to create jobs, and the sectors that are most promising. These technologies already represent a $1.5 trillion market, that could grow to over $9.5 trillion by 2030.

So far, developed countries have been the beneficiaries of most of these opportunities. The total exports of developed countries of

green tech dollars jumped from $60 billion in 2018 to triple at $156 billion in 2021. In the same period, exports from developing countries increased from a similar base, $57 billion, but only to $75 billion, and these exports include those from China. The exports from other developing countries are much lower. For electric vehicles, for example, exports of the top 15 exporter countries - all of them developed countries or China - increased from $28 billion in 2018 to $105 billion in 2021, that is, almost four times. China, the Republic of Korea, and Japan were the major players in the Asia Pacific region.

India's Position in the Frontier Technology Readiness Index

The UNCTAD 2021 report prepared a frontier technology readiness index that tried to assess the preparedness of countries to use, adopt, and adapt frontier technologies, and also considered how inclusive the adoption of the technology was in the society. The indexes combine dimensions related to ICT, skills, R&D, industrial capacity, and financial indicators.

In the 2023 report, UNCTAD ranked 166 countries, and these ranks are dominated by high-income economies, such as the United States, Sweden, Singapore, Switzerland, and the Netherlands. The emerging economies are primarily found in the second quarter of this list. The Russian Federation is in 31st position, China at 35, Brazil at 40, India at 46, and South Africa at 56. The index showed that some developing countries, particularly in Asia, performed better than expected. India was among them and was the greatest over-performer in 2021 by 65 positions considering the GDP per capita of countries and continues to be the greatest over-performer. Other countries that over-perform are the Philippines and Vietnam.

India is particularly well positioned for high-tech manufacturing, as well as in the digitally deliverable services. Comparing the average of the components of the frontier technology index of India with the other countries in South Asia, it is seen that India is performing better in almost every component, with the exception of finance and skills. India ranks high in R&D due to the number of patents and publications,

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however, there is a scope for improvement in that segment. Compared to other BRICS countries, India spends a lower amount on R&D as a percentage of GDP, about 0.66%. Brazil spends 1.17%, and China 2.14%. The United States and China still dominate the space for publications and patents with China making huge increases in the past decade to claim half of the patents on Industry 4.0. India also shows a significant number of publications in Industry 4.0 frontier technology, such as AI and IoT. Overall, India is among those competing in the production of knowledge products associated with frontier technologies. The number of Indian patents related to frontier technologies has increased and shows a big jump from 2008 to 2019.

In recent years, there has been a big increase in the participation of developing countries related to green transformation, in renewable energy, for example. India is among the top 10 economies that will install renewable energy capacity for wind energy, and solar PV. India has tripled its installed capacity in wind and bioenergy. In the case of solar PV, India was not among the top 10 in 2010, but in 2020, it became one of the leading economies.

Scenario of a Green Pathway for India

According to estimates, in a business-as-usual- scenario, India will produce 7.3 gigatons (gt) of CO2 equivalent in 2050. However, if India reduces these emissions and sets more ambitious goals, it could reduce its emissions to 2.2gtCO2 e by 2050. This would require the country to reduce emissions from the industrial, electricity, and transport sectors to 2.6gtCO2 e, 1.1gtCO2 e, and 0.7gtCO2 e, respectively. Achieving these targets will create new opportunities for India to invest in and reap economic benefits from the transition.

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In the electricity sector, India is already on track to deploy a significant amount of renewable energy, even under current practices. However, to reach its more ambitious goals, the country will need to invest heavily in solar PV (1450gw from the current 50gw capacity), wind (900gw from the current 40gw capacity), offshore-wind (500gw), and 450gw of storage capacity.

Similarly, the industrial sector will need to switch from fuel use to electricity, which could reduce emissions from 1588 to 9200 PJ/year. Investing in green hydrogen production could also create a significant wedge, increasing from zero to 4500 PJ/year, which would require about 150gw of electrolysis capacity.

In the transport sector, India will need to transition to an electric vehicle (EV) ecosystem, with more than four million cars, 52 million two-wheelers and three-wheelers, and more than a million buses and freight vehicles annually. A minimal addition of hydrogen vehicles (0.5 million cars and 1.2 million trucks per year) will also be necessary.

Overall, these estimates highlight the significant opportunity for India to invest in renewable energy and clean technologies in this decade to scale up and transition to a low-carbon economy beyond 2030.

Pathways for a green transition

Three pathways can be identified that could benefit a developing country like India from the green technological revolution. The first path is by developing and using renewable energy technologies. The second one is by greening traditional global value chains by switching to digital technologies associated with smart manufacturing. The third path is by diversifying the economies towards products and production sectors that are more complex, and require higher levels of technology, but are associated with lower carbon footprints. Additionally, skilling the population would be an important tool as countries that are in a better position to move to smart production using Industry 4.0 are those that have a stronger manufacturing base as well as high proportions of skilled workforce in the total workforce. Technological catch-up would not be possible without proactive strong government efforts with aligned industrial policy, environmental policy and energy policy. International cooperation, both in terms of multilateral trade rules and intellectual property rights (IPR) would be an integral factor in fostering green pathways. We briefly discuss these components here.

Renewable Energy Technologies: Learning from countries that were able to catch up, the best scenario is where a country has strong preconditions, and these preconditions are combined with a strong response from the country. To give an example, China had an edge in the development of technologies related to solar PV and biomass. This was coupled with the solar rooftop subsidy programme to boost the demand for solar PV, among others. There is, of course, a large variation in the catch-up trajectories across the sectors and at the country levels. However, in case a country does not have strong preconditions, it does not mean that the window of opportunity is closed. The response at different levels of government and the involvement of public and private stakeholders can be a game-changer. To illustrate, while moving to biofuel, Thailand had to address some weak initial preconditions. There was a low interest from the private sector because of the high investment costs. The government provided a very strong policy response with subsidies, tax incentives, and mandatory purchasing of energy generated. These developed a strong sectoral-based system that compelled domestic firms to use and interact with this technology creating an experience base.

For India, in the case of solar PV, the country has maximized the installed capacity by prioritizing cheaper prices by importing the components instead of building the domestic manufacturing capability. This attracted large projects offering low tariffs and incentivised energy developers to rely on the cheaper import of solar cells and panels. However,

there was a limited emphasis on R&D and building up domestic production capabilities. When local content requirements were introduced at some point, domestic capacity to fulfil the requirement was inadequate. In 2018, under pressure from domestic manufacturers, the government introduced some safeguards against solar cell imports from China and Malaysia, that led to slowing down of the bidding process slowed. Later on the Government launched the production-linked incentives to domestic manufacturers to expand the local production. There are still opportunities related to services on the value chain and not just for the manufacturing of components.

In the case of biofuels, there is the ambitious programme of Jatropha biodiesel development in India. However, production fell short of the capacity. Public institutes did not carry out sufficient research to increase the yields resulting in some short-duration crops. Perhaps a better approach could be to shift from Jatropha to using multiple types of feed-stocks or inputs instead of only one with a better system of incentives, both at the feed-stock and biodiesel production stage. This would require increasing efforts on R&D and increasing the yield from this feedstock.

Digitalization and Greening of Traditional Value Chains: India could benefit from two increasingly intertwined processes, the greening and digitalisation of global value chains. The greening of the global value chains can be done by switching to digital technologies associated with smart manufacturing. There are many examples of how Industry 4.0 can enhance sustainability, reduce energy and material use, and so on. The other way is through upgrading the value chain based on voluntary sustainability standards. This can trigger a series of changes in the value chain from upstream input to production process, from product design to downstream consumption. This has the potential to push a lot of change. The governance of the global value chain can impact this process as well. The brand company at the end of the value chain can however push the voluntary sustainability standards that might squeeze suppliers in developing countries, hence preparedness as well as some safeguards are essential.

Diversifying the economy towards complex production with a lower carbon footprint: The third path for developing countries like India would be greener production of more complex products that require higher levels of technology and are also associated with lower carbon footprints.

In most low-income developing countries, economic diversification is path-dependent because it involves emulating industries that already exist in more developed countries. Also, if a country is largely producing primary products, (commodity-dependent countries, as is the case of over 100 countries of the 195 UNCTAD member countries), there are fewer starting points for this kind of diversification. But whatever path a country chooses to take, switching to green is imperative, and governments in low and lower-middle-income developing countries have to act fast and decisively to identify these products.

A country like India which already has the capacity to manufacture medium and high-tech products will be in a much stronger position for this kind of production. However, it is not easy to identify these products. For example, the manufacturing of chemical products is very complex using high-end technology but is also associated with much higher carbon emissions. The UNCTAD study shows an index of economic complexity and carbon footprint for over 43,000 products exported in international markets and identifies the most complex sectors with low carbon footprints. For selecting more complex and greener directions, governments have to strengthen their national capacities to analyze these new

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sectors and also see how they can fit into global value chains.

Among the countries that have increased their economic complexity from 2000 to 2018 are India, Poland, China, Turkey, Romania, the Czech Republic, and Vietnam. In the case of India, there was an increase in the index of carbon emission but this was not high compared to the global average, so it was able to increase complexity without the associated cargo emissions. China also increased complexity but with a big increase in associated carbon emissions.

The Skill Factor: Countries that are in a better position to move to smart production using Industry 4.0 are those that have a stronger manufacturing base already as well as high levels of skills because these technologies augment skills. Advanced industrialized and knowledge economies as well as some in the Asia-Pacific region like Singapore and the Republic of Korea and developing economies well placed in the global value chain of high-tech products such as the Philippines and Malaysia have strong and high levels of skill. However, countries like India, China, Thailand, and Vietnam have manufacturing capabilities in value chains of high-tech goods but have fewer high-skilled jobs compared to the total number of jobs that could benefit from Industry 4.0. Not having large shares of high-skill workers in the total workforce adds to the risk of being left behind. There is an urgent need for India to focus on skilling its workforce towards Industry 4.0 compatible jobs.

Aligning Policies: As observed earlier, technological catch-up would not be possible without proactive strong government efforts. Strong participation of the government to align policies— industrial policy with environmental policy and energy policy—should be a priority for every government. It is important to provide incentivise shifting the consumer demand towards greener products, to renewable energy technology, investment in R&D, digital infrastructure, and skill base of the workforce as well as the industry.

In the earlier cited example of Thailand with biogas production, for instance, the Ministry of Energy in the country developed environmental regulations and also encouraged industry to invest in biogas production. Another example is the green hydrogen hub in the state of Sierra in Brazil where port infrastructure at the Port of Essene, solar and wind energy parks, and an export processing zone were part of the whole initiative. This is how governments at different levels, at the national, state, and local levels need to push for these transitions.

Consistency in Multilateral Trade Rules: Many of the successful domestic policies for developing countries will depend on international cooperation and international trade. WTO rules will need to be consistent with the requirements for implementation of international agreements for climate change. Trade rules should permit developing countries to protect their infant green industry through tariffs, subsidies, and public procurement so that they can develop them to not only meet their local demand but also reach scales to make exports competitive. Countries like India should be able to use some of these tools like incentives and infant industry protection to build scales in domestic production of solar and wind energy equipment for meeting the targets of clean energy transition and over time strengthening their capacity for exports. Improving trade facilitation and ensuring a stable environment for trade is crucial.

Intellectual Property Rights (IPRs): There is often a strong push for technology transfer in the talks around climate change, but similar effort is often absent on the trade agenda. This requires a more consistent approach. The introduction of greater flexibility with respect to IPRs like the measures taken during the Covid-19 pandemic and the HIV-AIDS drugs through Agreement on TRIPS and the Public

Health will be critical for less technologically capable developing countries to deploy the new technologies. International cooperation to extend a more flexible approach towards intellectual property rights would, therefore, be critical and be an integral factor in fostering green pathways, demonstrating seriousness of the international community about tackling climate change.

Furthermore, much of the technologies needed to promote sustainable economic growth and greener production are already available. What is needed is the political will to help developing countries like India to build their capacities to absorb these technologies and adopt innovation and industrial energy policies that are coherent to catch the green technological revolution at an early stage.

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