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# Collaboration Leads to Fusion that Accelerates Decarbonization

## *- Lessons from Japan, Learning from India*


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## Abstract

**India and Japan rank the 3rd and 5th in global $CO_2$ emissions.**

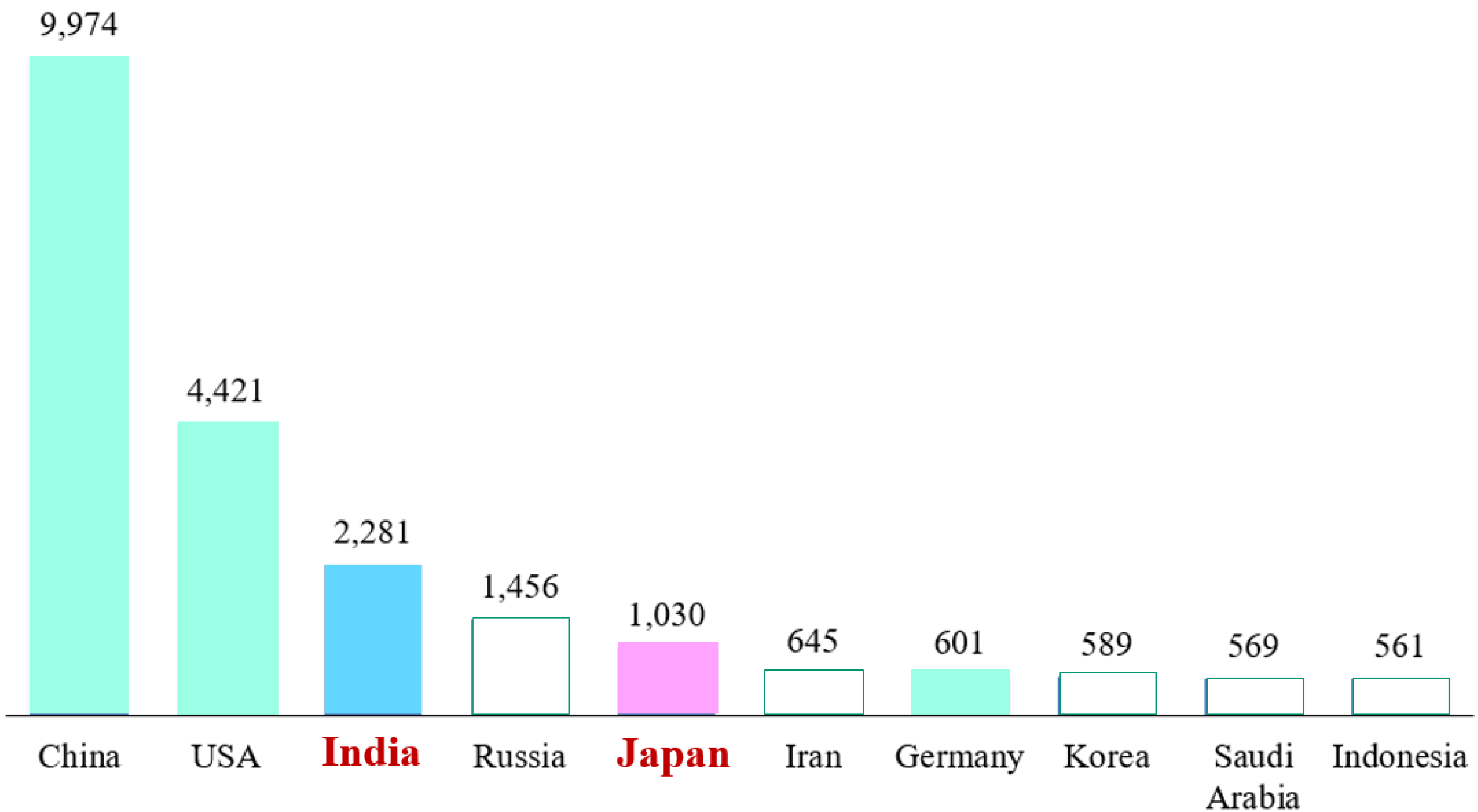
**While Japan is reducing $CO_2$ by R&D-driven energy/$CO_2$ reduction, India's economic growth results in $CO_2$ increase despite rapid DX.**

**This contrast reveals India's DX at a crossroads and highlights the significance of fusing with Japan's manufacturing strength.**

**This symposium triggers the peer effect leading to a snowball effect of this fusion, paving the way for a substantial decarbonization of the global south.**

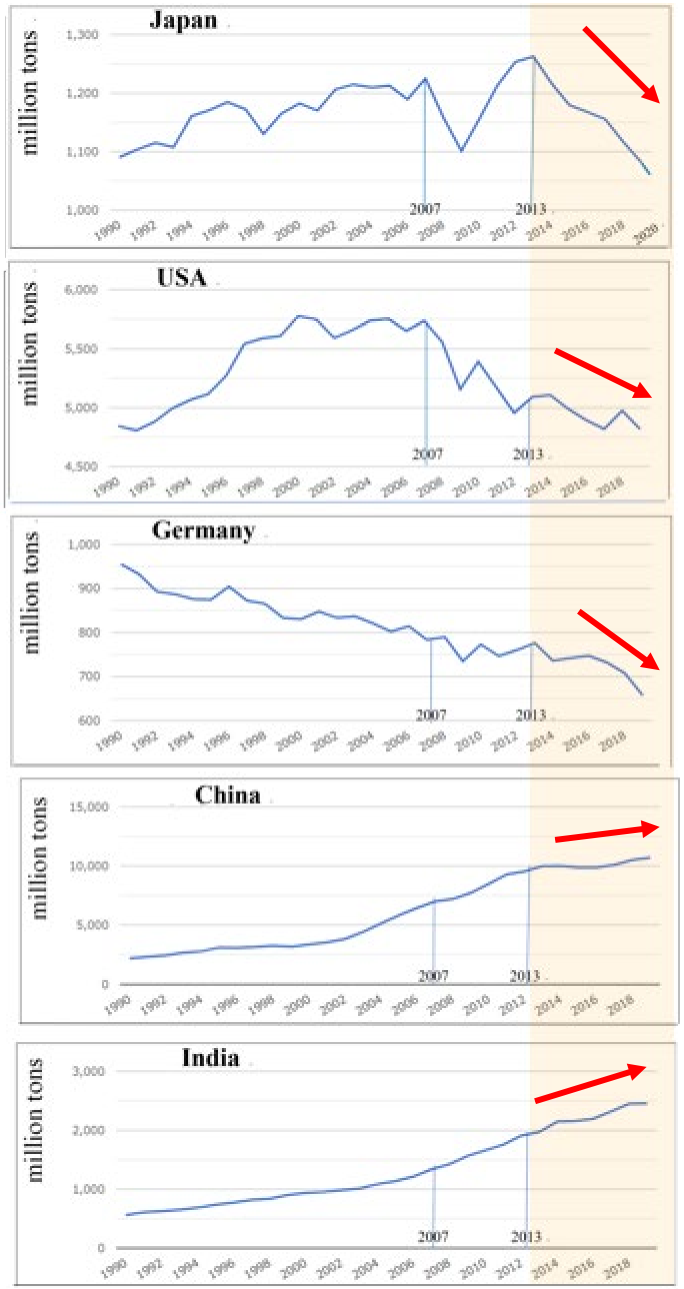
# 1. Top 10 $CO_2$ Emitting Countries in the World (2020) – million tons.

**India and Japan rank the 3rd and 5th in global $CO_2$ emissions.**



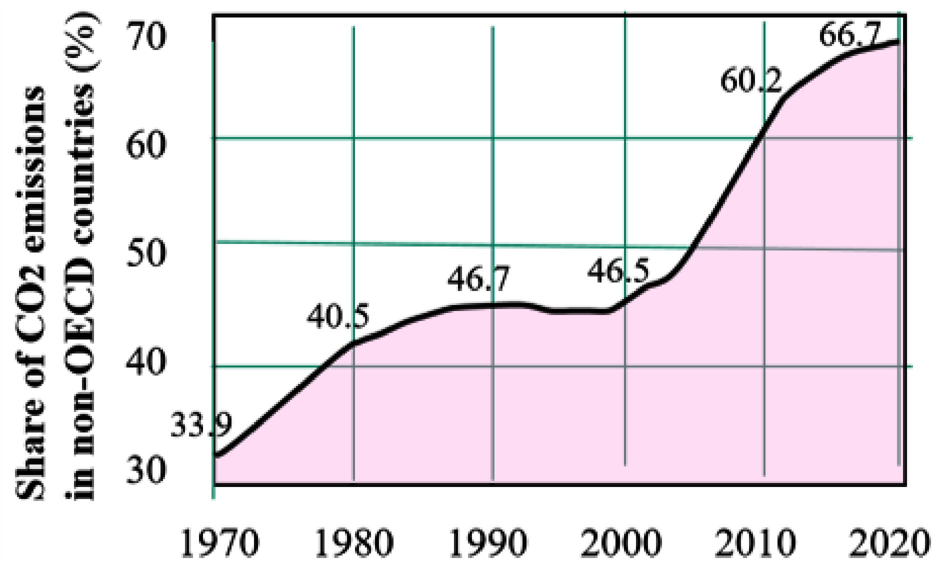

Source: BP Statistics (2022).

# 2. Trend in $CO_2$ Emissions in 5 Countries (1990-2020) – million tons.




**Contrary to declining trend in $CO_2$ emissions in Japan, USA and Germany, economic growth in China and India result in continuing increase in their $CO_2$ emissions.**

**$CO_2$ emissions in the global south have increased rapidly and now account for two-thirds of the world's total emissions, making their reduction a global challenge.**




**Trend in the Share of $CO_2$ Emissions in non-OECD Countries** (1970-2020) - %

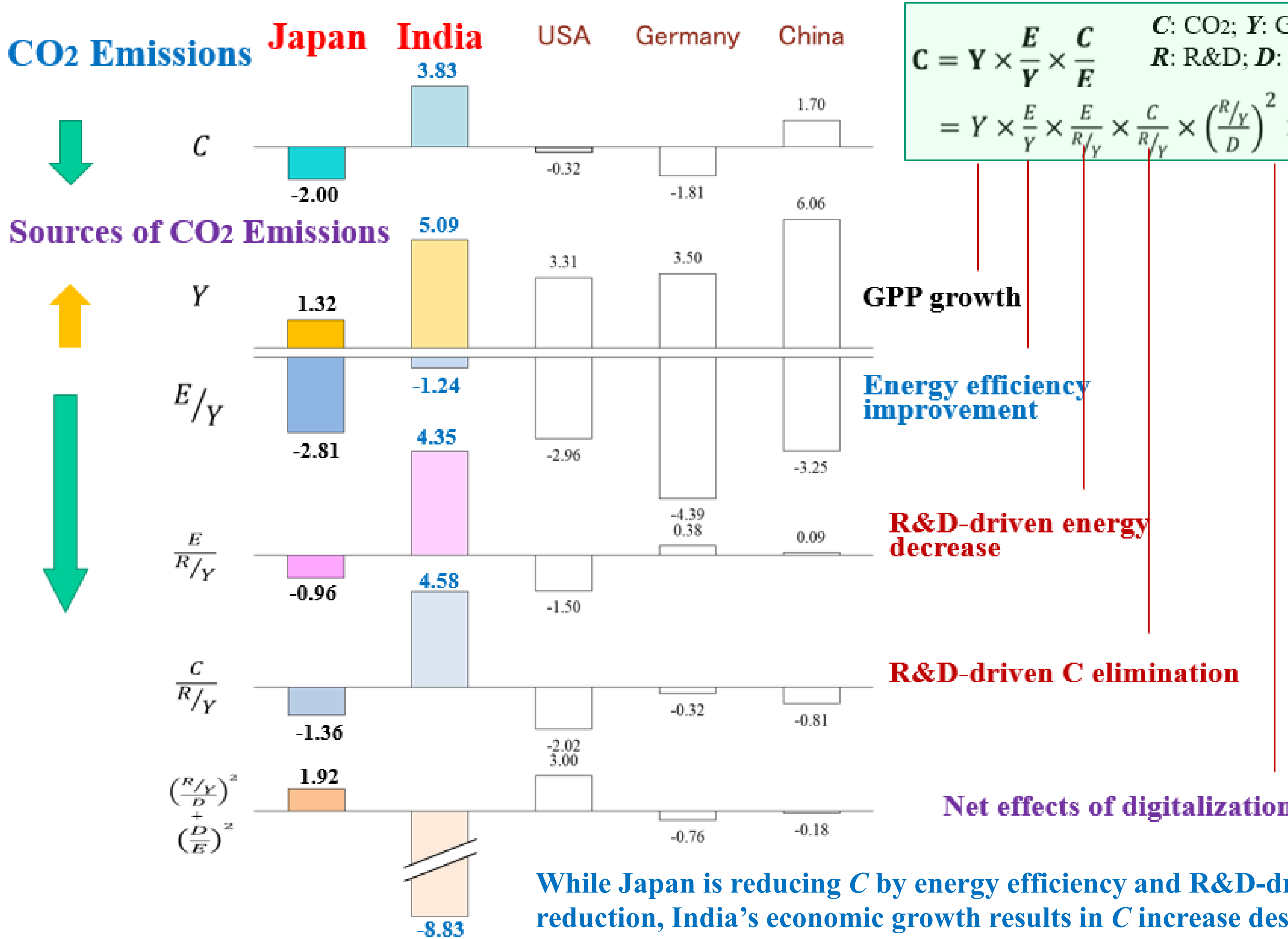
Source: World Bank Data Indicators.

# 3. Average Change Rate of $CO_2$ Emissions and Sources in 5 Countries (2013-2020) – % *p.a.*

$$C = Y \times \frac{E}{Y} \times \frac{C}{E}$$

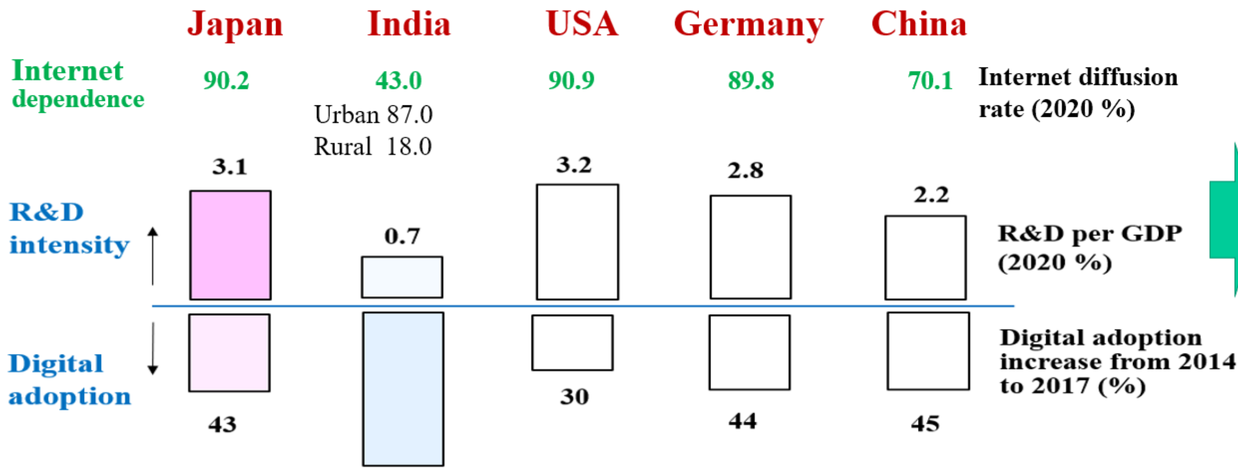
$$= Y \times \frac{E}{Y} \times \frac{E}{R/Y} \times \frac{C}{R/Y} \times \left(\frac{R/Y}{D}\right)^2 \times \left(\frac{D}{E}\right)^2$$

***C***: $CO_2$; ***Y***: GDP; ***E***: energy; ***R***: R&D; ***D***: digitalization

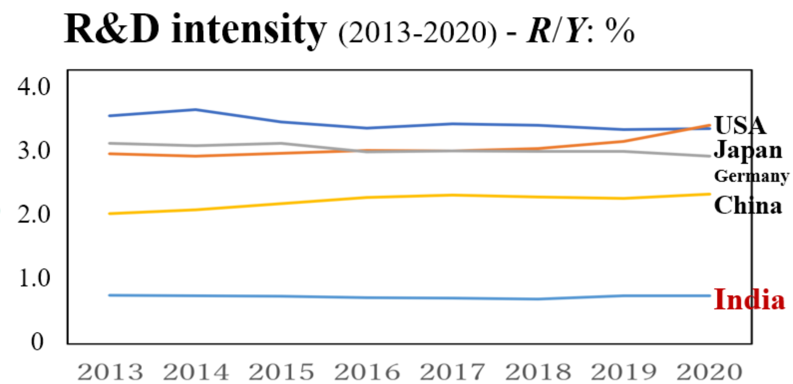


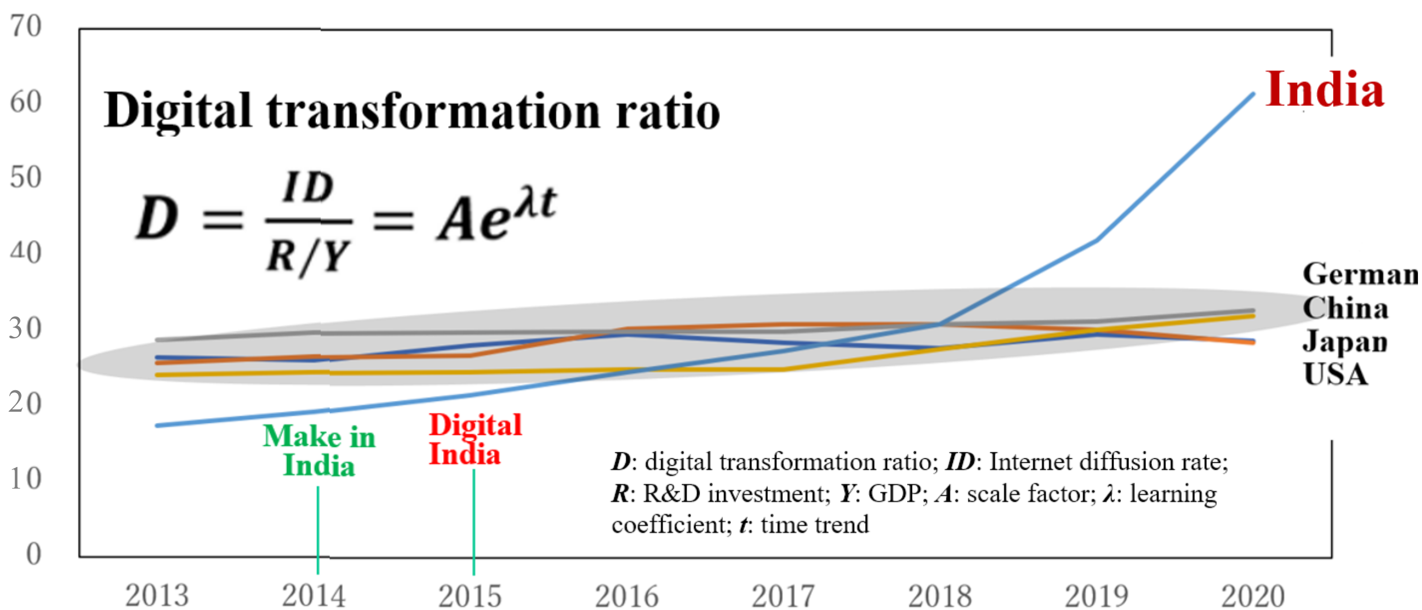

**While Japan is reducing *C* by energy efficiency and R&D-driven *E*/*C* reduction, India's economic growth results in *C* increase despite DX.**

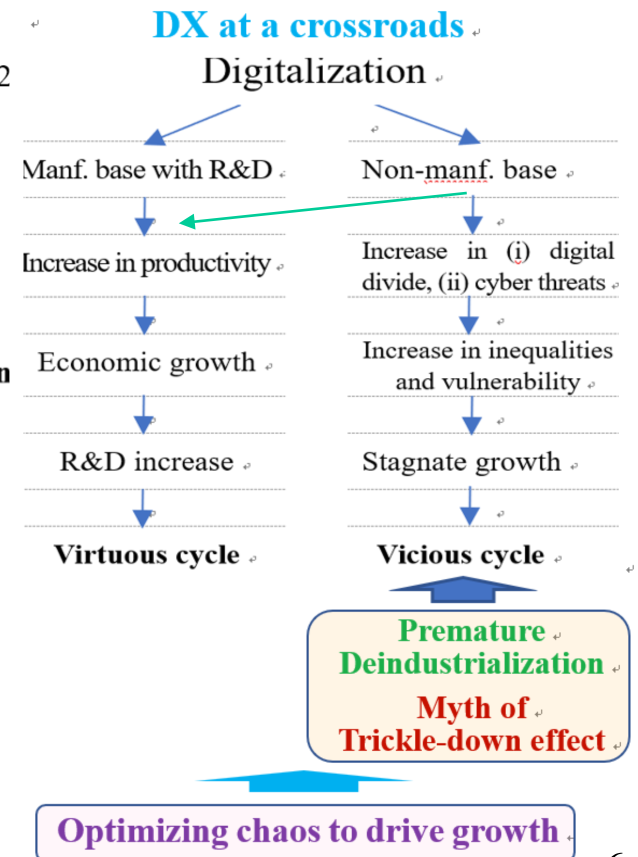
# 4. R&D Intensity and Digital Adoption in 5 Countries




Sources: World Bank (2022), OECD (2022), McKinsey Global Institute (202



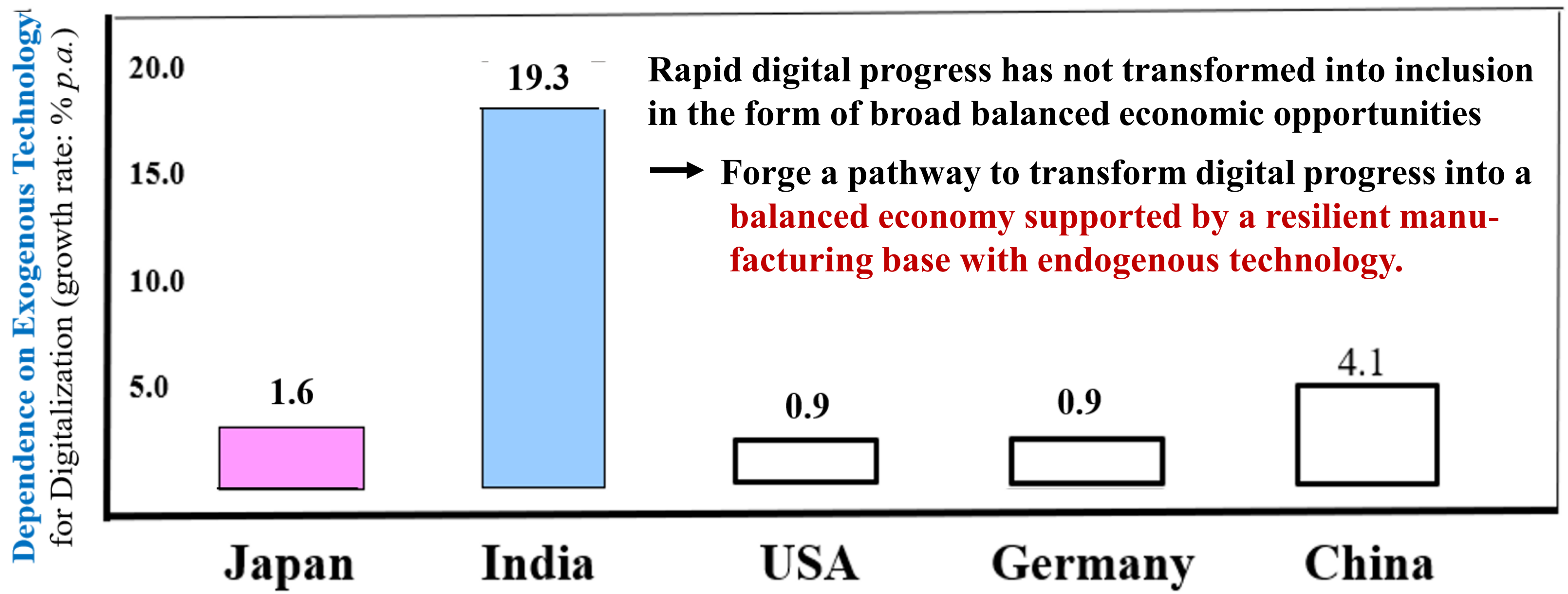




**While inclusive digitalization that contributes to economic growth is backed by a progress of R&D, digitalization in India is accelerating beyond the pace of R&D increase, resulting in its DX at a crossroads.**

# 5. Dependence on Exogenous Technology for Digitalization in 5 Countries

(2013-2020) **Such a rapid digitalization centered on exogenous technology requires balanced development that complements endogenous technology development.**

$\lambda$




**Digitalization state** is represented by **the Internet diffusion rate *ID*** governed by $R/Y$ and $\lambda$.

$$ID = Ae^{\lambda t} \cdot \frac{R}{Y}$$

$A$: scale factor, $\lambda$: learning coefficient, $t$: time trend, $R$: R&D investment, $Y$: GDP.

**Exogenous technology**

Only rich/skilled can enjoy → Exacerbate inequalities → **Vicious cycle**

→ Accelerate ***Leap Flog in a double truck***

$\ln ID = \ln A + \lambda t + \ln R/Y,$

$$\frac{\triangle ID}{ID} = \lambda + \frac{\triangle R/Y}{R/Y}$$

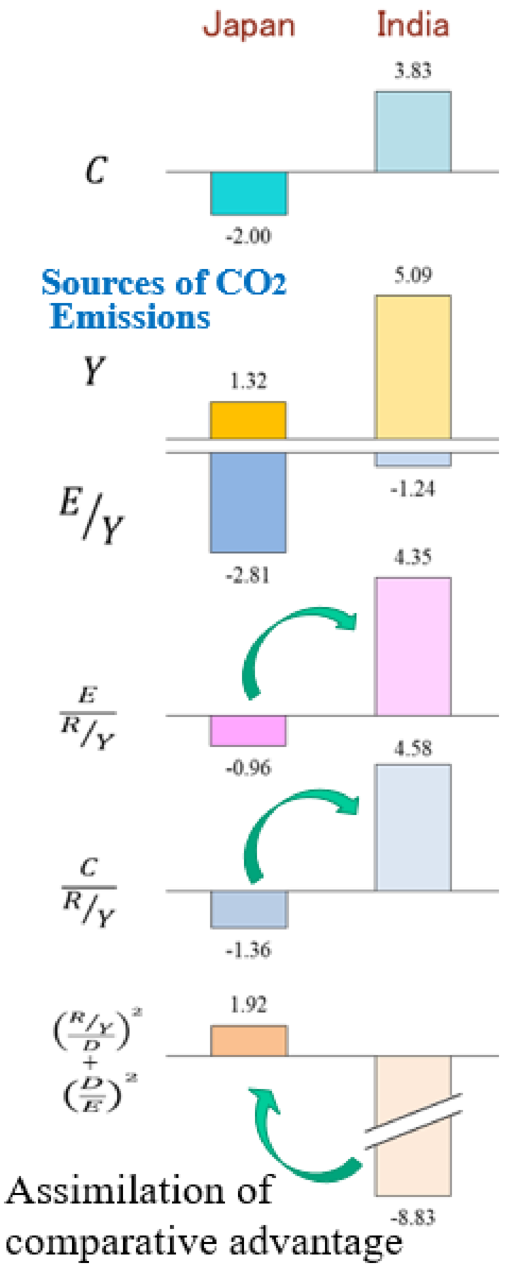
UPI (Unified Payments Interface)
+ UPI 123 Pay (by feature phone)
+ PI Lite (Offline payments)

**Endogenous technology**

**Virtuous cycle with growth → Synergy of ESG + growth**

# 6. Comparative Advantage between Japan and India and Assimilation Possibility (2013-2020) % *p.a*,

## $CO_2$ Emissions




| | $C$ | $Y$ | $\frac{E}{Y}$ | $\frac{E}{R/Y}$ | $\frac{C}{R/Y}$ | $\left(\frac{R/Y}{D}\right)^2$ | $\left(\frac{D}{E}\right)^2$ | $\varepsilon$ | $\left(\frac{R/Y}{E}\right)^2$ |
|---|---|---|---|---|---|---|---|---|---|
| **Japan** | **-2.00** | 1.32 | -2.81 | -0.96 | -1.36 | -5.92 | 7.84 | -0.11 | 1.92 |
| **India** | **3.83** | 5.09 | -1.24 | 4.35 | 4.58 | -41.87 | 33.04 | -0.12 | -8.83 |
| | $CO_2$ emissions | GDP growth | Energy efficiency Improve-ment | R&D-driven energy decrease | R&D-driven $CO_2$ elimination | **Decarboni-zation through DX** | **Green energy creation by digitalization** | Confoun-ding term | Net digitali-zation effects |

| $\frac{E}{R/D}$ | $\frac{C}{R/D}$ | $\frac{R/Y}{D}$ | $\frac{D}{E}$ |
|---|---|---|---|
| **R&D-driven energy decrease** | **R&D-driven $CO_2$ elimination** | **Decarbonization through digital transformation** | **Green energy creation by digitalization** |
| 1. Additive manufacturing (3D printing)<br>2. Robotics and automation<br>3. Energy-efficient equipment & machinery<br>4. Sensor technology & industrial IOT<br>5. Sustainable supply chain management | 1. Carbon capture & utilization (CCU)<br>2. Process optimization & efficiency<br>3. Sustainable materials & green chemistry<br>4. Circular economy & recycling<br>5. Smart manufacturing & industrial IOT | 1. Big data analysis & machine learning<br>2. Digital twin technology<br>3. Energy management systems (EMS)<br>4. Digital supply chain management<br>5. Remote monitoring & collaboration tools | 1. Sustainable energy sources<br>2. Virtualization & cloud computing<br>3. Data center optimization<br>4. Renewable energy procurement<br>5. Electrification and alternative fuels |

Japan's comparative advantage    India's comparative advantage

**This requirement highlights the significance of the fusion of Japan's manufacturing strength with India's DX.**

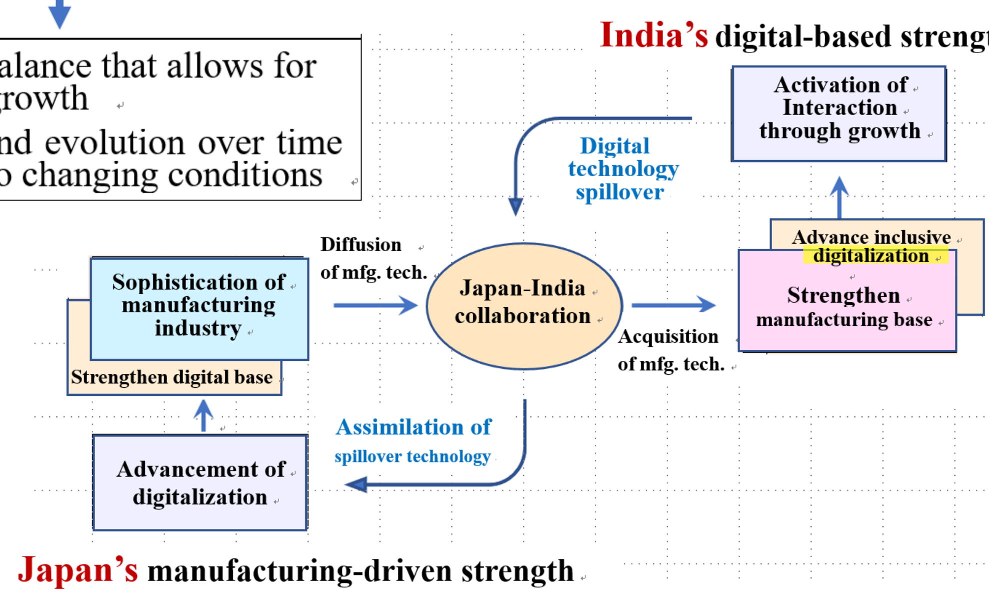
# 7. Jugaad: India's Unique Innovation Inducing System

**The Role of Fusion in "Jugaad "** (Indian indigenous innovation inducing system), **in contrast to Forest Ecosystem**

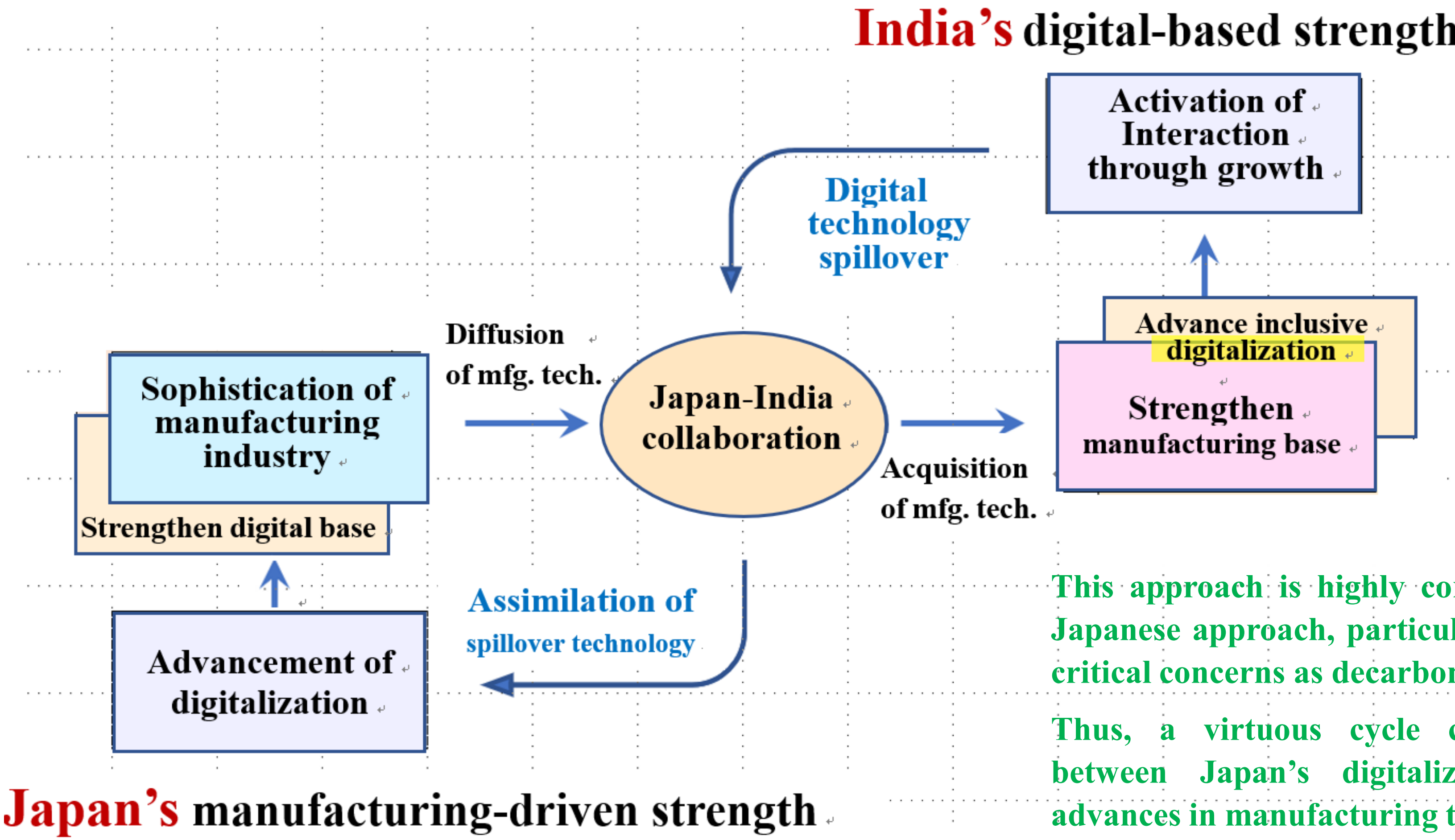
| | Jugaad that optimizes chaos to drive growth | Forest ecosystem |
|---|---|---|
| Potentials | 1. Resourceful<br>2. Diverse skills and ingenuity<br>3. Adaptive solutions<br>4. Innovation-seeking<br>5. Problem-solving | 1. Resourceful<br>2. Diverse species with strengths<br>3. Adaptive survival<br>4. Co-evolution with environment<br>5. Survive in a changing environment |
| | **Fusion of strengths** | |
| Challenges | 1. Innovation against chaotic or resource-constrained environments<br>2. **Collaboration** to find innovative solutions beyond individuals | 1. Go through cycles of growth, decline, and regeneration<br>2. Collaboration through symbiotic relationships |
| | **Growth and sustainability** | |
| Outcomes | 1. Sustainable solutions that optimize available resources<br>2. Resilience to evolve in the face of uncertainty and chaos | 1. Maintain a balance that allows for sustainable growth<br>2. Resilience and evolution over time in response to changing conditions |

**The increasing importance of such fusion facilitates Japan-India collaboration as it leads to a fusion of their strengths that is key to India's indigenous innovation inducing system, "Jugaad," which optimizes chaos to drive growth in a frugal, flexible and inclusive way.**

**Jugaad is similar to the sustainable growth of forest ecosystems and has an affinity with Japan's system of transforming crises into springboards for innovation.**



# 8. Dynamism of Fusing Japan's Manufacturing Strength with India's Digital Transformation




This approach is highly complementary to the Japanese approach, particularly to the common critical concerns as decarbonization.

Thus, a virtuous cycle could be triggered between Japan's digitalization and India's advances in manufacturing technology.

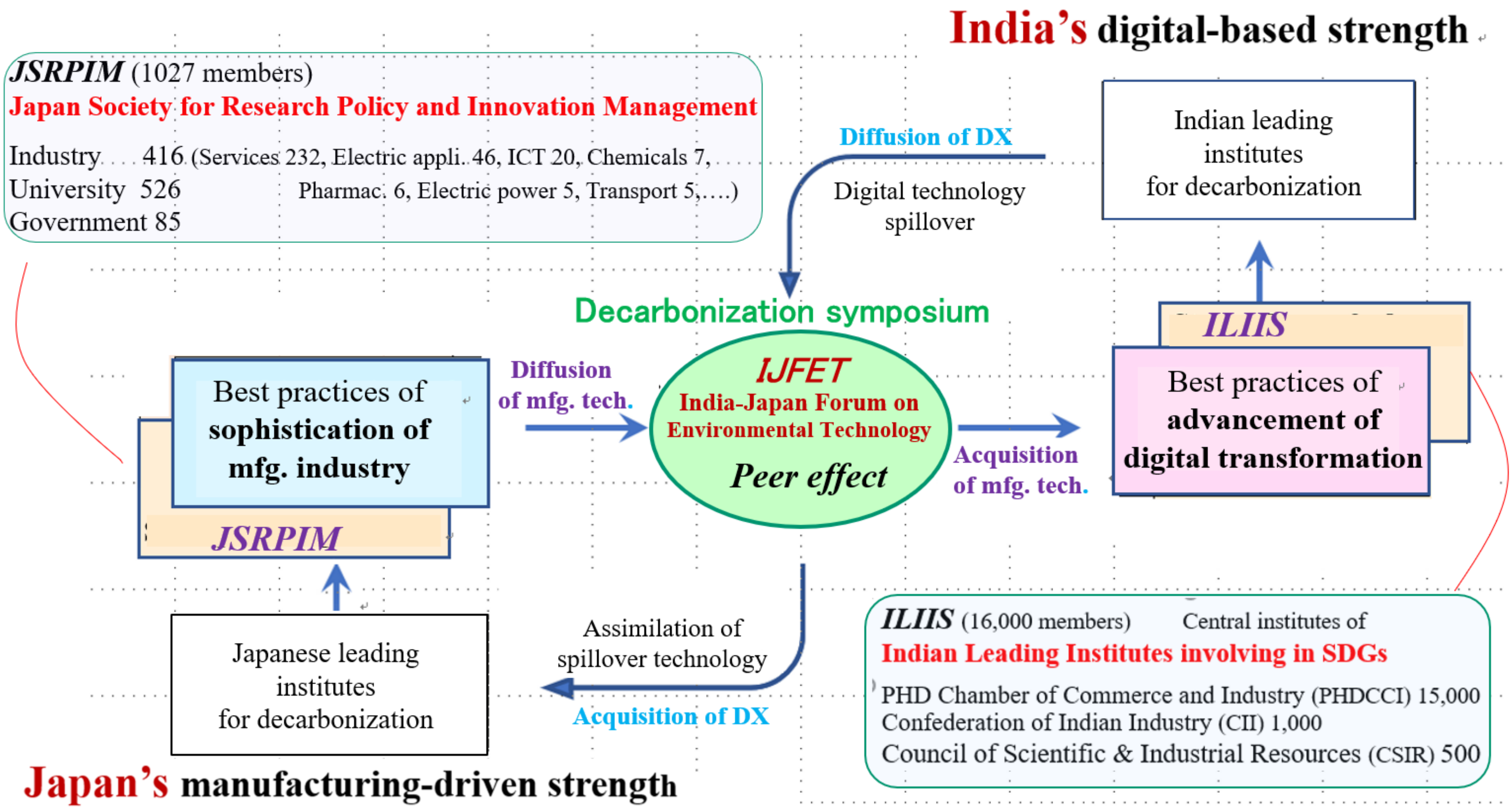
It would be effective to build a platform that exerts a "peer effect" by sharing the comparative advantages of Japan's manufacturing and India's DX, and to induce a virtuous cycle in which fusion matching increases like a snowball.

This will lead to global standards with practical, innovative, frugal, flexible and comprehensive solutions that can be applied in the global south. Japan will also incorporate India's DX towards decarbonization.

A multilayered virtuous cycle towards decarbonization can be built between Japan, India, and the countries of the global south

# 9. Organization of Japan-India Symposium towards Decarbonization of the Global South

## - Fusing Japan's Manufacturing Strength with India's Digital Transformation




**This symposium, organized by *IJFET*, triggers the peer effect between *JSRPIM* and *ILIIS* leading to a snowball effect of the fusion of Japan's manufacturing strength with India's DX, and paves the way for a substantial decarbonization of the global south.**

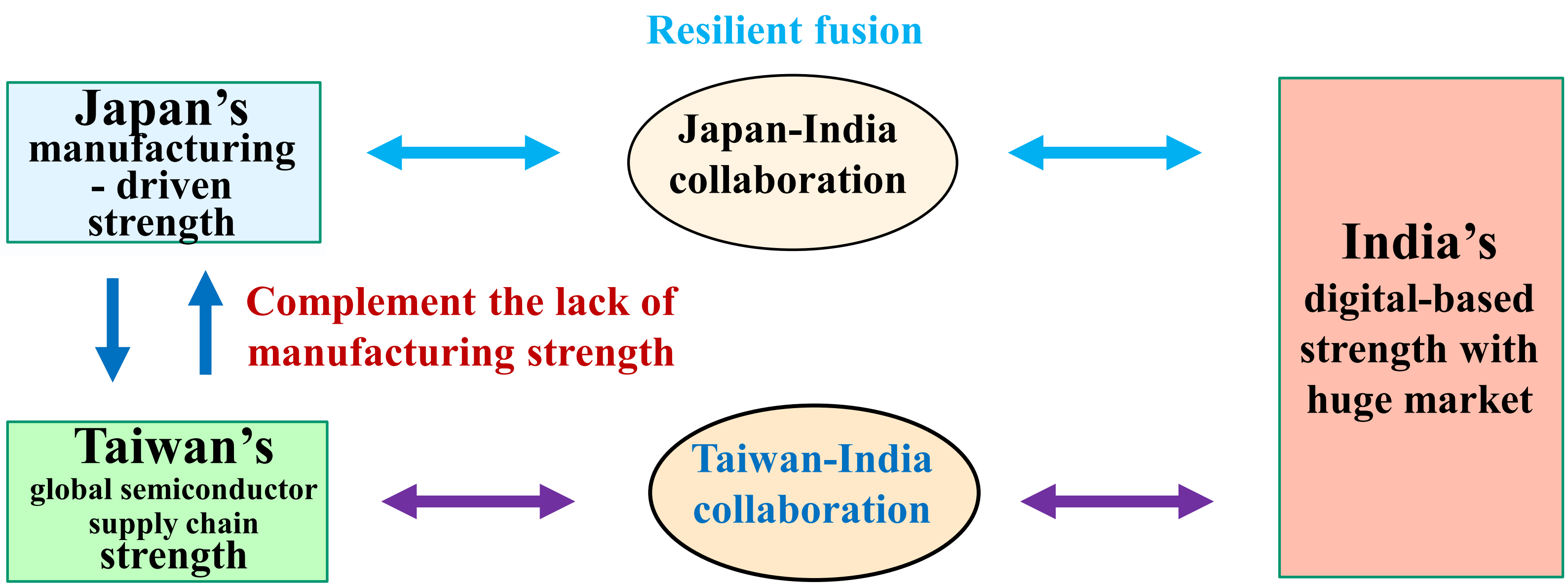
# 10. Resilient Fusion by Complementing the Lack of Manufacturing Strength

Needless to say, Japan's manufacturing technology is not omnipotent; for example, cooperation with Taiwan is essential for constructing a global semiconductor supply chain which is indispensable to accelerating the transition to a low-carbon economy.

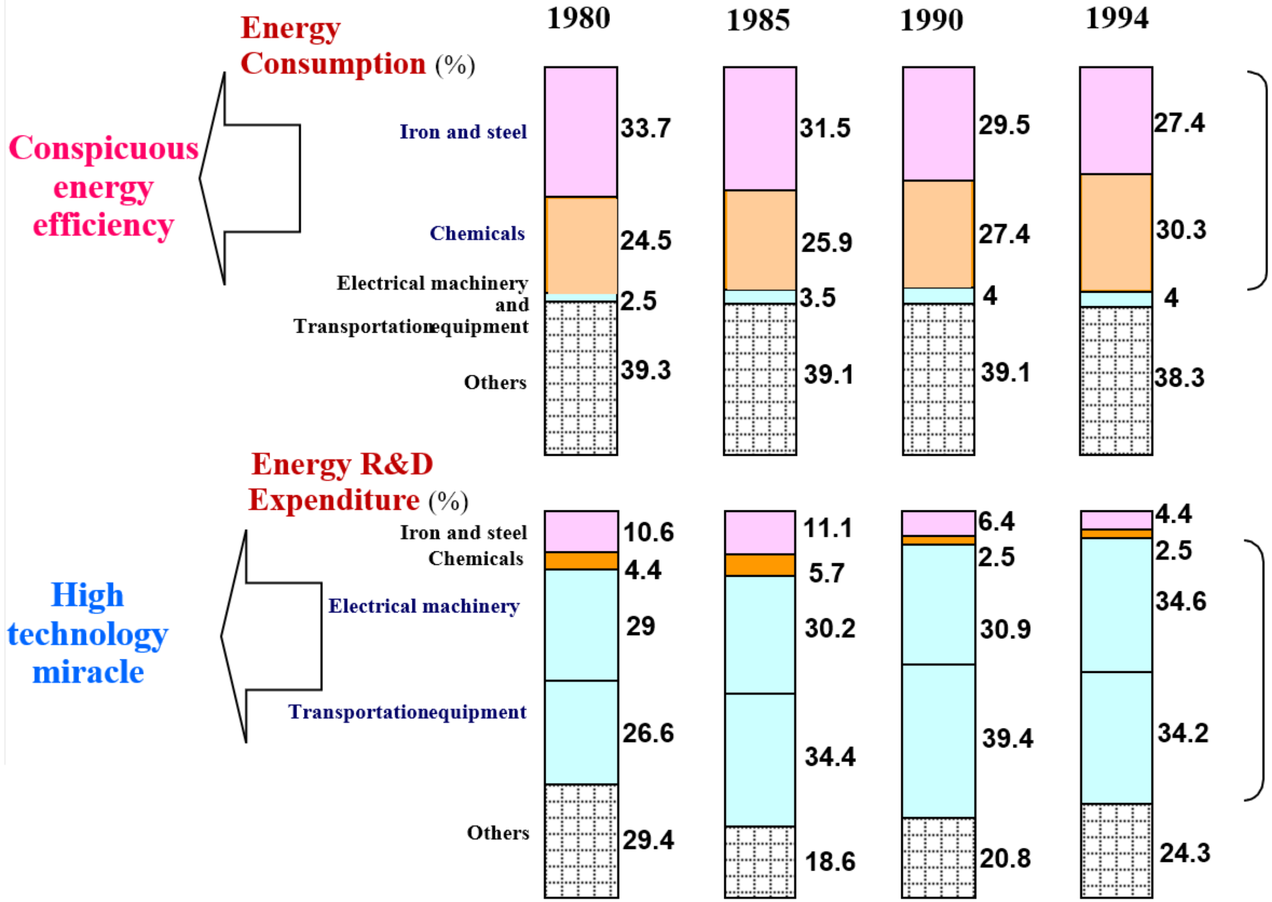
Taiwan is also strengthening its relationship with India due to market size and geopolitical issues.

Therefore, the approach to fusing the strengths of Japan's manufacturing industry and India's DX will incorporate learning from the Taiwan-India semiconductor cooperation.

This complements the lack of Japan's manufacturing strength and leads to a virtuous cycle towards a resilient fusion.



# Appx 1. Trans-Sectoral Technology Spillover Leading to Notable Energy Efficiency Improvement by Fusing Comparative Advantages – *Lessons from Japan*




Technology spillover

To iron & steel, chemicals

**High. tech. on**

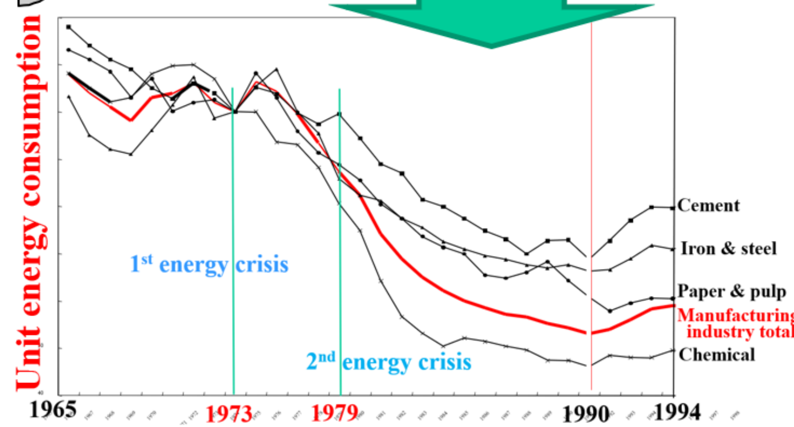
**(i) Sensors**

**(ii) Monitors**

**(iii) Controllers**

From electrical machinery, transportation equipment

**Technology Spillover from Electrical Machinery and Transportation Equipment to Iron & Steel and Chemicals in Japan *(1980-1994)*.**




**Unit Energy Consumption in the Japanese Manufacturing Industry** *(1965-1994)* – Index: 1973 = 100.

**Japan's notable energy efficiency improvement in the 1980s can be attributed to a fusion of cross-sectoral strengths and provides insightful suggestions.**

# Appx 2. Sources of $CO_2$

$$C = Y \times \frac{E}{Y} \times \frac{C}{E}$$

where $Y$: GDP; $\frac{E}{Y}$: energy efficiency improvement, and $\frac{C}{E}$: fuel switching.

Taking **effects of R&D and digitalization**, $\frac{E}{Y}$ and $\frac{C}{E}$ can be transformed as follows:

$$\frac{E}{Y} = \frac{E}{R/Y} \times \frac{R/Y}{Y} = \frac{E}{R/Y} \times \frac{R/Y}{D} \times \frac{D}{E} \times \frac{E}{Y}, \qquad \frac{C}{E} = \frac{C}{R/Y} \times \frac{R/Y}{E} = \frac{C}{R/Y} \times \frac{R/Y}{D} \times \frac{D}{E}$$

where $R$: R&D investment, $R/Y$: R&D intensity, and $D$: Digital transformation ratio ($DXR$), which indicates the degree of digitalization for R&D in general.

Since the digitalization status is represented by the Internet diffusion rate $ID$,

$D$ can be expressed as $D = \frac{ID}{R/Y}$.

Thus, $C$ can be decomposed as follows:

$$C = Y \times \left(\frac{E}{R/Y} \times \frac{R/Y}{D} \times \frac{D}{E} \times \frac{E}{Y}\right) \times \left(\frac{C}{R/Y} \times \frac{R/Y}{D} \times \frac{D}{E}\right)$$

$$= Y \times \frac{E}{Y} \times \frac{E}{R/Y} \times \frac{C}{R/Y} \times \left(\frac{R/Y}{D}\right)^2 \times \left(\frac{D}{E}\right)^2 = Y \times \frac{E}{Y} \times \frac{E}{R/Y} \times \frac{C}{R/Y} \times \left(\frac{R/Y}{E}\right)^2$$

where $\frac{E}{R/Y}$: R&D-driven energy decrease; $\frac{C}{R/Y}$: R&D-driven $CO_2$ elimination;

$\frac{R/Y}{D}$: **decarbonization through digital transformation**; $\frac{D}{E}$: **green energy creation by digitalization**; and $\frac{R/Y}{E}$: net effects of digitalization.

# Appx 3. Direction of DX toward Decarbonization

## Decarbonization through DX

$$\frac{d\frac{R/Y}{D}}{d\,R/Y} = \frac{1}{D}\left(2 - \frac{d\ln ID}{d\ln R/Y}\right) < 0$$

$$\longrightarrow \quad \frac{d\ln ID}{d\ln R/Y} > 2$$

***R/Y* highly inducing *ID***
(Level already reached)

## Green energy creation by digitalization

$$\frac{d\frac{D}{E}}{d\,R/Y} = \frac{1}{E \cdot \frac{R}{Y}}\left[D\left(\frac{d\ln ID}{d\ln R/Y} - 1\right) - \frac{d\ln E}{d\ln R/Y}\right]$$

$$> \frac{1}{E \cdot \frac{R}{Y}}\left(D(2-1) - \frac{d\ln E}{d\ln R/Y}\right)$$

$$= \frac{1}{E \cdot \frac{R}{Y}}\left(D - \frac{d\ln E}{d\ln R/Y}\right) < 0$$

$$\longrightarrow \quad \frac{d\ln E}{d\ln R/Y} > D$$

***R/Y* inducing green energy with higher elasticity than *D*.**
(Extremely challenging levels)

## Appx 4. Average Change Rate of $CO_2$ Emissions and their Sources in 5 Countries (2013-2020) - % *p.a.*

| | $C$ | $Y$ | $\frac{E}{Y}$ | $\frac{E}{R/Y}$ | $\frac{C}{R/Y}$ | $\left(\frac{R/Y}{D}\right)^2$ | $\left(\frac{D}{E}\right)^2$ | ε | $\left(\frac{R/Y}{E}\right)^2$ |
|---|---|---|---|---|---|---|---|---|---|
| **Japan** | **-2.00** | 1.32 | -2.81 | -0.96 | -1.36 | -5.92 | 7.84 | -0.11 | 1.92 |
| **India** | **3.83** | 5.09 | -1.24 | 4.35 | 4.58 | -41.87 | 33.04 | -0.12 | -8.83 |
| **USA** | **-0.32** | 3.31 | -2.96 | -1.50 | -2.02 | 1.60 | 1.40 | -0.15 | 3.00 |
| **Germany** | **-1.81** | 3.50 | -4.39 | 0.38 | -0.32 | -8.18 | 7.42 | -0.22 | -0.76 |
| **China** | **1.70** | 6.06 | -3.25 | 0.09 | -0.81 | -12.12 | 11.94 | -0.21 | -0.18 |
| | $CO_2$ emissions | GDP growth | Energy efficiency Improve -ment | R&D-driven energy decrease | R&D-driven $CO_2$ elimination | Digitali -zation | Energy depend -ency of digital. | Confoun -ding term | Net digitali-zation effects |

***C***: $CO_2$ emissions (World Bank – Data Indicators; BP Statistics), ***Y***: GDP (World Bank – Data Indicators), ***E***: Primary energy consumption (BP Statistics), ***R***: R&D expenditure (OECD Science Indicator), ***D***: Digital R&D intensity: Internet penetration rate/R&D intensity (World Bank; ITU Statistics).

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