Side Event

Science, Technology and Innovation for Sustainable Development

Keun Lee

Director, Center for Economic Catch-up

Professor, Seoul National University

21 March 2013

Background

- ECOSC: theme of 2013 AMR

  = STI for promoting sustainable development and achieving the MDGs

- CDP to examine and make recommendations on this theme at its 15th plenary session

- 3 dimensions of sustainable development:

1) Economic; how to sustain economic growth

   > poverty trap; middle income trap

2) Environmental: ecological and climate crisis

3) Social: inequality; exclusion; inclusive development

2 Simple Goals

- How to use STI

  -> to make economic growth sustained,

  rather than short-lived

  (assuming it also helps social dimension of SD;

  b/c growth collapse is one reason for inequality)

- How to use STI

  -> to change the current 'environment-unfriendly' growth trajectory into more environment-friendly growth

- But gradual shift to new growth;

  -- not to scrap old industries in the South right away

  but first to make them more STI intensive

Specifically,

1) Policies to advance STI capabilities of the latecomers to sustain economic growth

2) Application of STI in transformation of industrial structures in developing countries,

- while meeting environmental objectives.

3) Latecomers in a position to leapfrog into environment-saving technologies to take a different path of development than the old path of the current North.

4) What can be done to achieve these

Several Challenges

1) Middle income trap, poverty trap, and the adding-up problem

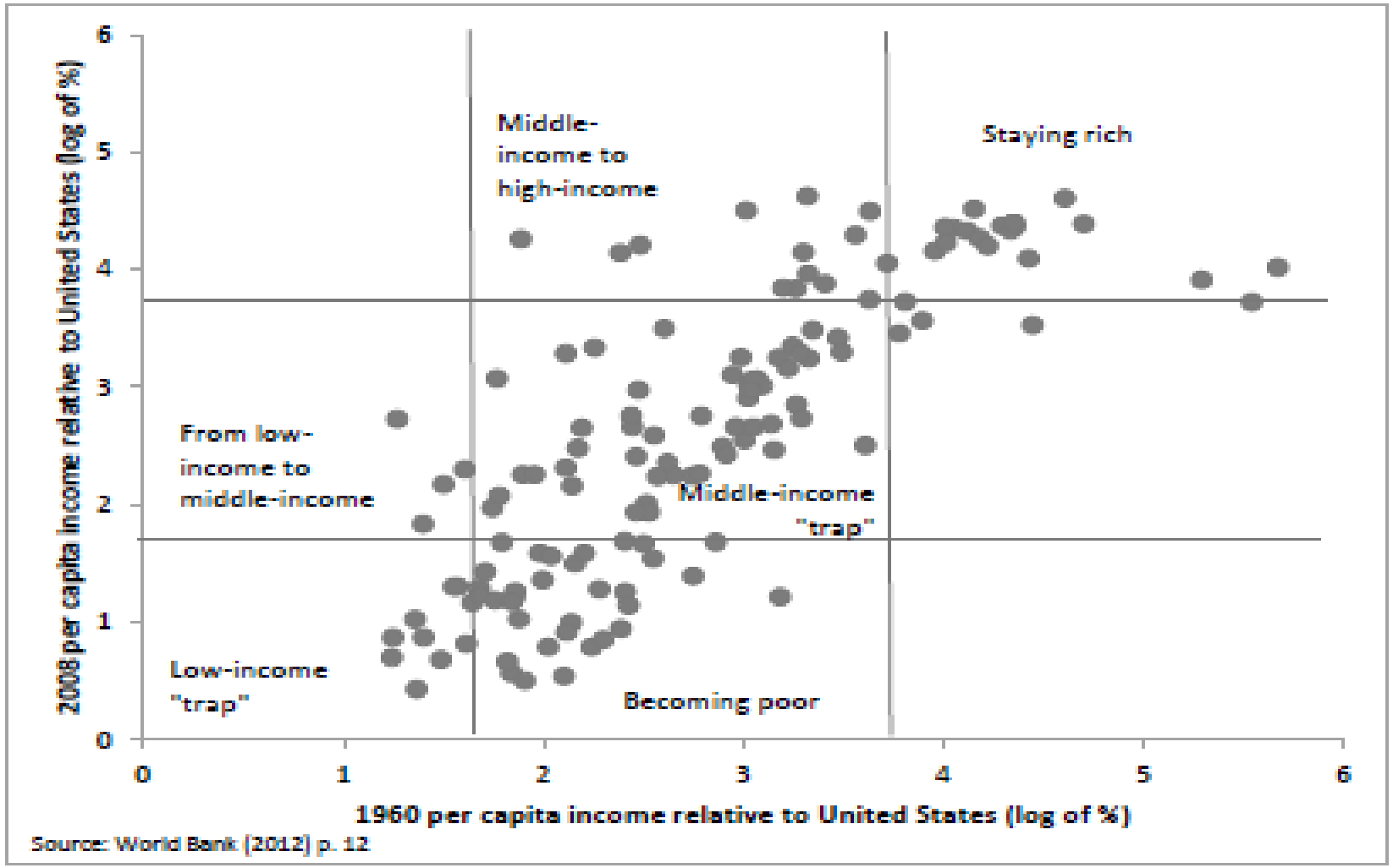
2) Environment-friendly development;

-- level of human activity: threatening to surpass the limits of the Earth's capacity;

-- the South to bear 75% of costs and more vulnerable

3) Intellectual Property Rights: incentive or barrier for Catch-up Development?

Middle- and Low-income Traps: connected



Source: World Bank (2012) p. 12

Middle income Trap and Adding up problem

MIT =middle-income countries face a slowdown of growth;

-- caught between low-wage manufacturers and high-wage innovators.

Adding-up problem:

developing countries flood the market with the same goods that they produce well,

-- resulting in a decrease in the prices of these goods and less profits (Spence, 2011)

Why the Middle Income Trap important?

1) 70% of World Poor in MICs

2) It is future of the LICs

3) MIT linked with the adding-up problem.

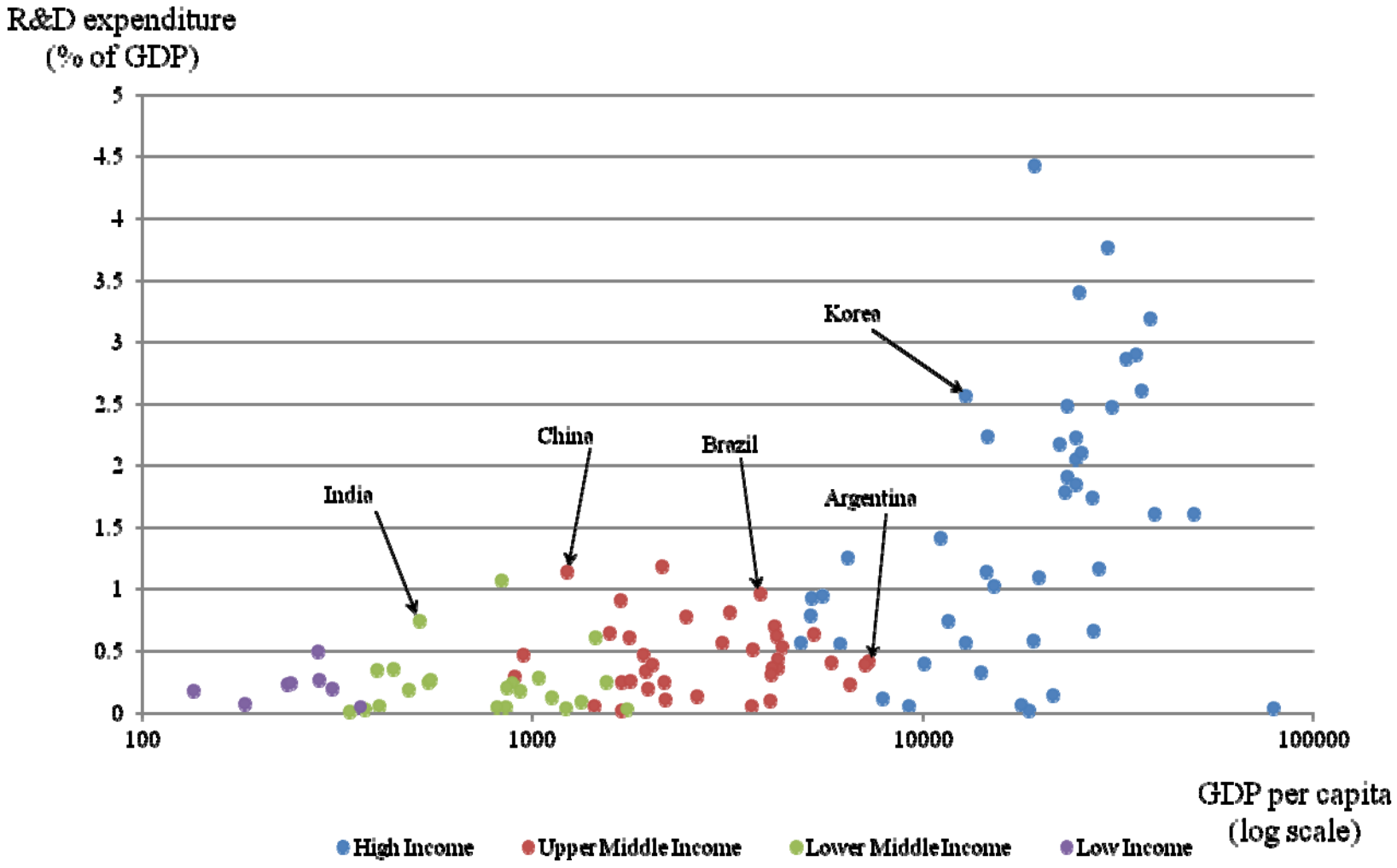
(Eg; adding up in flower industries in E Africa)

Eg) China needs to go quickly beyond the low-end goods based growth, so that it may leave rooms for other low income countries

➔To be free from adding-up, you got to differentiate your products

–>need to have innovation capabilities

Weak STI (weak R&D) as Source of the MIT (flat R&D/GDP ratio for MICs)



Different Factors at different Stages (Lee and Kim 2009 WD)

1) **For lower income & lower middle income countries:**

Secondary education & institutions mattered;

+ basic infrastructure (SOC)

2) For upper middle and higher:

a) college education and innovation

b) **big business (Lee et al ; JCE) mattered**

Theoretical Framework for Catching-up and Leapfrogging Development

Latecomers' Advantage (Leapfrogging) vs. Forerunners' Trap

- Leapfrogging: Perez and Soete (1988)

->Emerging technological paradigms

= a window of opportunity

-> not being locked into the old technological system and thus being able to grab new opportunities in the emerging industries. for the catching up country,

- Cf) Forerunners' Trap: locked into exiting technologies

due to the sunk costs of their investment.

2 Kinds of Latecomers' Advantage

1) Advantage in Mature Industries (Gerschekron)

-> possibility of low cost-based entries without bothering to bear the burden of R&D costs

-> you can adopt most up-to-data facility or products

2) Advantages in Emerging Industries

-> entry at an earlier stage with the same entry costs

but without the sunk costs or being locked into old technologies.

-> Leapfrogging

3 Patterns of Technological Catch-up (Lee & Lim 2001)

Path of the Forerunner : stage A --> stage B --> stage C --> stage D

Path-Following Catch-up : stage A --> stage B --> stage C --> stage D

eg. PC, some consumer goods, and Machine Tools

Stage-skipping Catch-up (leap-frogging I) :

stage A ----------> stage C --> stage D

eg. Hyunda's fuel-injection engine (cf. carburetor engine)

Samsung' 64 K D-Ram production technology; 256 K D-ram design technology

Tlephone switch in in China

Path-Creating Catch-up (leap-frogging II)

stage A --> stage B --> stage C' --> stage D'

eg. CDMA development, digital TV

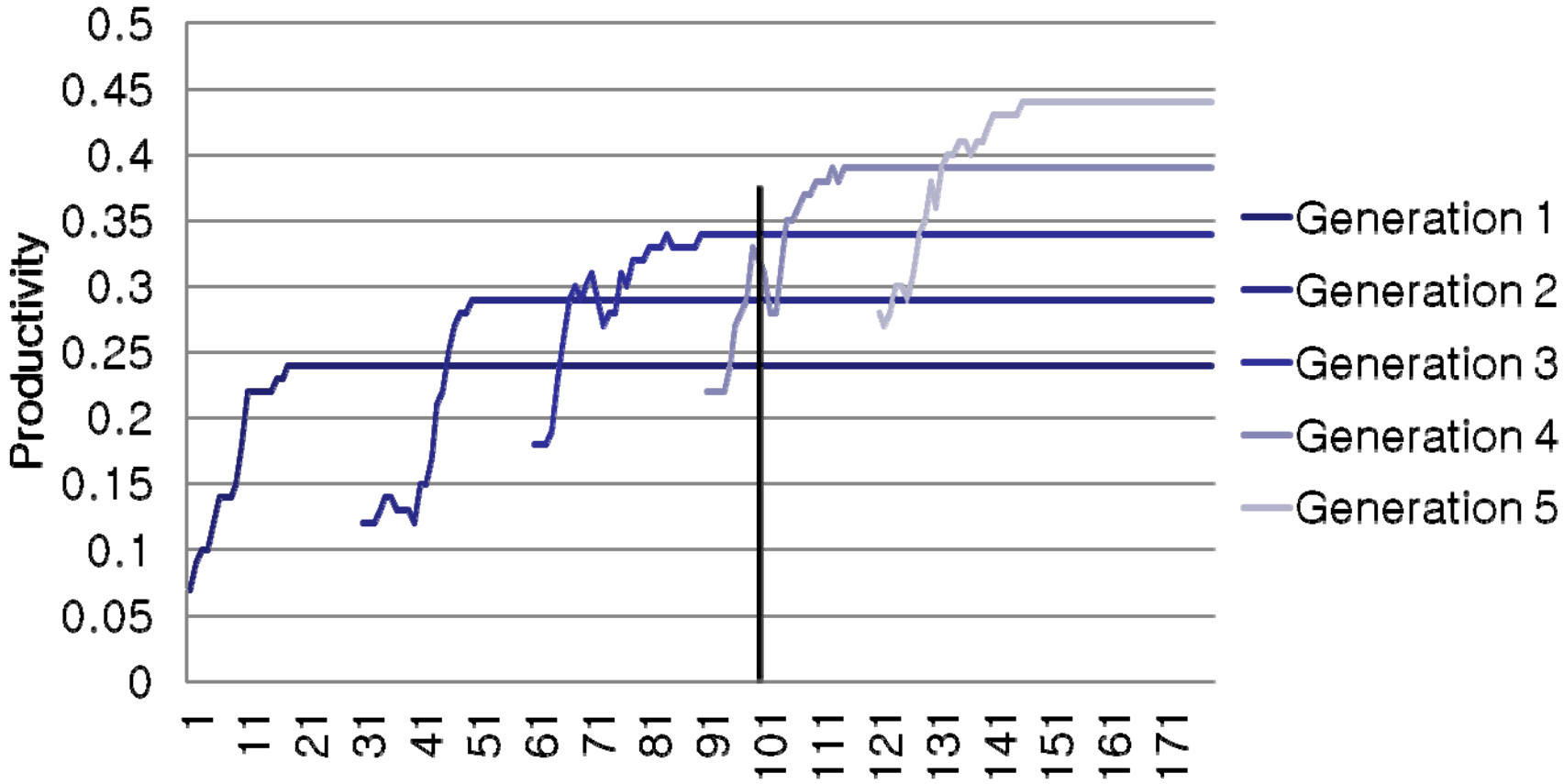
(Notes: C and C', represent competin technologies.)

3 strategies in Graphs

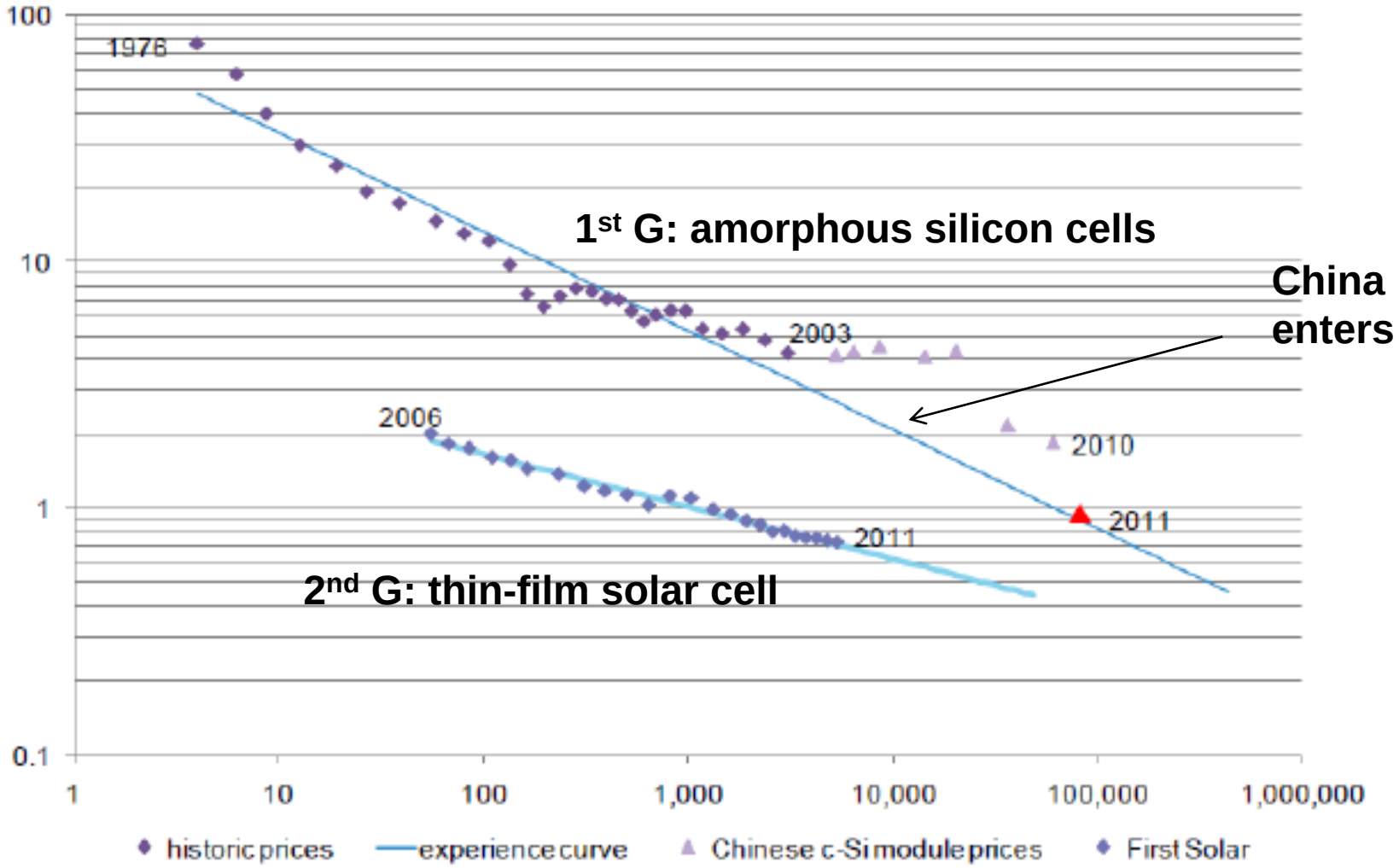
- Path-following = start from generation 1

  stage-skipping = from generation 3 (most productive and stable)

  Path-creating = from generation 4 (emerging technology)



Solar power cost; now reduced $1 per watt , cheaper than diesel; affordable to the South



Cost of solar PV cells, falling 45% per year

Source: BNEF Bazilian et al (2012), Fig. 1

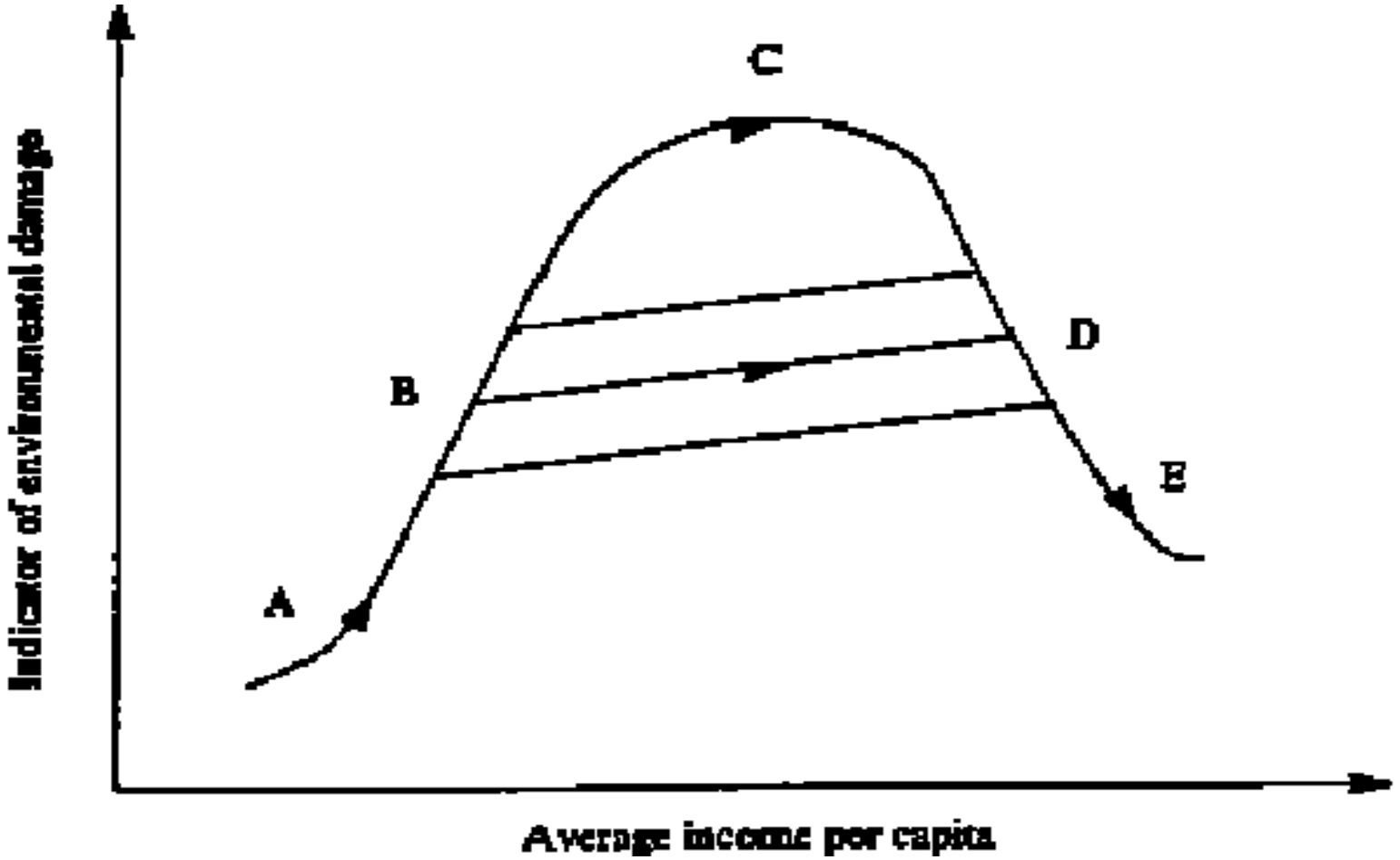
Now
Another Paradigm Shift

1) New Energy Revolution (Renewable Energies)
to replace fossil-fuel

2) Fusion of Technologies (IT, BT, NT,)
in search for new solutions

-> Best Time for Leapfrogging
and
already happening;
former latecomers are no more latecomers

Stage-skipping and Leapfrogging in the Environmental Kuznets Curve



Source: adapted from Assefa (2011)

Examples of Leapfrogging 1

Wind-Turbines, Solar power, Solar Thermal Heating in China

- Wind Turbines

- By early 2000s, China relied heavily on European suppliers for most of the production and parts

-- but localized much of the production process and required inputs owing to national procurement policy and local content requirements.

-- China became the leader by 2010.

- Solar thermal heating in China (developed by Tsinghua Univ)

- Rural area bypassed the stage of gas or electricity based heating but leapfrogged into solar thermal based heating.

-- Solar water heater = huge disruption on the existing residence style of urban dwellers,

whereas rural areas: no such lock-in.

→ Leapfrogging driven not by supply-side (technology)

but by mismatch with the demand side

Examples of Leapfrogging 2

Bio-Ethanol and Bio-Diesel in Brazil

- Brazil: green industrial restructuring
- Technology for ethanol production was initially imported and rapidly localized with subsidies on alcohol and ethanol
- and then diffused rapidly through the R&D efforts of Brazilian Agricultural Research Corporation, EMBRAPA.

- This public entity maintained a technological watch on global developments and utilized advanced technological methods for researching Brazil's sources of comparative advantage,
  - e.g. soils suitable for sugar cane cultivation as revealed by satellite surveillance.

Mozambique: from Black to Green Development

- Mozambique: state oil company Petromoc (modelled on Petrobras) has partnered with the Portuguese oil company Galp and local company (Ecomoz) in a $19 million investment to produce biodiesel from jatropha.
- Up to 50,000 hectares of land will be dedicated to the project. Endowed with land, sunshine and adequate rainfall.
- Good prospects to become a bio-fuels powerhouse, which could reduce the country's dependence on imported fossil fuel, contribute to diversify exports
- These projects financed by its Coal Exports

-> (Turning Black into Green)

- Also, South-South Cooperation: help from India & Korea

Nigeria: Solar power

In desert grasslands rural area

- Jigawa State in Nigeria:
- No water supply in this semi-desert area

- Traditional options:

-- Open wells with rope and bucket; hand pumps;

or Government supplied diesel-powered pumps that work only until they break down or until villagers run out of money to buy the expensive diesel.

- Now, solar-powered pumps designed to run maintenance free for eight to ten years or more
- Solved the problem

Need incentives/promotion
For early adopters/developers

- Market-based approach:

  - Often not adequate to bring in necessary new technologies and replace unsustainable old ones in the remaining time frame before irreversible environmental damage occurs
- Policy intervention: justified to correct market failures and make green technologies more profitable than less sustainable ones.

- India's Solar power

  - Jawaharlal Nehru National Solar Mission (NSM)

-- used competitive reverse bidding for tariffs (rents).

STI Policy
for National Development

The 3 Failures as Justification for Gov't Activism

	Market failure	System failure	Capability failure
Focus	Market institutions	Interaction among actors	**Actors (firms)**
Source	Knowledge as public good	Cognition failure from tacitness of knowledge	**historically given; No learning opportunity**
Example problem	Sub-optimal R&D	R&D impact: low	**No R&D**
Solutions	R&D subsidies	Reducing cognitive distance	**Access to knowledge and help in learning**
School Analogy	Tuition support	Making more friends	**Targeting student learning**
Relevance	Developing and advanced countries	Developing and advanced countries	**More unique to developing countries**

From Keun Lee, a coming chapter in Stiglitz & Lin eds,

Policy to cultivate directly capabilities of private firms

- To raise “capability failure” as a justification for gov’t activism,
- To suggests ways to cultivate capabilities of firms.

-- In developing countries where firms have a low R&D capability, a safer way of doing business is to buy or borrow external technologies or production facilities, as well as to specialize in less technical methods or assembly manufacturing.

- To move beyond such states (middle income trap),

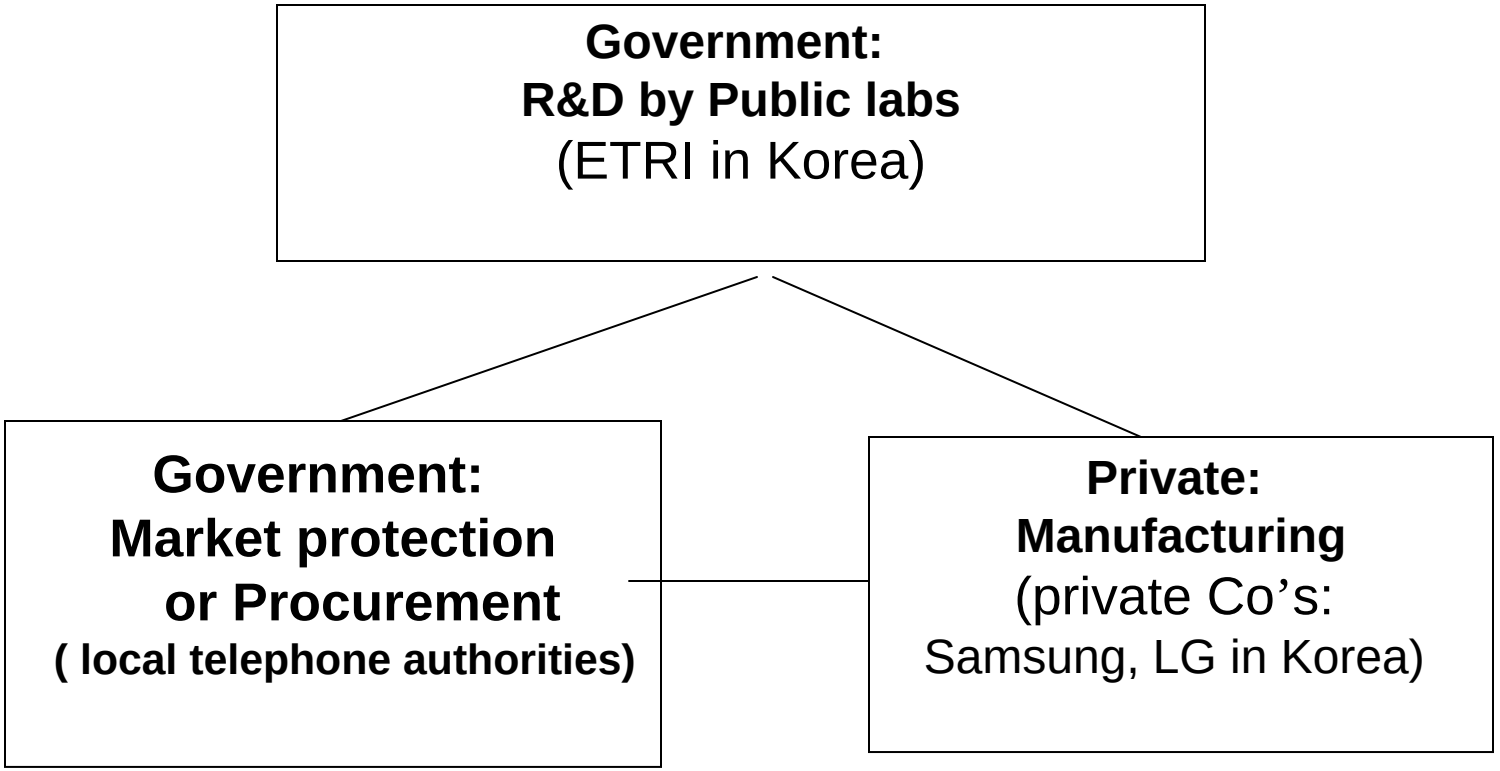
-> effective policy to include not the simple provision of R&D funds but various ways to cultivate R&D capability itself.

Stages of Knowledge Learning/ Creation and Catch-up

	Stage I	Stage II	(crisis) Stage III	Stage IV
Stages of Catch-up	Duplicative Imitation	Duplicative Imitation	Creative Imitation	Real Innovation
	OEM	OEM	ODM/OBM	OBM
Patterns of Catching-up	Path-following	path-following/ stage-skipping	stage-skipping	path-leading/ path-creating
Learning Objects	operational skills	production/ process technology	design technology	Product Development technology
Learning Mechanism	Learning by doing	by producing/ organizing following foreign designs	How to Learn: crisis-> in-house R&D Overseas R&D P&P R&D consortium	Co-development strategic alliance

Learning how to Design
By Gov't-Private-Gov't (GPG1):

eg) Telephone switch development in Korea & China

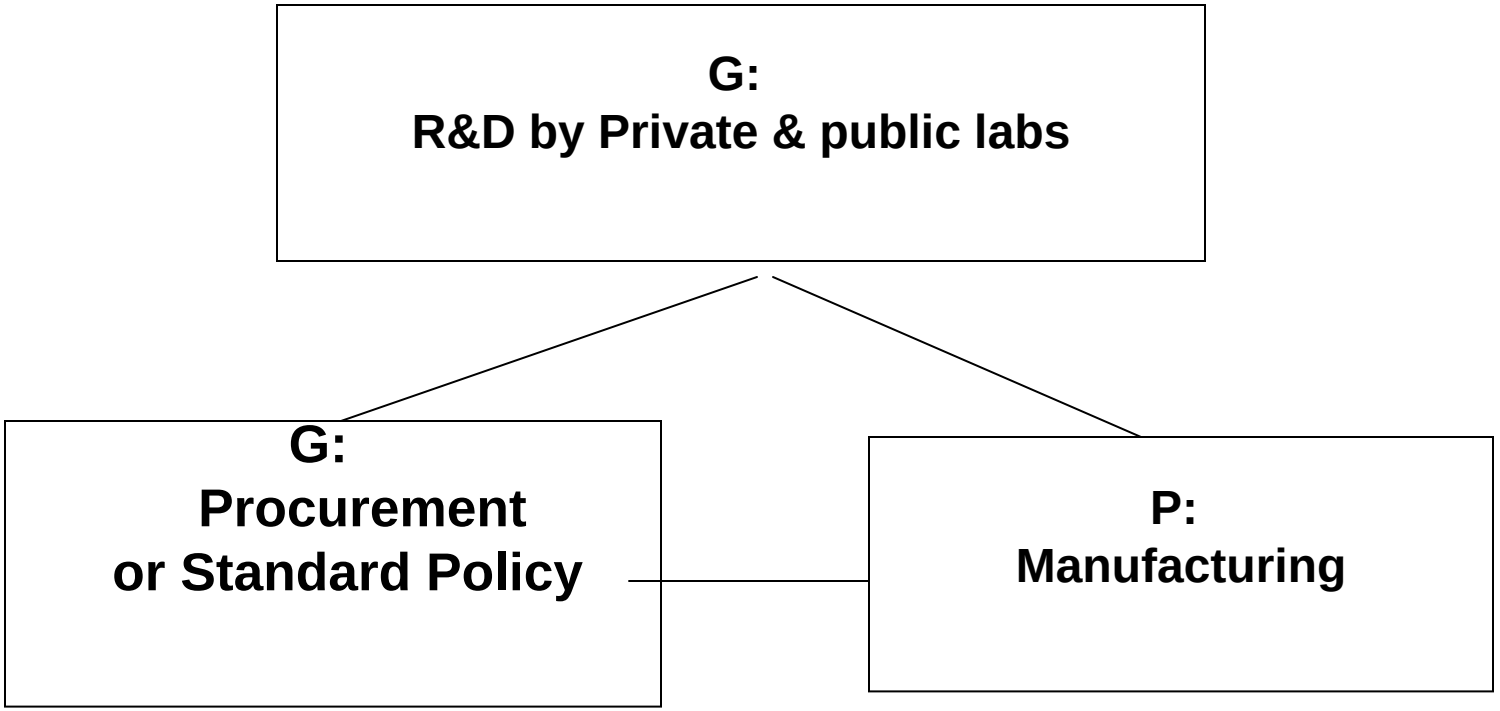


India & Brazil had the same development but not sustained without initial protection;

=> Infant protection still matters, together with joint PP R&D

Leapfrogging into Emerging Technologies By GPG2

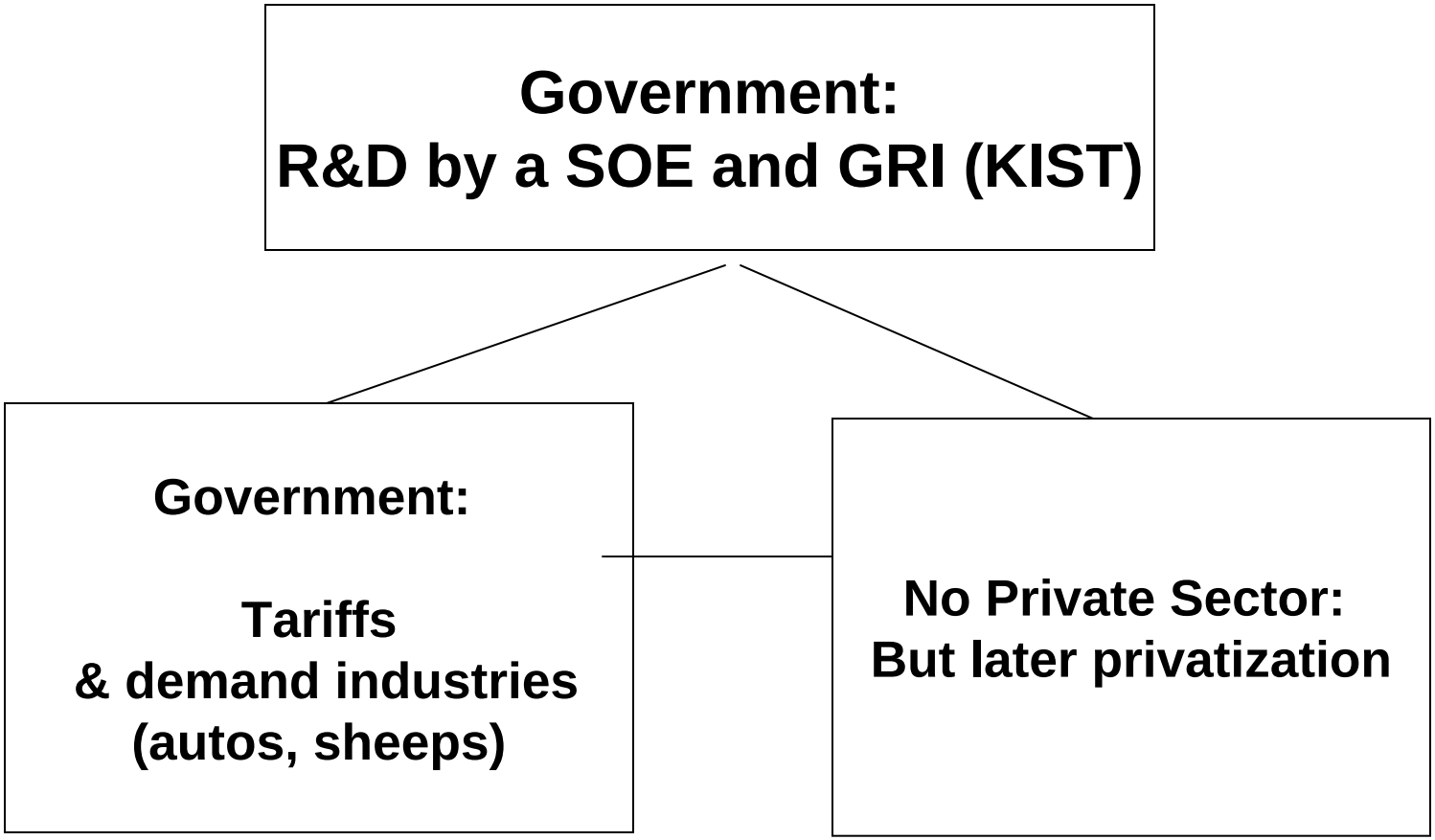
eg) Korea: Digital TV, mobile phones (CDMA) ;
China: 3G TD-SCDMA, Photovoltaic; electric vehicles



Policy tools: Standards policy matter,
eg), exclusive standards in wireless.

GPG0 (GG) in Steel (POSCO: a SOE)

Production & R&D by SOEs



From GPG model to FLG (Foreign actor-local firm-Government) Model

1st Stage	**GPG0**	**F-L-G0**
Tech Trasnfer/R&D	PRO/Foreign Actor	Foreign Cooperation partner
production	SOEs/:Pirvate firms	Local firm (private, SOEs)
market promotion/protection	Gov't	Gov't
2nd Stage	**GPG1**	**FL-P-G (FLG1)**
R&D	PROs/Univ.s	Joint R&D by foreign & Local PROs/firms
production	private firms	Local Private Firms
market promotion/protection	Gov't	Gov't
3rd Stage	**GPG2**	**G-P-G2 (FLG2)**
R&D	public & Private Joint R&D	Local public & Private Joint R&D
production	private firms	Local Private Firms
market promotion/protection	Gov't	Gov't
4th Stage	**GPG3 (PG)**	**G-P-G3 (FLG3)**
R&D	private firms	Local Private Firms
production	private firms	Local Private Firms
market promotion/protection	None	None

Examples of F-L-G Model: Green Revolution & SRI

1) Green Revolution:

→ saved over a billion from starvation.

- R&D & diffusion : performed by a int'l network: -→ Consultative Group on Int'l Agri. Research (CGIAR).
- In response, Governments/regions expanded roads, irrigation systems and electrical power supply --- to support farmers to adopt the new technology.
- International lending: also prioritized for this

2) System of Rice Intensification (SRI): in 40 countries

SRI first assembled in Madagascar in 1983;

- but spread to the world with Cornell Univ. participation

-- India one of the biggest beneficiaries

- ***Two kinds of upgrading via capability building***

1) Upgrading in the same Industry
(moving into higher value segments)
= intra-industry diversification

2) Upgrading by entry into new (higher VA) industries
which results in inter-industry diversification

-> Examples from East Asia

3 Stages: OEM – ODM – OBM : Upgrading in a given sector into higher value segments

	Assembly/ Production	Design (R&D)	Marketing	
OEM (own equipment)	0			Apparel; sweat shops
ODM (own design)	0	0		Foxxcom for Apple
OBM (own brand)	0	0	0	

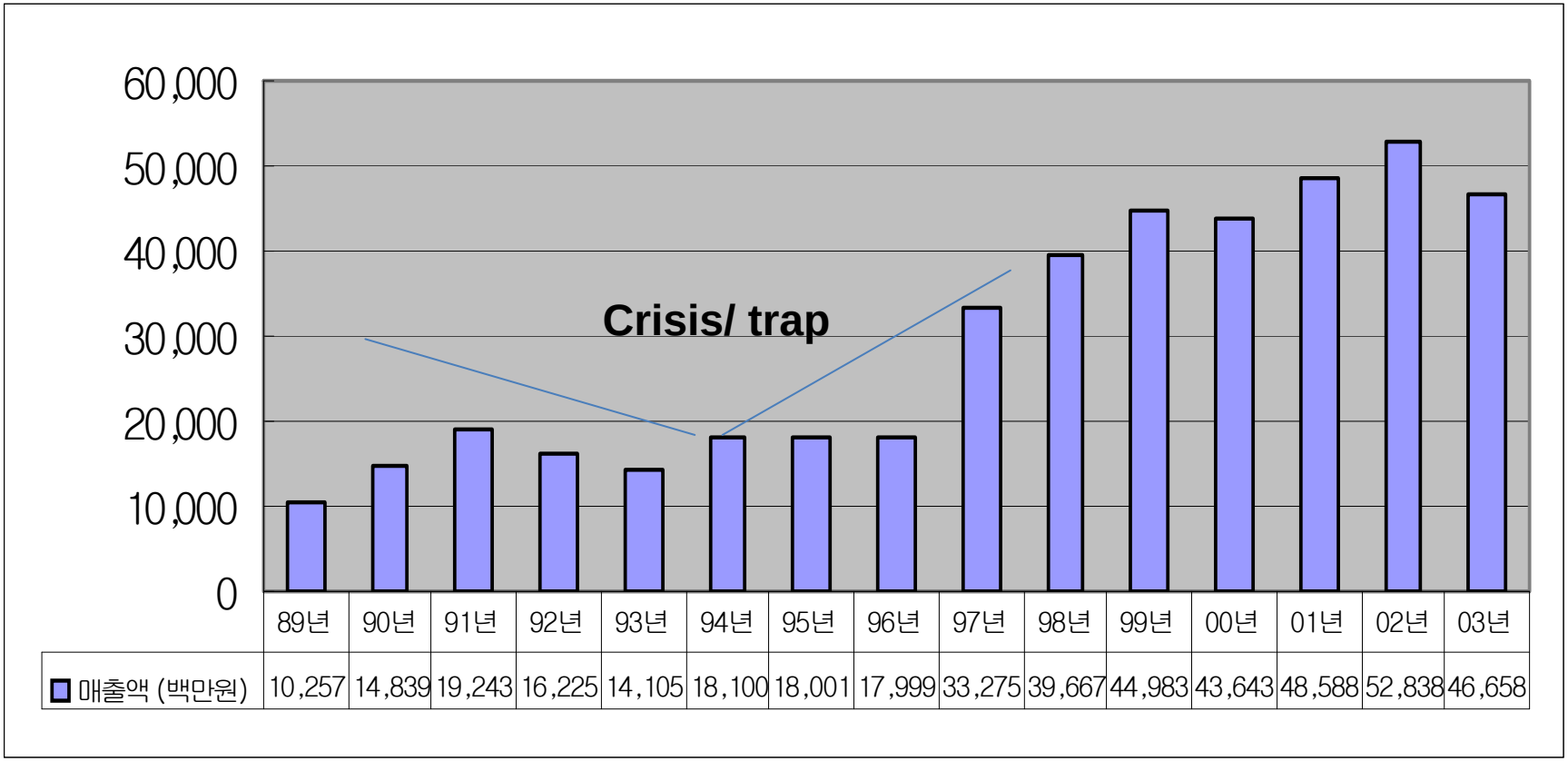
→ Often not easy or quite difficult;
Many stuck in OEM Trap (low end good production)

Trends of Sales by Aurora World

with 1992 the year of own brand marketing

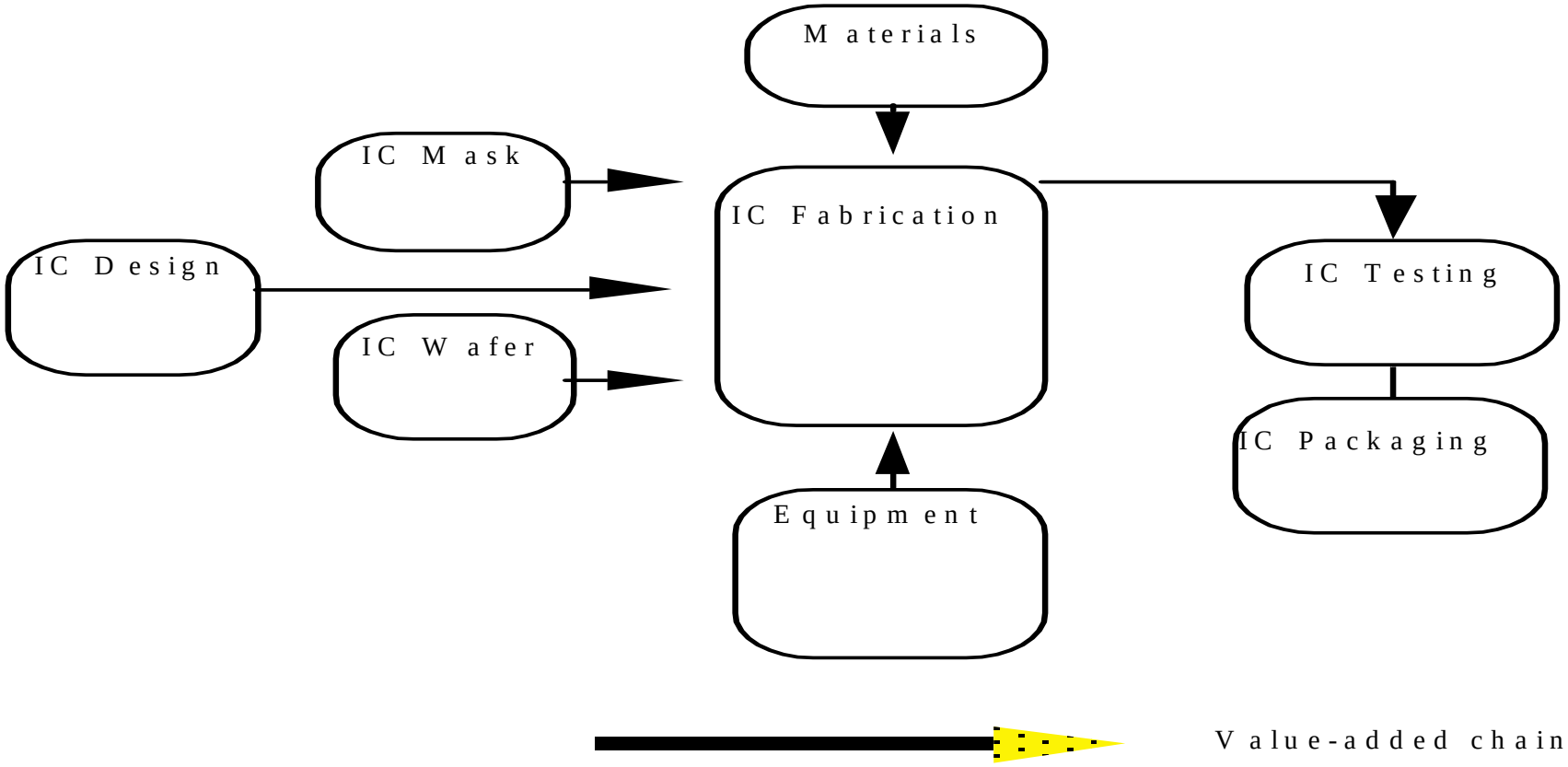
showing “U” shaped OEM trap over 1991-97

(unit: million Won)



	89년	90년	91년	92년	93년	94년	95년	96년	97년	98년	99년	00년	01년	02년	03년
매출액 (백만원)	10,257	14,839	19,243	16,225	14,105	18,100	18,001	17,999	33,275	39,667	44,983	43,643	48,588	52,838	46,658

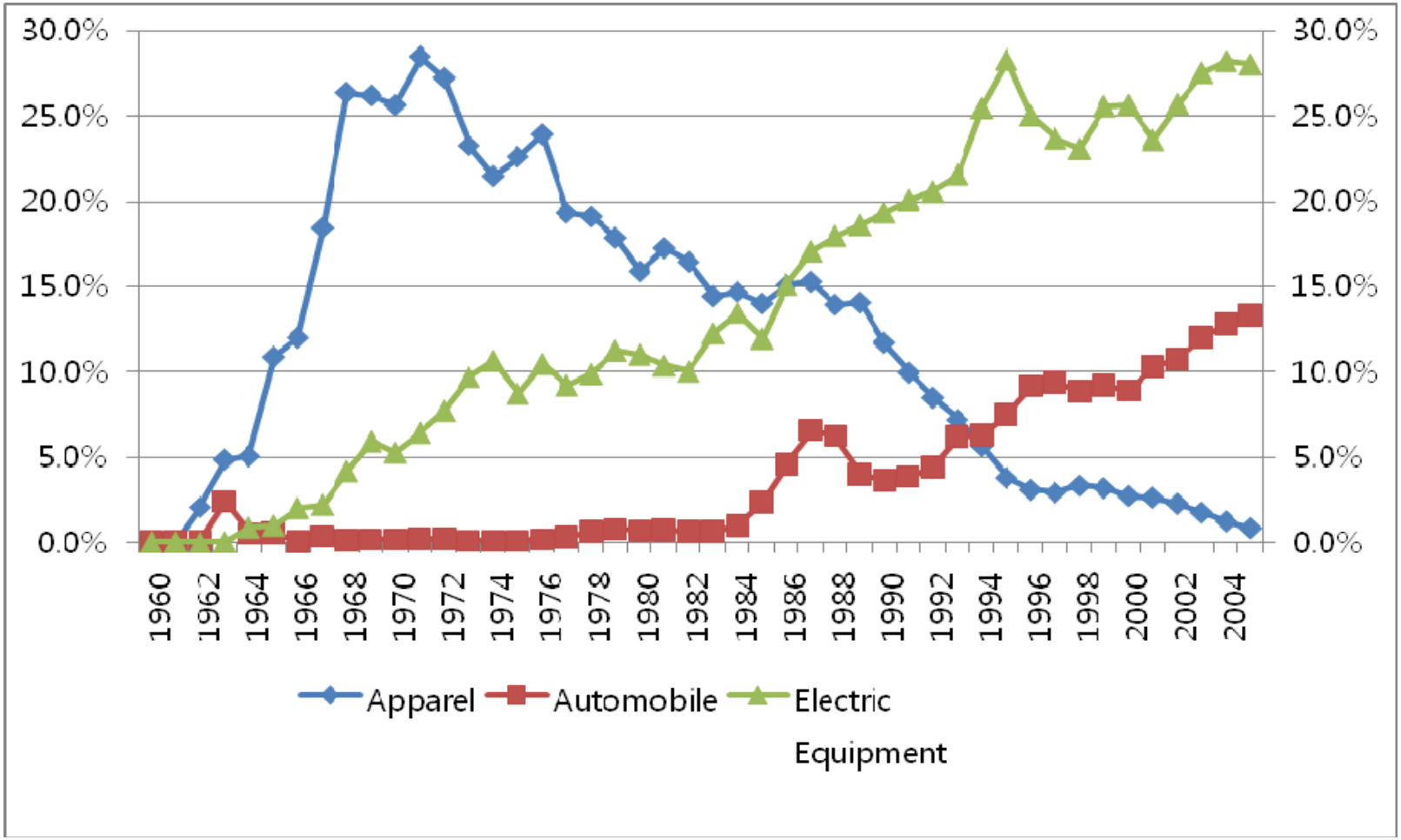
Upgrading in the same industry:
Value Chain in Semiconductor Sector



High value-added

Low value-added

Korea's Entries into New Industries: Composition of Major Export Items, (% Share)

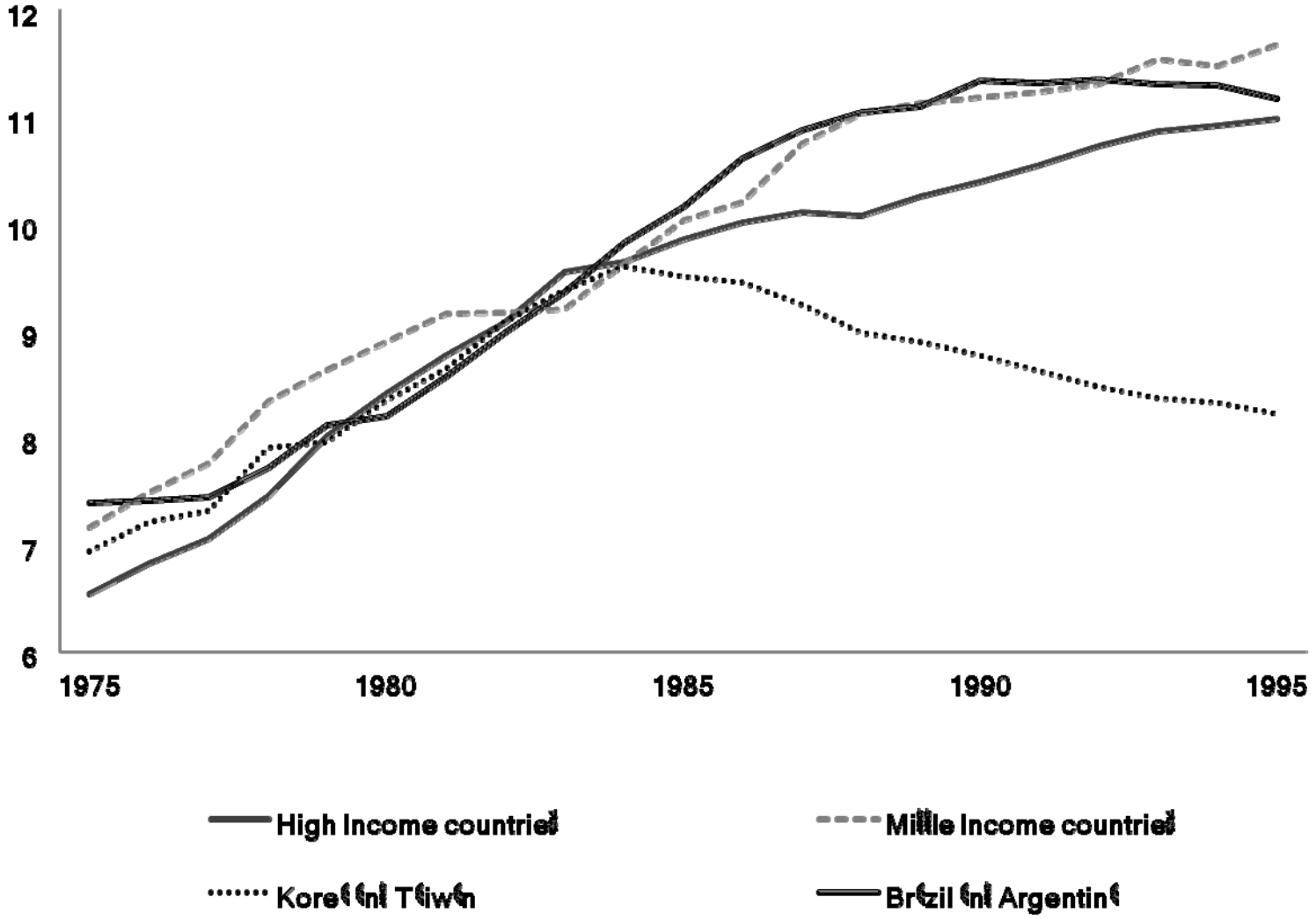


3 Steps along the Catch-up Process

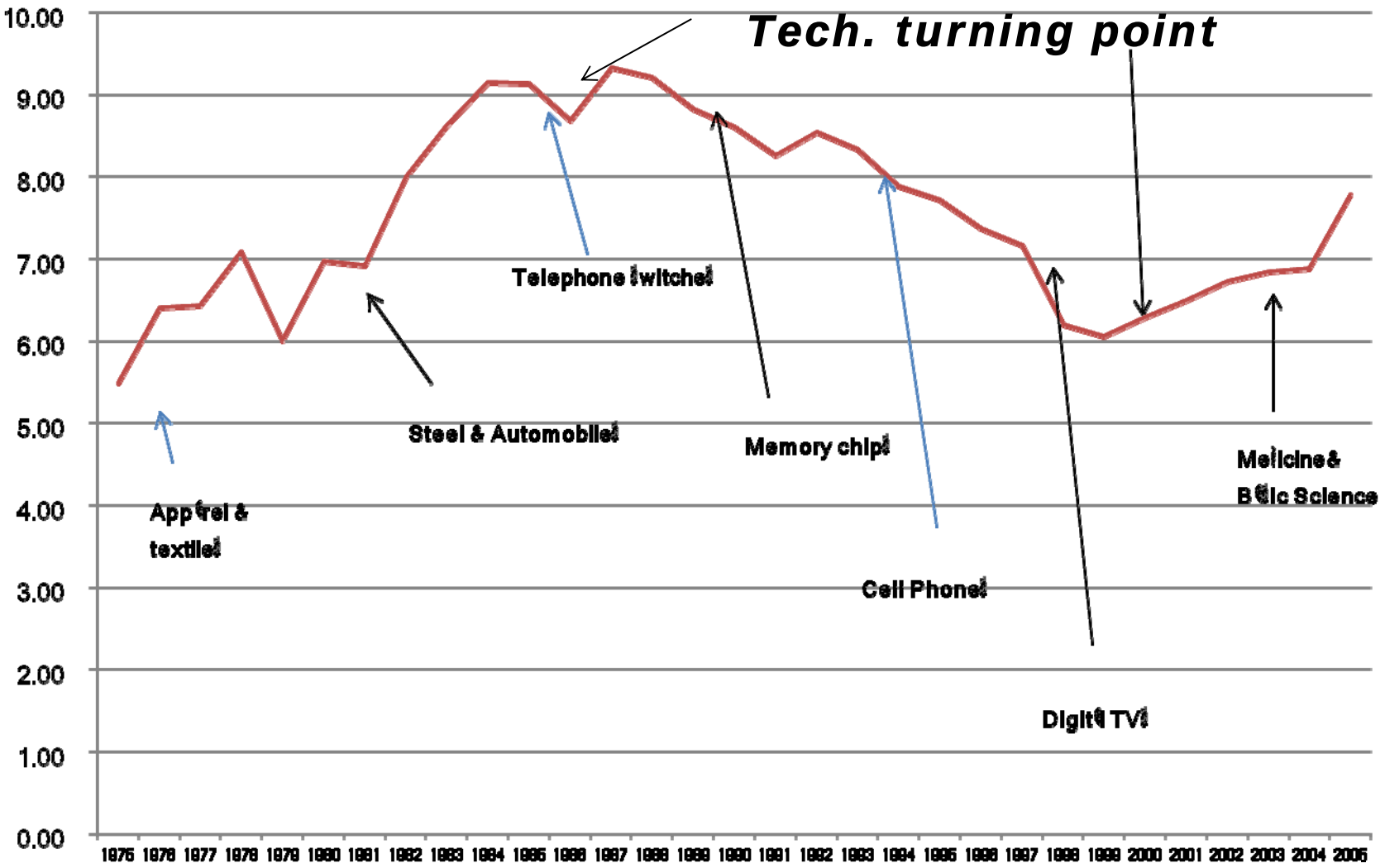
1) Acquiring Design Capability
(to move beyond OEM/assembly)

2) Targeting/Entering
the mature/medium short- cycle sectors
or low-end segment of short cycle Sectors

3) Leapfrogging into New/Emerging Technologies
in the Short-cycle Sectors


Cycle Time of Technologies
12
11
10
9
8
7
6
1975
1980
1985
1990
1995
High Income countries
Middle Income countries
Korea and Taiwan
Brazil and Argentina

Diversification by moving into shorter cycle technology sectors



Dynamics of industrial policy from low- to middle-income and beyond the middle-income trap		
Stages	Low or lower-middle income	Upper-middle income toward high income
Policy tools	Industrial policy: (tariffs, undervaluation of currency, entry control)	Technology policy (public-private R&D consortium, R&D subsidies, standardization policy)
Access to External/Foreign knowledge	FDI, OEM/ Assembly work/ Licensing	Collaboration with public research labs and universities, Overseas R&D outposts, International M&As, contracted R&D (based on in-house R&D efforts)
Type of specialization	Trade specialization	Technology specialization
Criterion of Specialization	Labor or resource-intensive industries	Short cycle/emerging technologies
End goal	Competitive export industries	Indigenous knowledge creation and diffusion
Background theory	Product life cycle (inheriting)	Catch-up cycle (leapfrogging)

Suggested Examples of Upgrading in Africa

Upgrading in the same Industry

Make Flower/Coffee Higher value-added using STI

(entry into more & higher value segments)

eg) Make flower insects/disease free; last longer

with specific flavour/smells

Coffee: from crude coffee to processed coffee

promote your own brand: "Kaffa"

"Kaffa Inside" like "Intel inside"

In both: enter into R&D & distribution/marketing segments rather than just production

Second Kind upgrading in Africa

***Upgrading by entry into new industries*

related /unrelated diversification

a) entries into seed/ plant variety industries

to save or generate royalty incomes;

b) into IT services (eg: India as benchmark)

Lower entry barriers

(->English speaking IT manpower)

c) into manufacturing from mining:

eg Nigeria: oil refineries; Botswana: Diamond polishing

d) at later stages: entries into genetic engineering; biotechnologies (fusion of IT and biology)

Concluding Remarks

Overall Message

Now = paradigm shift in energy and climate change

-> offering potential for leapfrogging by the South.

However, to realize this potential,

need to build up technological capabilities and have enhanced access to global knowledge .

Reviewed the experience of selected developing countries in capability building and policy options

To find: while private firms emerge to play critical roles, Governments provided strategic framework to nurture the growth of the both old and new industries.

-> From G-P-G to F-L-G Model of Stages of Capa. Building

Recommendations

1) Environment-friendly technologies as global public goods; to be promoted by shared incentives for early adoption.
2) From protection of IT to more use of IP:
   - Broad research exemption for experimental users;
   - Judicial power to require nonexclusive licensing in the spirit of anti-blocking or public interest;
   - petite patents (utility model) as alternative IPRs
3) Latecomers: Policy space to nurture their local firms
   (need to reform of global rules and governance)
4) New forms of cooperation and technical assistance:
   such as LFPs, STI doctors ; UNIDO programs
5) Potential for South-South cooperation in the area of technology transfer and leapfrogging.

References (www.keunlee.com)

- Lee, Keun, 2013 (in print), Schumpeterian Analysis of Economic Catch-up: Knowledge, Path-creation and middle income trap, Cambridge Univ. Press
- Lee, Keun, & BY Kim,"Both Institutions & Policies matter but differently at differnent income levels: long run economic growth,: World Development (2009)
- Lee, Keun, & C. Lim (2001), "Technological Regimes, Catching-up & Leapfrogging: the Findings from the Korean Industries", *Research Policy*, 459-483.
- Lee, Keun, "Asymmetric Protection leading to not Productivity but Export Share Changes: the case of Korean Industries, 1967~1993," (with H. Shin), *Economics of Transition,* 2012 no. 4.
- Lee, Keun, C.Lim, and Wichin Song (2005), "Digital Technology as a Window of Opportunity and Technological Leapfrogging: Catch-up in Digital TV by the Korean Firms", *Inter.J. of Tech. Management*, Vol. 29, 1/2, pp. 40-64.
- Lee, Keun, "Making a technological Catchup." Asian J.of Tech. Innovation, 2005.
- Lee, Keun, "From the Washington Consensus to the BeST Consensus for World Development (with John Mathews)," *Asian-Pacific Economic Literature*, May 2010.
- Kim, YK, Keun Lee, W. Park, K. Choo, Appropriate Intellectual Property Protection and Economic Growth in Countries at Different Levels of Development," *Research Policy* 41, no 2: 358-75.March 2012