Technological Learning Systems, Competitiveness and Development

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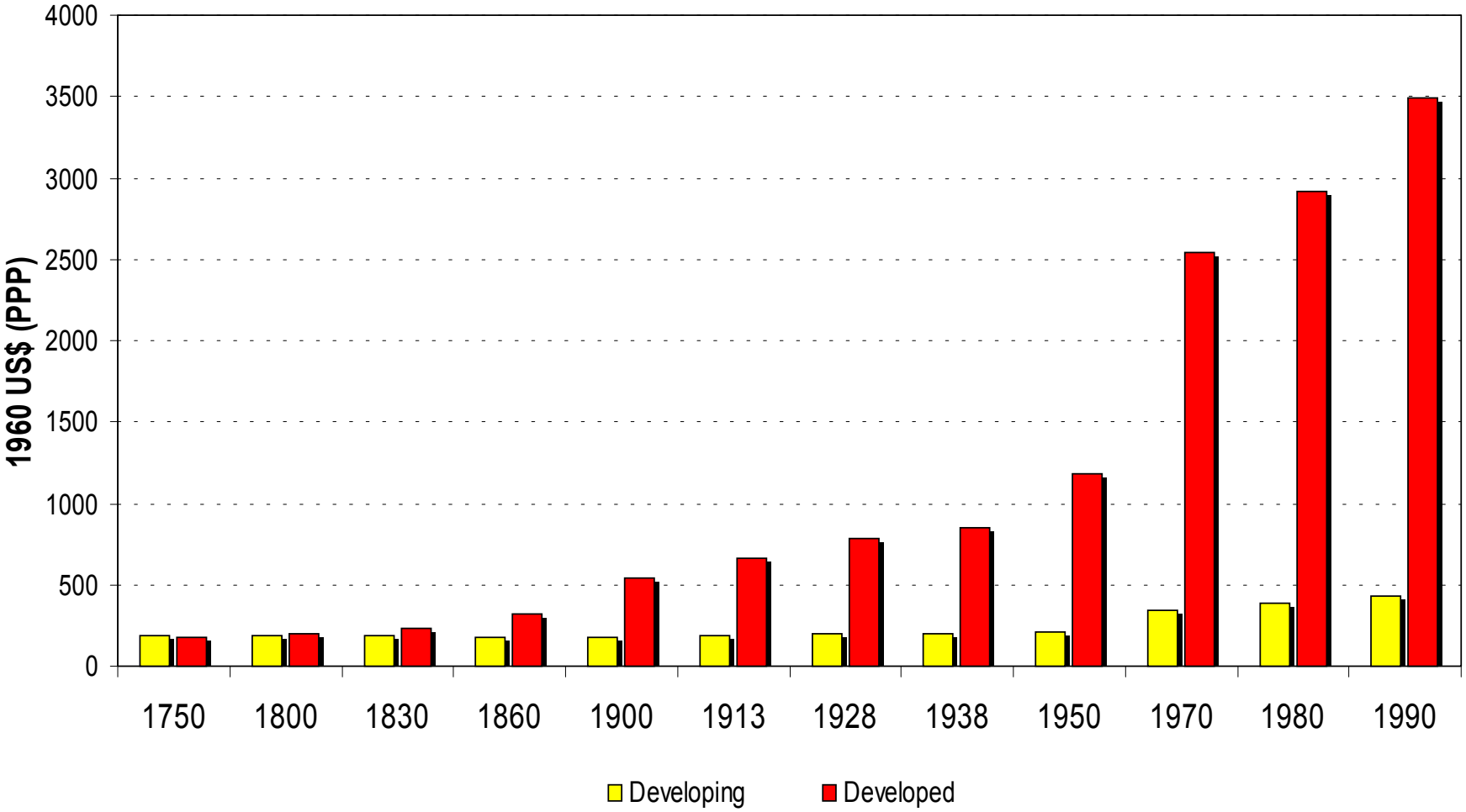
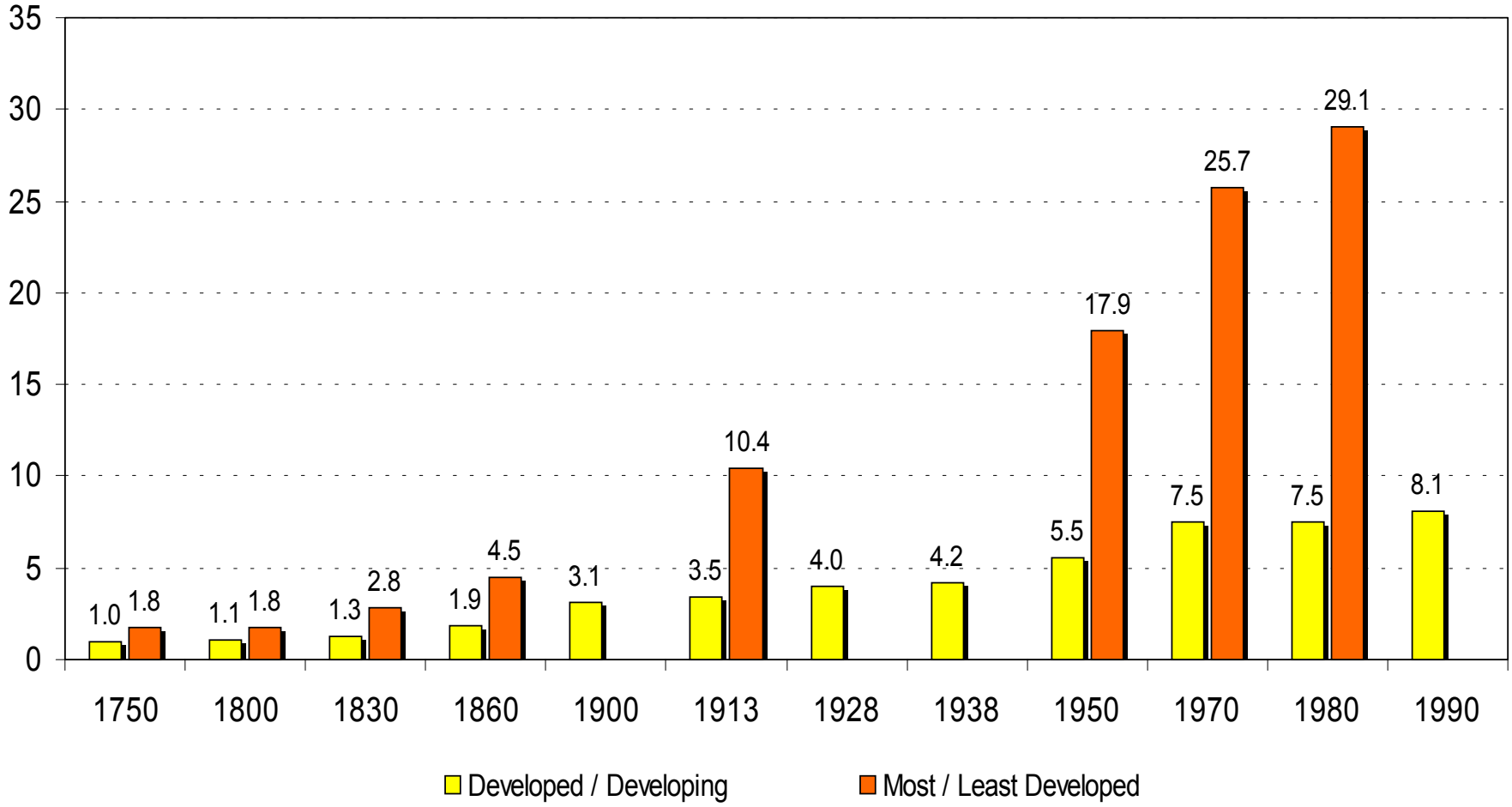
Have developed and developing economies always existed?

REAL PER CAPITA INCOME ESTIMATES
Developing "X" Developed Economies
(1750 - 1990)



RATIOS OF REAL PER CAPITA INCOMES
Developing "X" Developed Economies
(1750 - 1990)



Comments on the graphs about per capita incomes

- Before the Industrial Revolution, there was no meaningful difference in per capita income between the countries that are now developed and those that are now developing.
- The difference emerged and increased systematically after the Industrial Revolution.
- Per capita income of developing economies remained stagnated for approximately 200 years.
- Incomes of developing economies started to rise only after the industrialization process began to thrive in those economies.
- Nonetheless, the income divergence continued.

What is the main reason for the divergence?

LABOR PRODUCTIVITY IN COTTON SPINNING (18th Century – 1990)

Technology	Period	Operative Hours to Process 100 lbs of Cotton	Relative Productivity
Indian Hand Spinners	18th Century	50,000	1
Crompton's Mule	1780	2,000	25
100-Spindle Mule	c. 1790	1,000	50
Power-assisted Mules	c. 1795	300	167
Roberts' automatic Mule	c. 1825	135	370
Most efficient machines	1990	40	1.250

Comments on the table about labor productivity (1)

- Differences in labor productivity are the most important reason for countries' income differences.
- The main engine of labor productivity is technical change.
- New technologies are usually superior to the old ones.
- After the introduction of new spinning technologies, the Indian hand spinner would never be competitive in the long run no matter how cheaper the Indian labor was, compared to the British.
- At the same time, it was precisely the higher productivity of the British worker that made it possible for him to enjoy a much higher standard of living than that of the Indian worker.

Comments on the table about labor productivity (2)

- Orthodox (neoclassical economics') models of international trade, that assume that each and every country has access to the same set of technologies (i.e., have equal production functions), disregard the main cause for countries unequal productivity and levels of development.
- Similarly to what happened in the cotton spinning industry, the continuous process of development and adoption of new technologies in the economies that became industrialized was responsible, on the one hand, for the extraordinary growth of their labor productivities and, on the other hand, for the growing lag of productivity and loss of competitiveness of developing economies.

What was the main engine of technical change?

The industrialization process

- Before industrialization, tradition (kept by guilds and their masters) was the main factor determining which technology would be employed.
- The industrial sector became the vehicle for the systematic introduction of technical change in the economy as a whole.

Wouldn't then industrialization be the way out of underdevelopment?

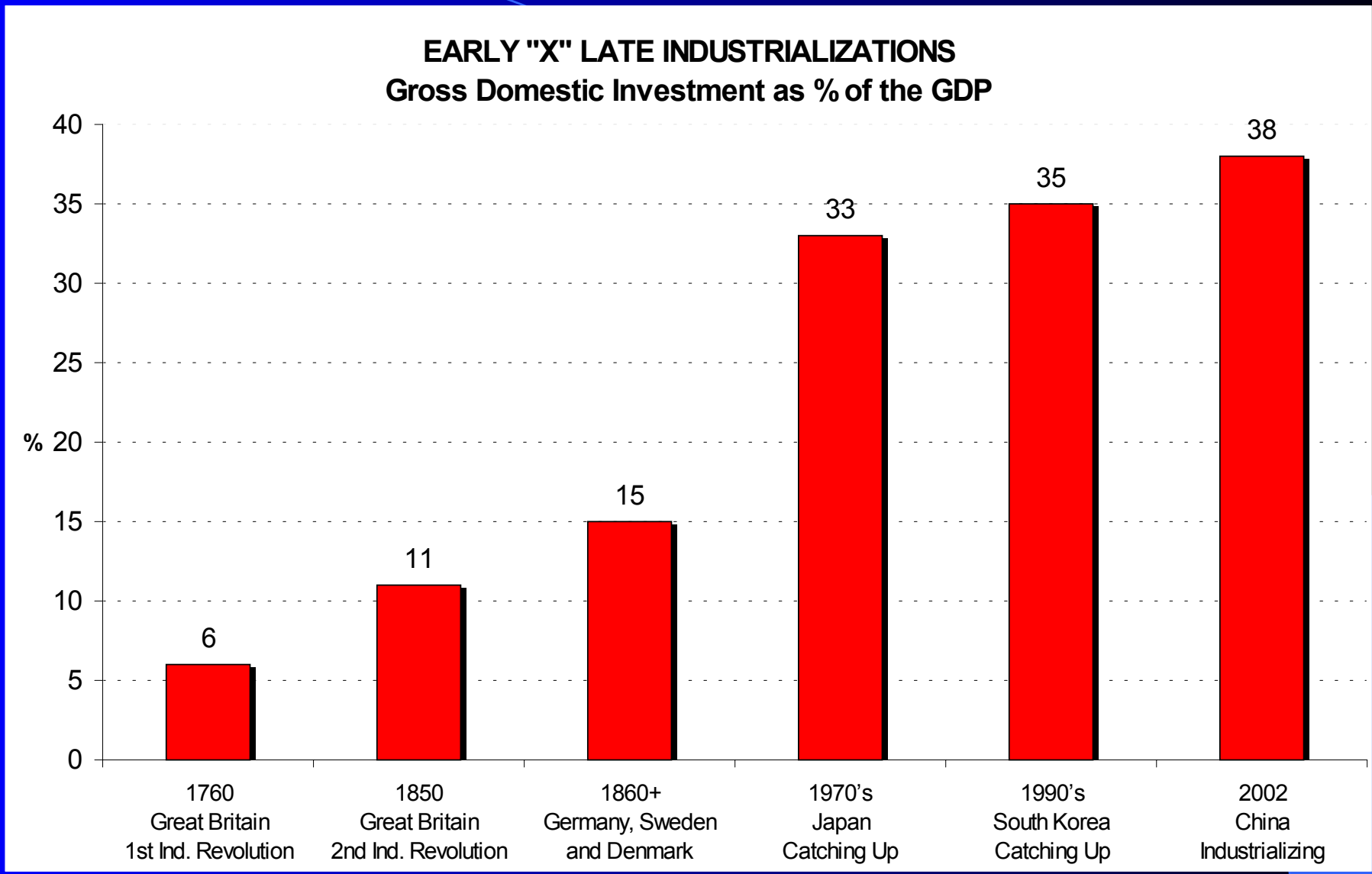
(as suggested by almost all theories of development)

Late industrialization (1)

- Late industrializing economies, however, are not allowed to follow the same path of gradual introduction of technologies pursued in the original industrialization process.
- There is no sense, for instance, in adopting first the “Indian hand spinning” technology; a few decades latter, the “Crompton’s mule”; twenty years later, the “100-spindle mule”; and so on … in order to achieve the current productivity of a British worker in cotton spinning around the middle of the 23rd century.
- It would also be economically unfeasible.

Late industrialization (2)

- Late industrialization is a process completely different from the original industrialization.
- Latecomers are required to leap to steps of the technological ladder that industrial economies took centuries to achieve in a progressive process of technological and capital accumulation.
- Latecomers' rates of investments must be huge in comparison with earlier industrilizers.
- Latecomers must overcome the entrance barrier represented by the need to compete with products that already exist in international markets and are produced, in almost all cases, with the help of technologies which are more efficient than those a latecomer is able to access.


EARLY "X" LATE INDUSTRIALIZATIONS
Gross Domestic Investment as % of the GDP
%
40
35
30
25
20
15
10
5
0
6
11
15
33
35
38
1760
Great Britain
1st Ind. Revolution
1850
Great Britain
2nd Ind. Revolution
1860+
Germany, Sweden
and Denmark
1970's
Japan
Catching Up
1990's
South Korea
Catching Up
2002
China
Industrializing

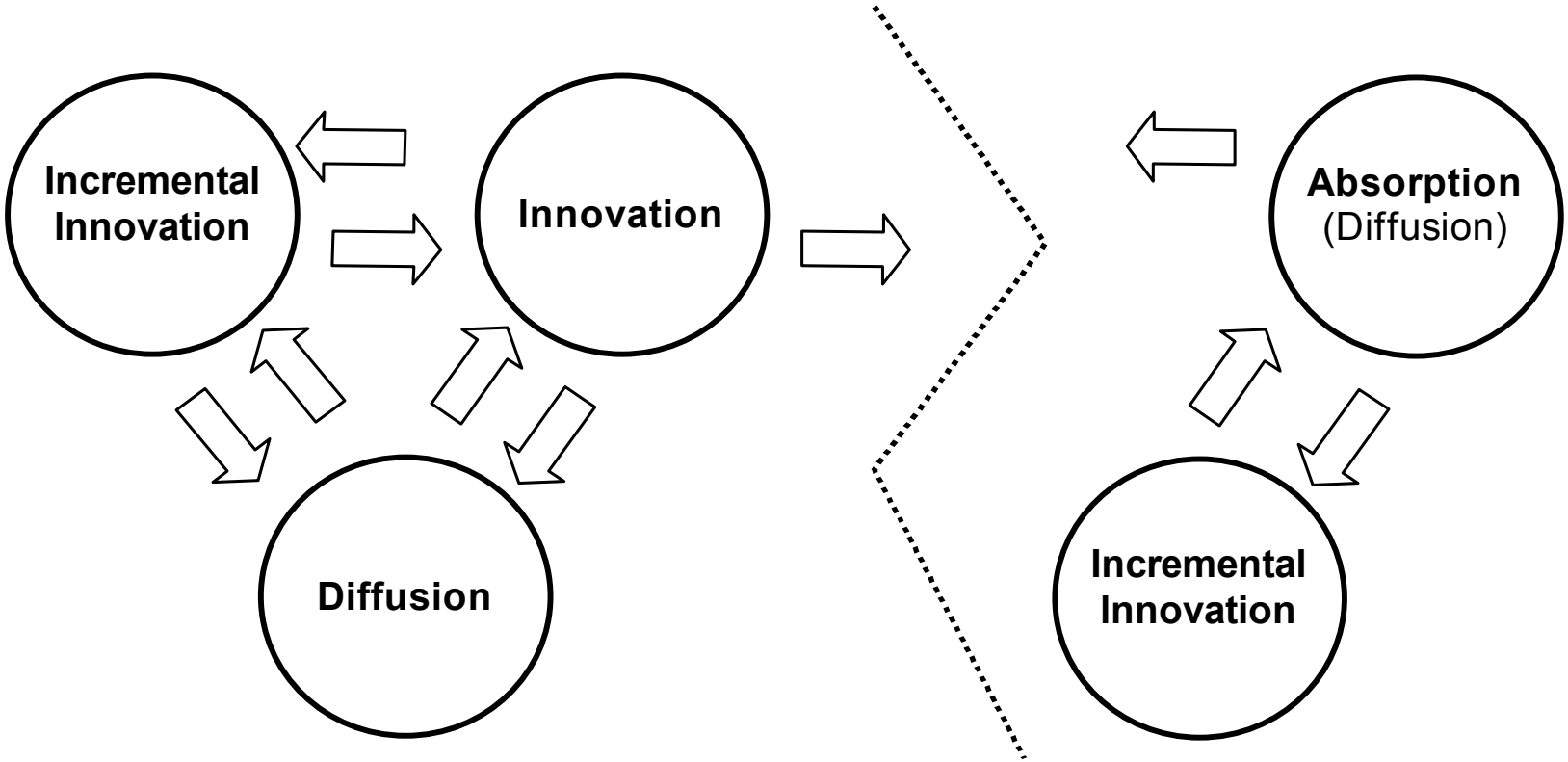
How different is the process of technical change of latecomers?

NATIONAL INNOVATION SYSTEMS

(Industrialized Nations)

NATIONAL LEARNING SYSTEMS

(Late Industrializing Nations)



Innovation and learning (definitions)

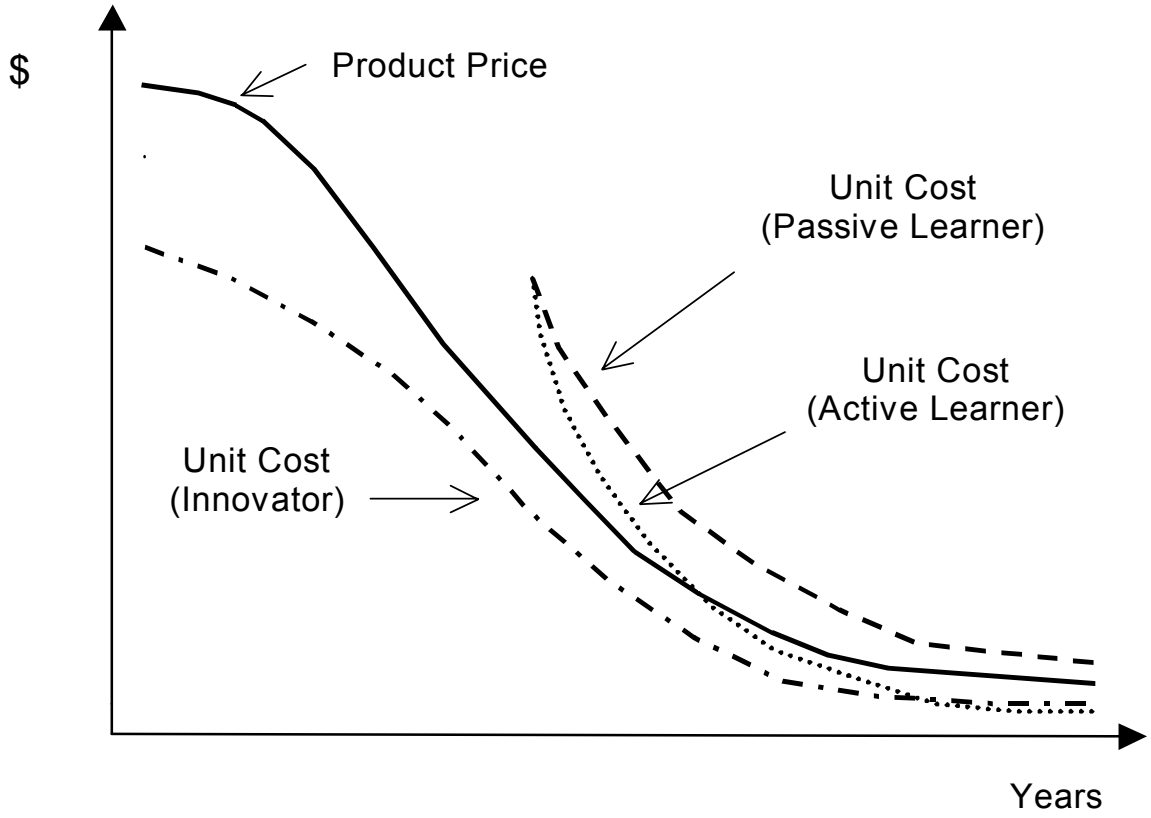
- **Innovation** is the process of technical change achieved by the introduction of (the first commercial transaction involving) a new product, process, system or organization. (New to the world, and not to the firm, country or region.)
- **Technological learning** is the process of technical change achieved by:
- 1. the absorption of already existing techniques, i.e., the **absorption** (diffusion) of innovations produced elsewhere, and;
- 2. the generation of improvements in the vicinity of acquired techniques, i.e., **incremental innovation**.

Technological Learning Systems

- Late industrialization is usually deprived of the innovation element.
- Late Industrialization and catching up are basically a process of “learning”, and not of innovation.
- The use of the concept of innovation as a kind of synonym of technical change hinders the ability to understand the differences in the processes of technical change typical of developed and developing economies.
- The limited nature of the latecomer’s process of technical change (learning) is the main reason why developing economies have low productivities and per capita incomes, and high inequity.

How learning affects latecomer's competitiveness?

COMPARATIVE EVOLUTION OF UNIT COSTS
Innovator, Passive and Active Learners



Comments on the graph about unit costs (1)

- Innovators usually enjoy a kind of Schumpeterian surplus.
- These extraordinary profits could fund innovators' R&D, modernization investment and capital accumulation, creating the conditions for them to retain their innovation lead, extraordinary profits, and competitive advantages trough time.
- They could also become the object of appropriation by consumers, workers and the state, without jeopardizing the process of capitalist accumulation.
- This mechanism is vital for the authentic competitiveness of innovators, as well as for building societies with high standards of living and relatively equitable income distributions, which characterizes developed economies.

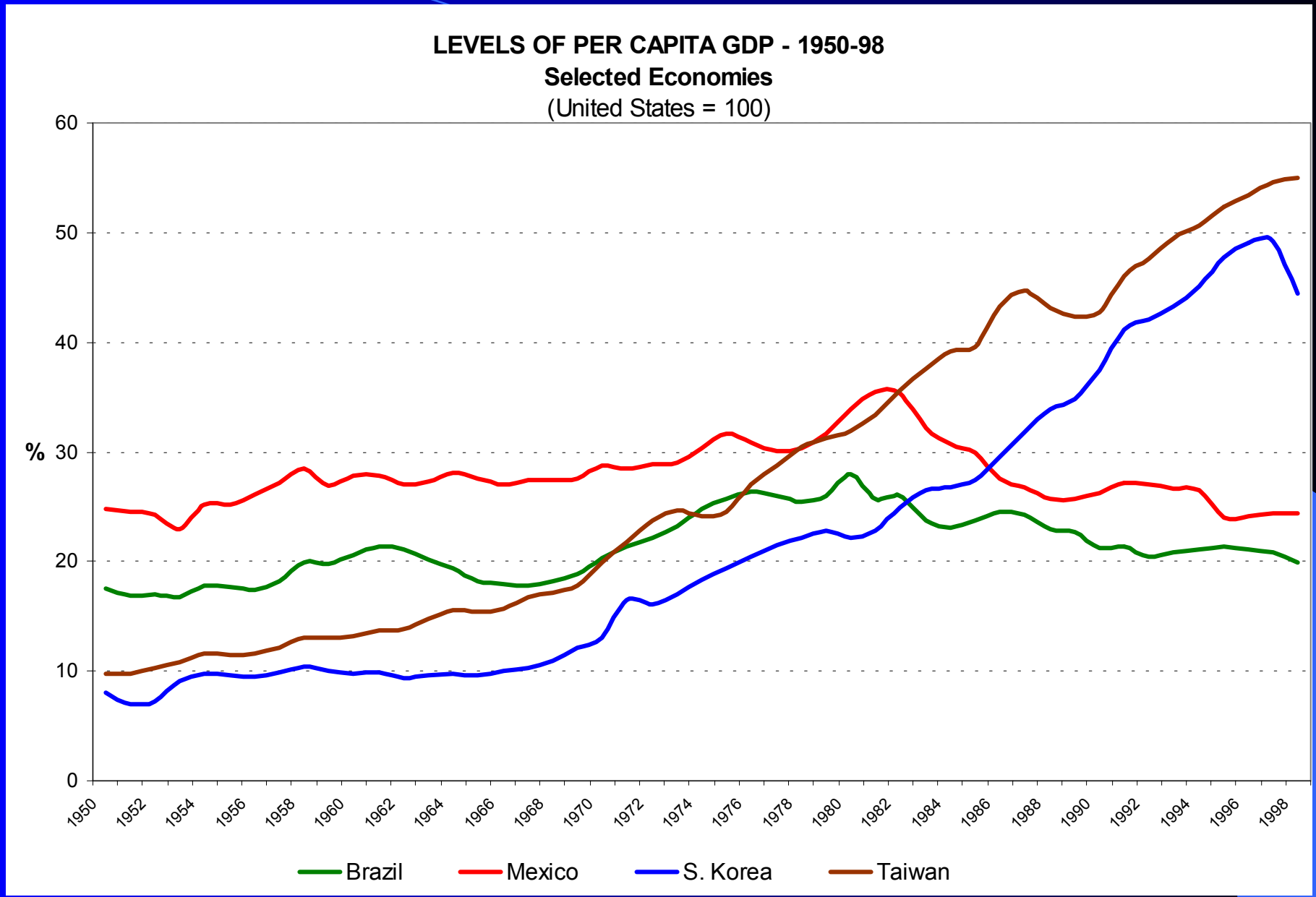
Comments on the graph about unit costs (2)

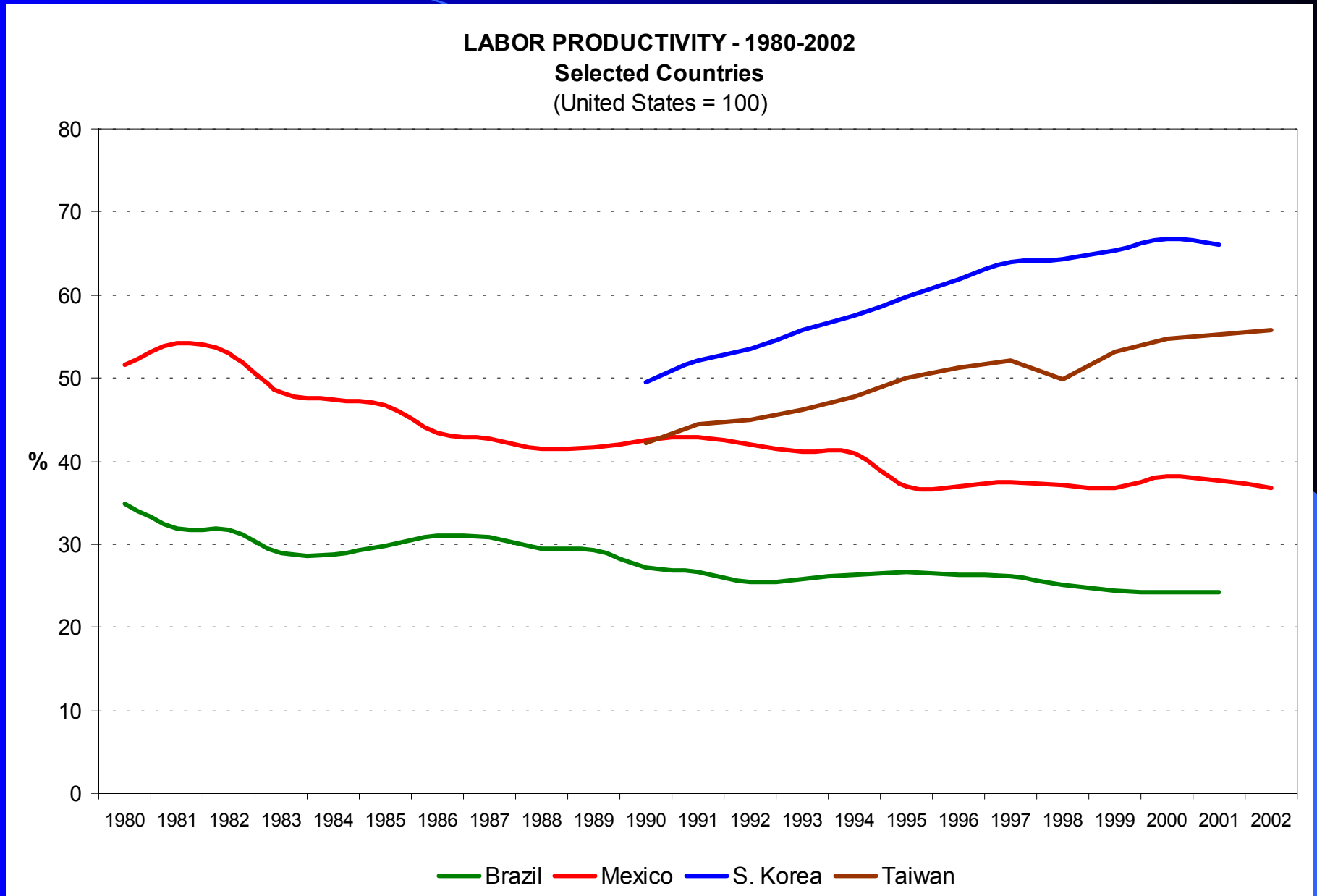
- The imitator is banned from the pool of extraordinary profits that is a privilege of innovators.
- Its profit margin is squeezed by its relatively high cost.
- Some times, it needs to fund, at least initially, an extraordinary cost that is represented by the amount its unity cost exceeds the market price.
- This initial burden must be overcome by means of mechanisms such as low wages and state subsidy or protection (spurious competitiveness).
- The structural difficulties described here are some of the most important reasons why latecomers have difficulties in achieving higher levels of income and equitability.
- Higher wages, for instance, could jeopardize one of the few sources of competitiveness of these economies.

Comments on the graph about unit costs (3)

- If the imitator is not able to advance its process of cost reduction at a speed higher than that of its competitors in order to close the productivity gap it will extend indefinitely its dependency on the spurious mechanisms to sustain its competitiveness. (Passive Learner)
- When the imitator achieves successful processes of continuous, fast and efficient technology absorption and improvement, it develops the ability to achieve rates of productivity increase (cost reduction) higher than that of their competitors, and progressively moves towards authentic competitiveness. (Active Learner)
- S&T policies of developing economies should be focused on the role these policies play in, first, the reduction of the imitation time lag, and, second, the speed and efficacy of the process of technology absorption and improvement.

Are there examples of passive and active learning?


LEVELS OF PER CAPITA GDP - 1950-98
Selected Economies
(United States = 100)
%
60
50
40
30
20
10
0
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
Brazil
Mexico
S. Korea
Taiwan


LABOR PRODUCTIVITY - 1980-2002
Selected Countries
(United States = 100)
%
80
70
60
50
40
30
20
10
0
1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Brazil
Mexico
S. Korea
Taiwan

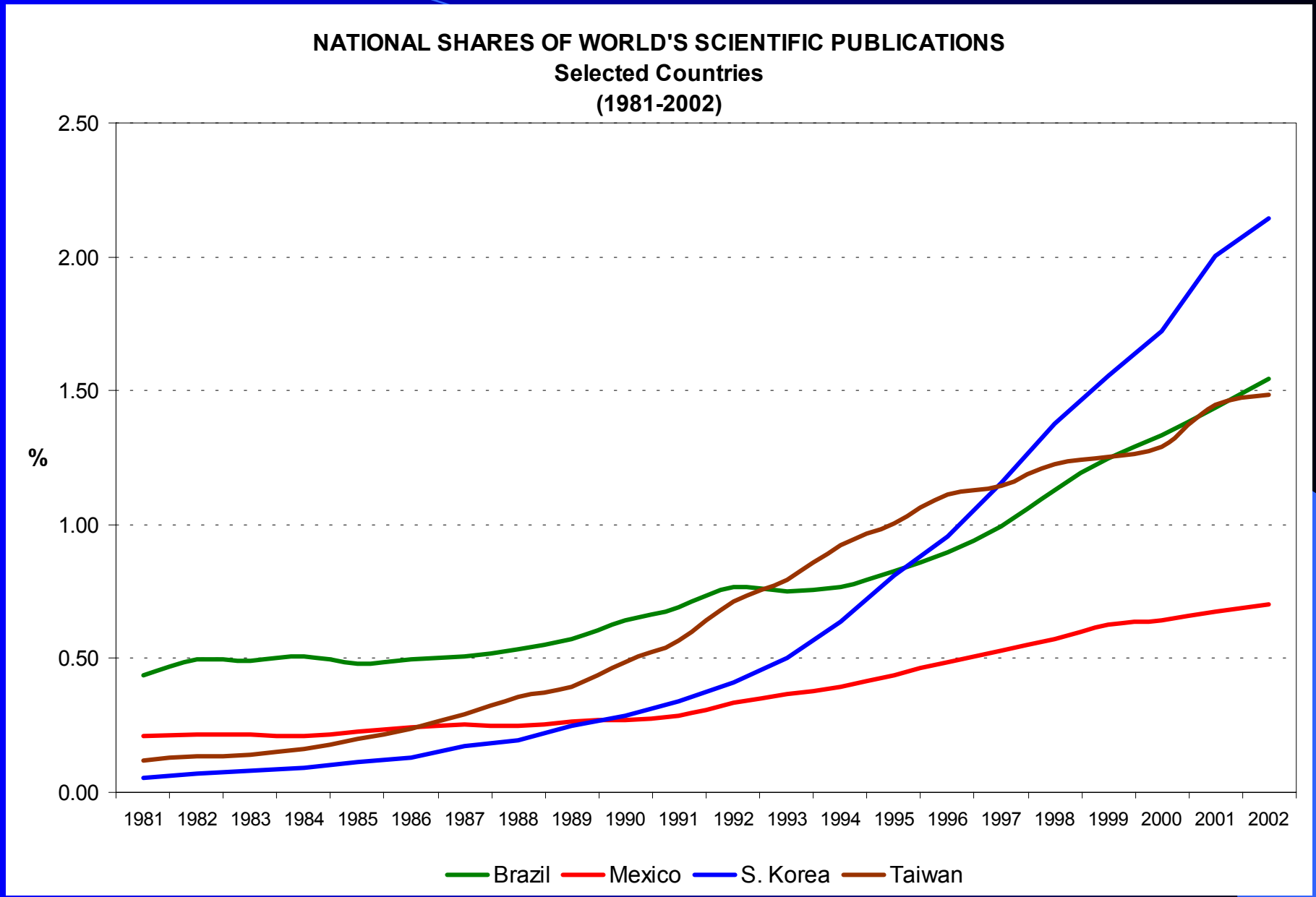
Comments on the graphs about per capita income and labor productivity

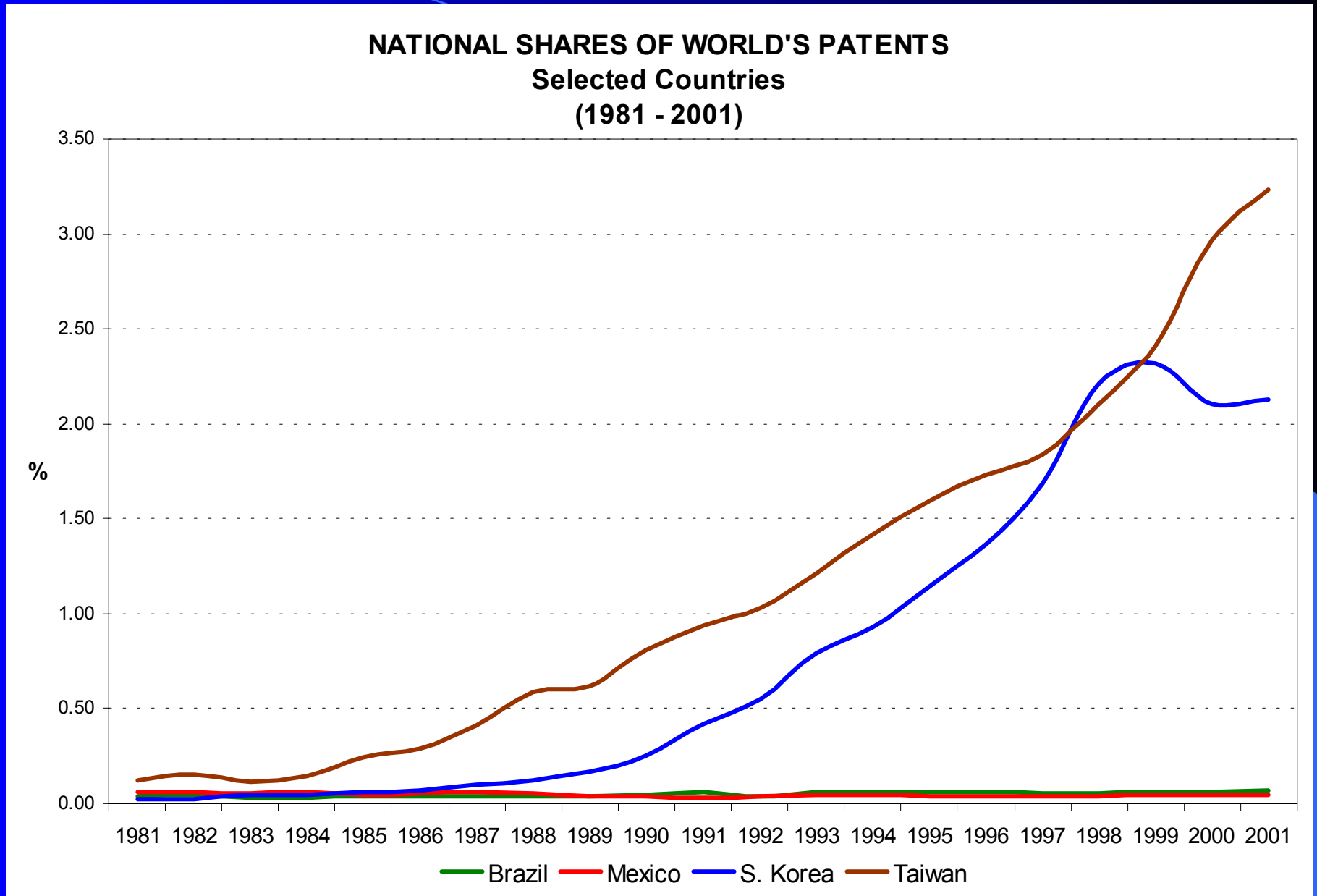
- The larger picture shown by both series is clear. South Korea and Taiwan are following a steady and sound pattern of catching up with the leading economy, whereas Brazil and Mexico are being left behind since the beginning of the 1980's.
- Brazil and Mexico are examples of passive learners.
- Korea and Taiwan are examples of active learners.

How conventional wisdom in S&T policy would explain Brazil and Mexico's poor performance in labor productivity?

The lack of R&D (especially in basic research)

- The linear model is what inspires conventional wisdom in S&T policy.
- “Basic research is the pacemaker of technological progress” (Bush), the principal source of innovation.
- “Applied research invariably drives out pure.” (Bush)
- “Those who invest in basic science will capture its return in technology as the advances in science are converted into technological innovation.” (Bush according to Stokes)


NATIONAL SHARES OF WORLD'S SCIENTIFIC PUBLICATIONS
Selected Countries
(1981-2002)
2.50
2.00
1.50
1.00
0.50
0.00
%
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
Brazil
Mexico
S. Korea
Taiwan


NATIONAL SHARES OF WORLD'S PATENTS
Selected Countries
(1981 - 2001)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
%
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001
Brazil
Mexico
S. Korea
Taiwan

Comments on the graphs about publications and patents (1)

- Brazil's share of world's scientific publications in 2001 (1.44%) was more than 20 times greater than its share of the world's (US) patents (0.07%).
- Mexico's share of world's publications in 2001 (0.67%) was more than 13 times larger than that of patents (0.05%).
- Korea's share of patents was more than 30 times that of Brazil in 2001.
- Taiwan's share was more than 64 times greater than that of Mexico in 2001.
- Korea managed to achieve in 2001 a patents' share 71 times larger than that it had in 1981.
- Taiwan increased its share almost 27 times during those 20 years, whereas Brazil went just slightly over its double, and Mexico even reduced it.

Comments on the graphs about publications and patents (2)

- Contrary to what would be expected within the framework of the linear model, Brazil and Mexico's scientific production seems to have had no meaningful impact on their respective technological productions during the last two decades of the 20th century.
- The policies of the 1980's and 1990's, a period of mounting competitive pressures and strengthening of intellectual property rights in those economies, followed by an expressive and effective expansion of their pool of scientific knowledge, seems not to have contributed to improve the traditionally poor technological performances of Brazil and Mexico.

What are the implications of this framework of analysis for latecomer's S&T policies?

Policy implications for latecomers (1)

- Conventional S&T policies, stressing basic research, tough competition and high levels of intellectual property rights, seem to be unable to push countries through the pathway of catching up, from passive to active technological learning, and possibly towards innovation.
- Latecomers' S&T policy should be evaluated mainly in terms of its contribution to the reduction of the imitation lag and of the productivity gap.
- The broad objective should be to target active learning, i.e., to build the institutions and the right set of incentives and disincentives in order to foster active learning.

Policy implications for latecomers (2)

- Building firm's technological capabilities is crucial. Academic, basic research and R&D institutions have a fundamental role, but should be articulated with the country's learning effort and should target scientific fields that are more promising for nurturing the development of an innovation process within the country.
- When one realizes that innovation is not the only objective and that active learning is also a very important target, latecomers' S&T policy and corporate strategy become more feasible and less risky. R&D for adaptation and improvement, manufacturing extension, technical assistance, demonstration and diffusion, networking of producers-suppliers and labs, and benchmarking become essential.

Policy implications for latecomers (3)

- Firm's shop floor is critical for learning. Issues like labor education and training, a cooperative environment between management and workers, few hierarchical layers and total quality management become very important.
- S&T policy must be articulated with economic, industrial and educational policies.
- Picking the right sector or technology becomes crucial. The less mature the technology, the higher the technological opportunities for active learning or even innovation, the rates of market growth and the possibility of relatively high profit margins. Mature technologies are mostly a dead end for active learning.

Policy implications for latecomers (4)

- Tough competitive pressure alone, achieved by means of open and liberalized domestic markets, usually induces price competition, specialization in industries intensive in labor and natural resources, or mature technologies. As a consequence, it favors passive learning and spurious competitiveness.