S&T Policy and Development: Reflections from a Brazilian perspective

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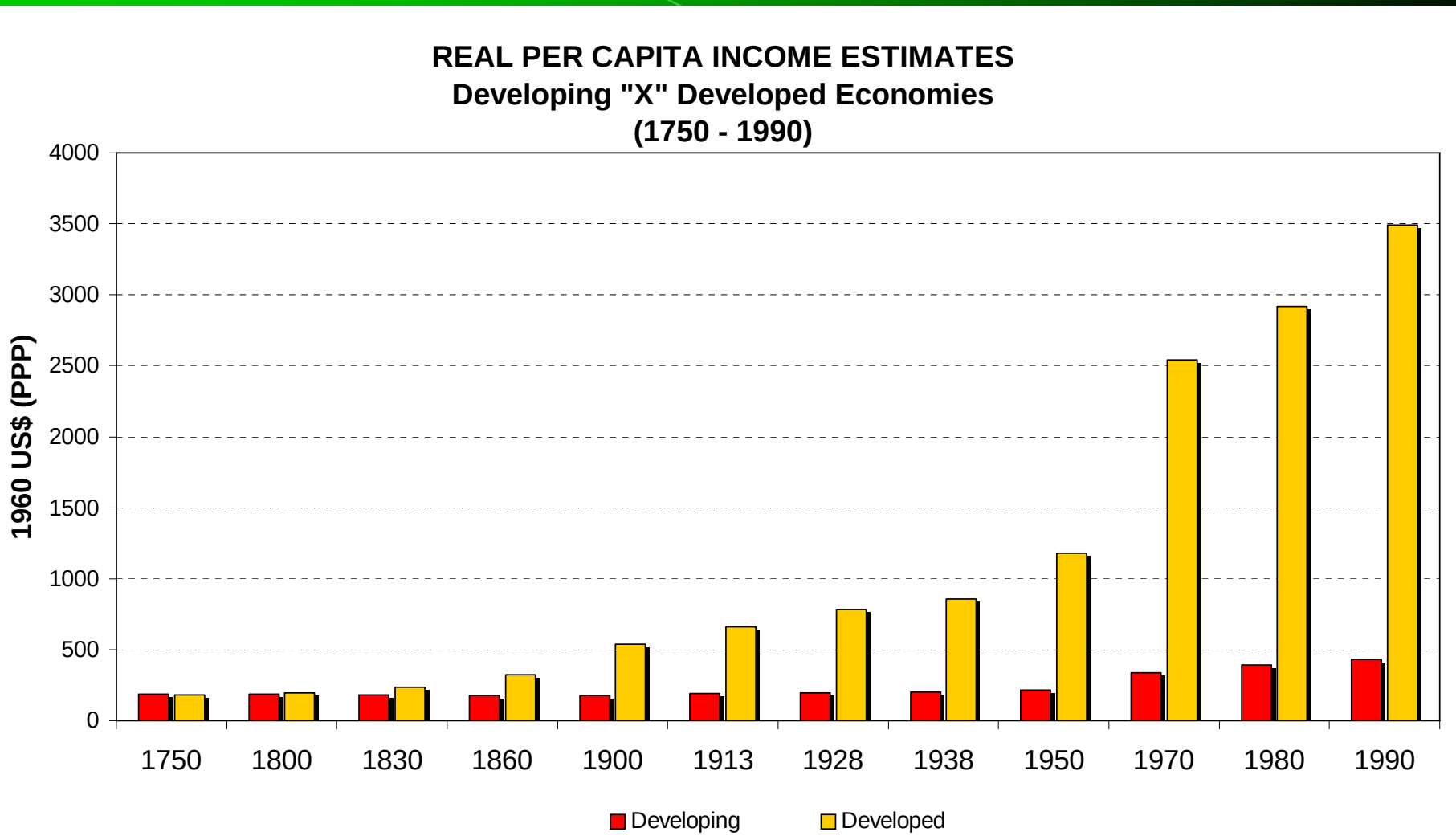
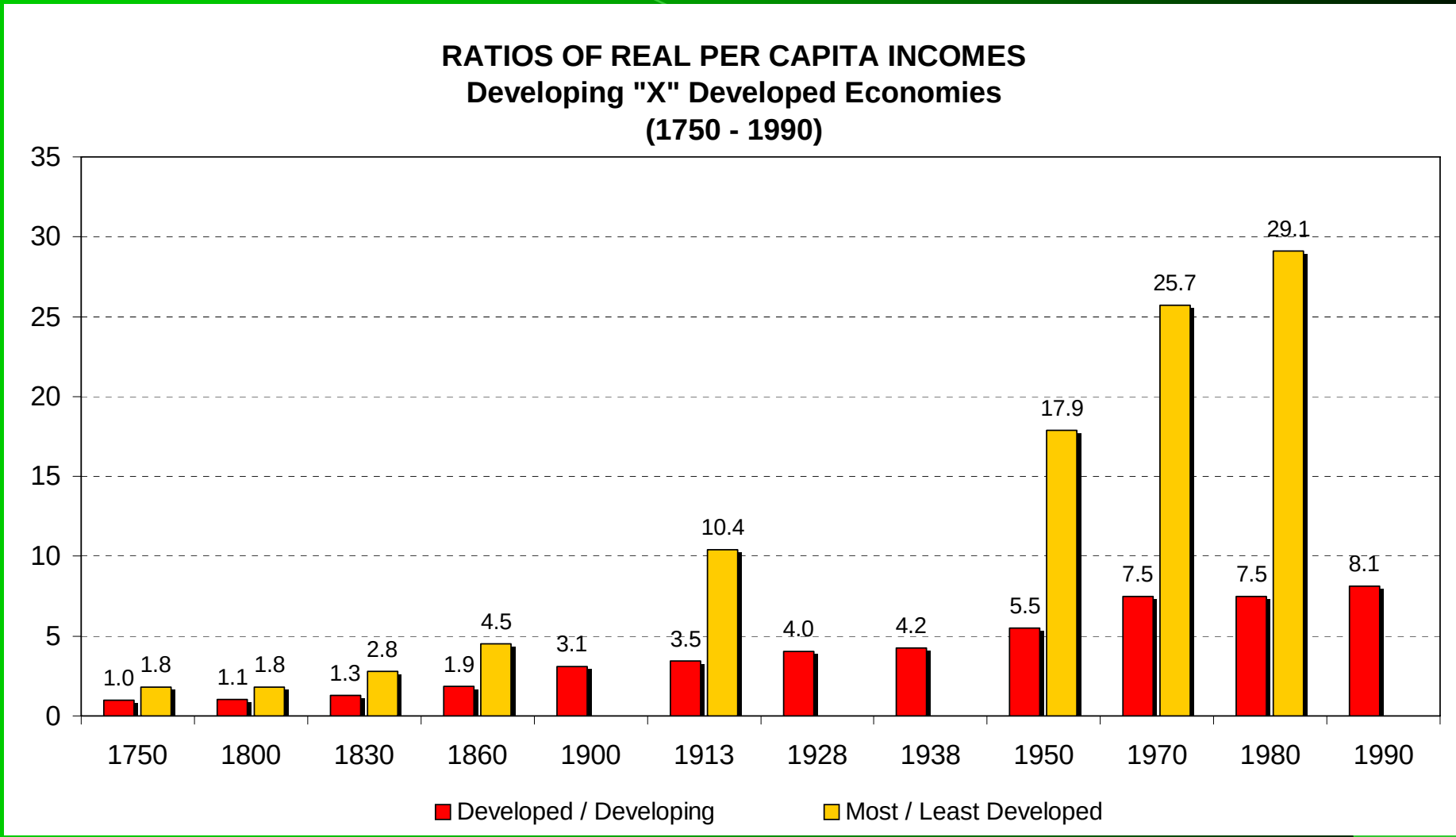
Have developed and developing economies always existed?



Source: Bairoch (1993, p. 95).



Source: Bairoch (1993, p. 95) and Bairoch & Levy-Leboyer (1981, pp. 7-8)

Per capita incomes of developed x developing economies

- 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, when technical change became a permanent feature of the economy.
- 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.
- Even so, the income divergence continued to growth.

What is the main reason for that divergence?

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

Technology	Period	Operative Hours to Process 1000 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

Source: Jenkins (1994), *apud* Freeman (1999, p. 153).

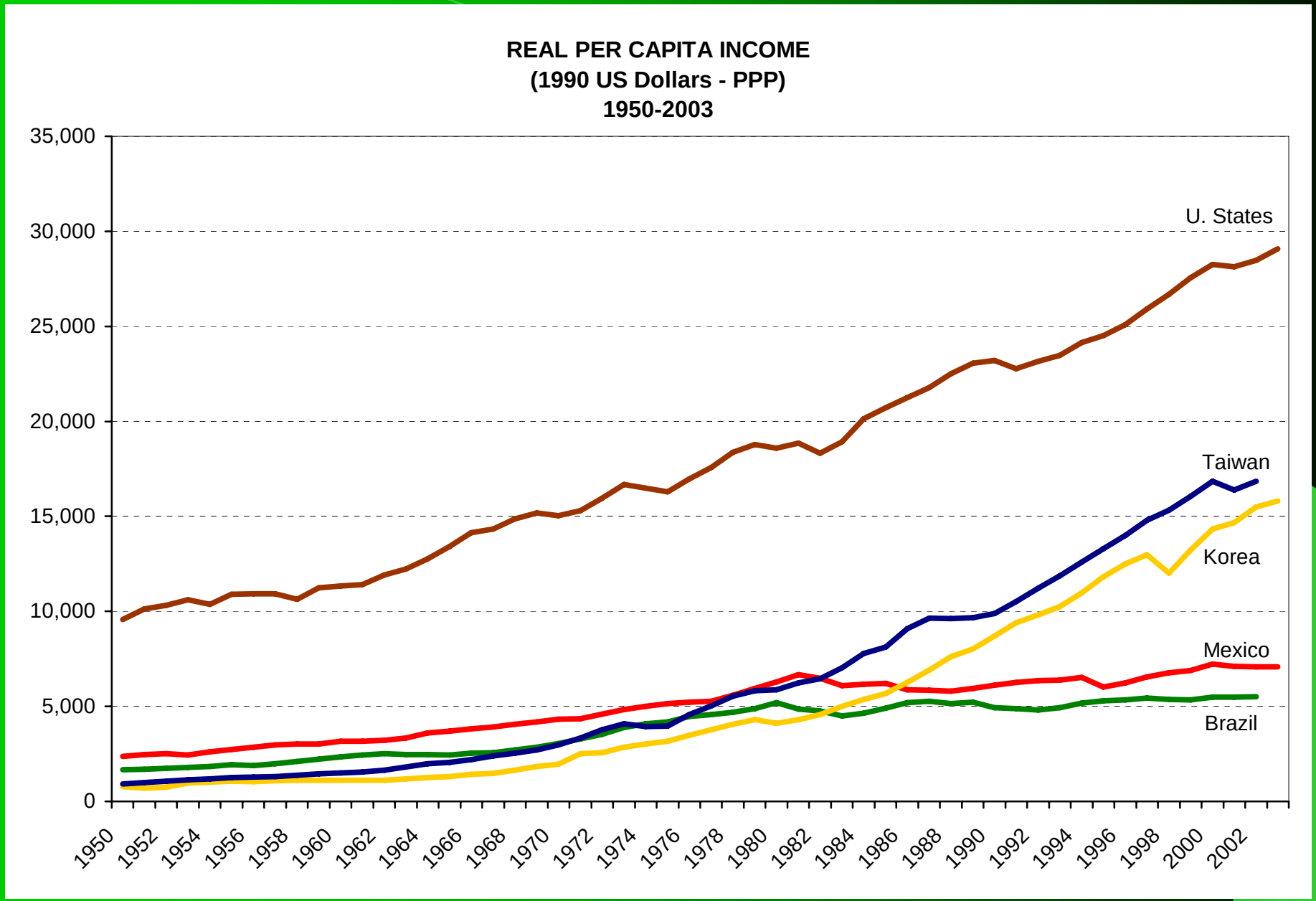
Labor productivity in cotton spinning (1)

- 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. (There is no "technical choice" in the long run.)
- 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.

Labor productivity in cotton spinning (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 gap of productivity and loss of competitiveness of developing economies.

How per capita income and labor productivity evolved in Brazil?


REAL PER CAPITA INCOME
(1990 US Dollars - PPP)
1950-2003
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
U. States
Taiwan
Korea
Mexico
Brazil
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
2000
2002

Catching up and lagging behind

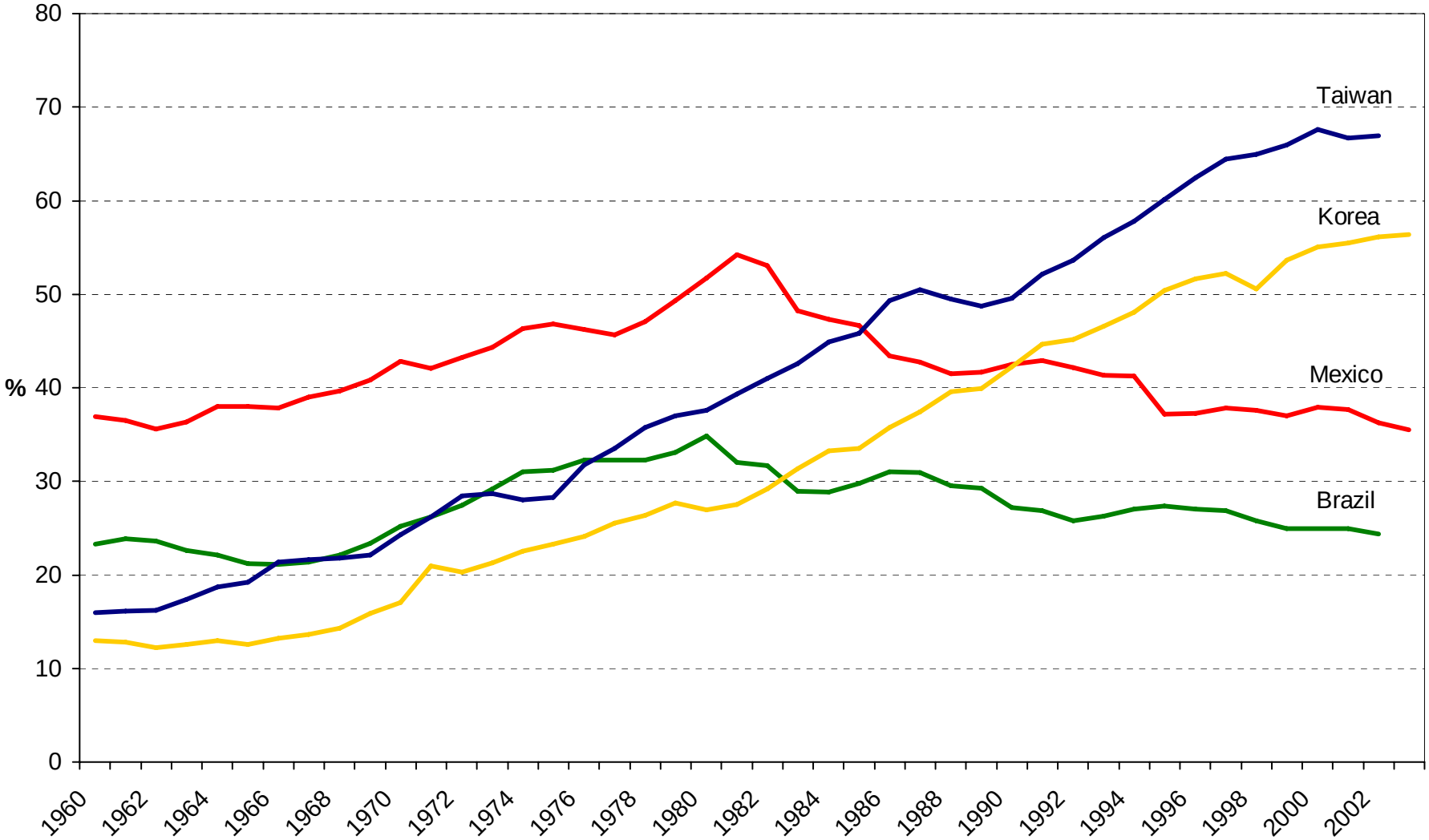
	Real per capita income (US = 100)		
	1950	1980	2002
Brazil	17.5%	28.0%	19.3%
Mexico	24.7%	33.9%	24.8%
South Korea	8.1%	22.2%	54.4%
Taiwan	9.7%	31.6%	59.2%

Catching up and lagging behind

- The large picture is clear:
  - South Korea and Taiwan are following a steady and sound pattern of catching up with the leading economy;
  - Brazil and Mexico are being left behind since the beginning of the 1980's. (The period in which the neo-liberal policy ruled.)

- (Brazil and Mexico could be taken as examples of passive learners.)
- (Korea and Taiwan could be taken as examples of active learners.)

LABOR PRODUCTIVITY
(United States = 100)
1960-2003



Productivity growth (1)

- The productivity of the average Brazilian worker doubled between 1960 and 1980, but it remained stagnated thereafter.
- During the period in which the labor productivity in Brazil remained stagnated, the productivity of several of its competitors was growing.
- For instance, between 1980 and 2002, labor productivity in the leading industrial economy (US) increased 40%.
- In 1980, the product of 1 US worker corresponded to that of 3 Brazilians.
- In 2002, it was necessary to add up the work of 4 Brazilians to produce approximately the same as 1 US worker.

Productivity growth (2)

- In 2002, the productivity of the Brazilian worker, relative to that of the US worker, went back to levels similar to those that prevailed in the year 1960.
- The poor performance of labor productivity in Brazil during the last decades is at the core of the difficulties the country has experienced in terms of growth, competitiveness and standard of living of its population.
- The poor performance of Brazilian productivity is associated with to the lack of dynamism of the processes of innovation and technological learning of the country.

How conventional wisdom in S&T policy would explain such a poor performance in labor productivity?

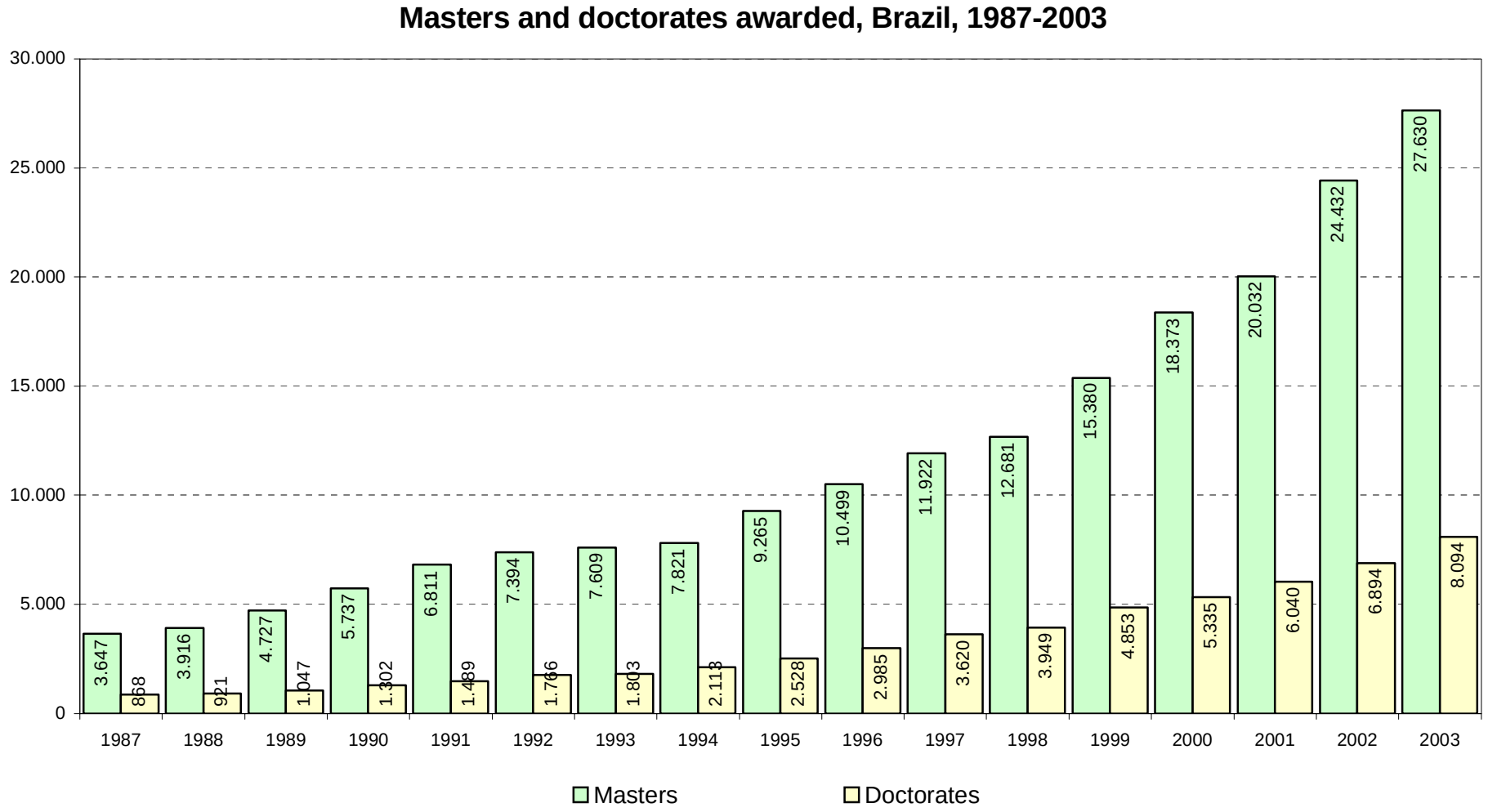
Conventional wisdom in S&T policy (1)

- Linear Model:
  - Lack of R&D personnel;
  - Lack of scientific production (lack of “supply of knowledge”).

- Neo-liberal prescriptions:
  - Lack of intellectual property protection;
  - Lack of foreign direct investment;
  - Lack of competition (economic openness).

How those factors evolved lately in Brazil?

R&D Personnel (1)



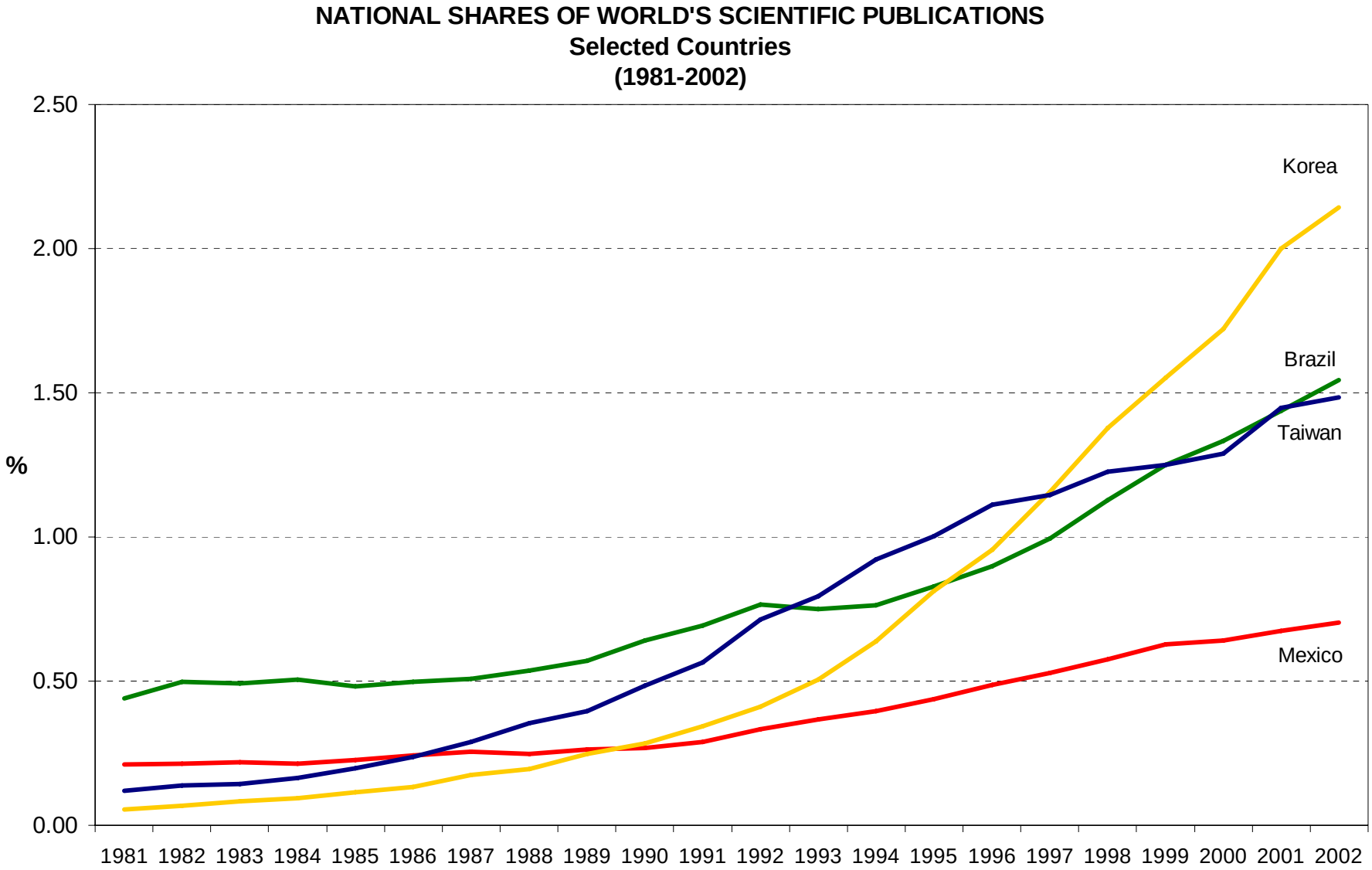
Sources: CAPES. Plano Nacional de Pós-graduação 2005-2010, CAPES, MEC, Brasília, December 2004.

R&D Personnel (2)

- The potential supply of R&D personnel, master and doctorate earners, presents a sustained pattern of high growth in Brazil.
- Between 1987 and 2003, the number of master and doctorate degrees warded in Brazil increased respectively by 757% and 932%.
- Just in 2003, more than 27 thousand Brazilians graduated in masters programs and more than 8 thousand were warded with PhD.

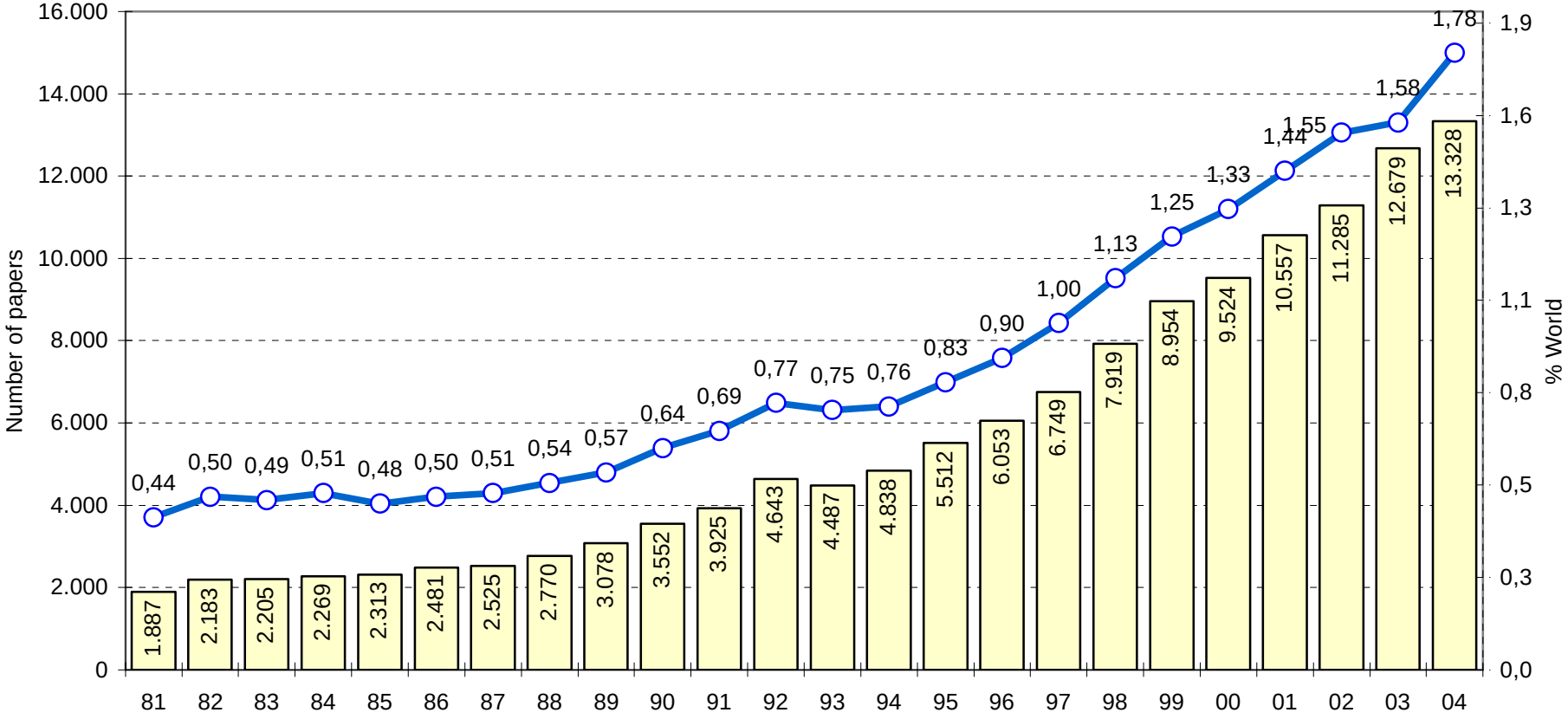
- Nonetheless, according to the Brazilian innovation survey, only (a stock of) 3 thousand graduates were involved in intramural industrial R&D in the year 2000.
- In that same year, Brazilian universities warded (a flow of) 18 thousand master degrees and 5 thousand doctorates.

Scientific production (“supply of knowledge”)



Scientific production (“supply of knowledge”) (1)

Number of scientific publications by Brazilian residents and share of the world total, 1981-2004



Source: Institute for Scientific Information (ISI), National Science Indicators.

Scientific production (“supply of knowledge”) (2)

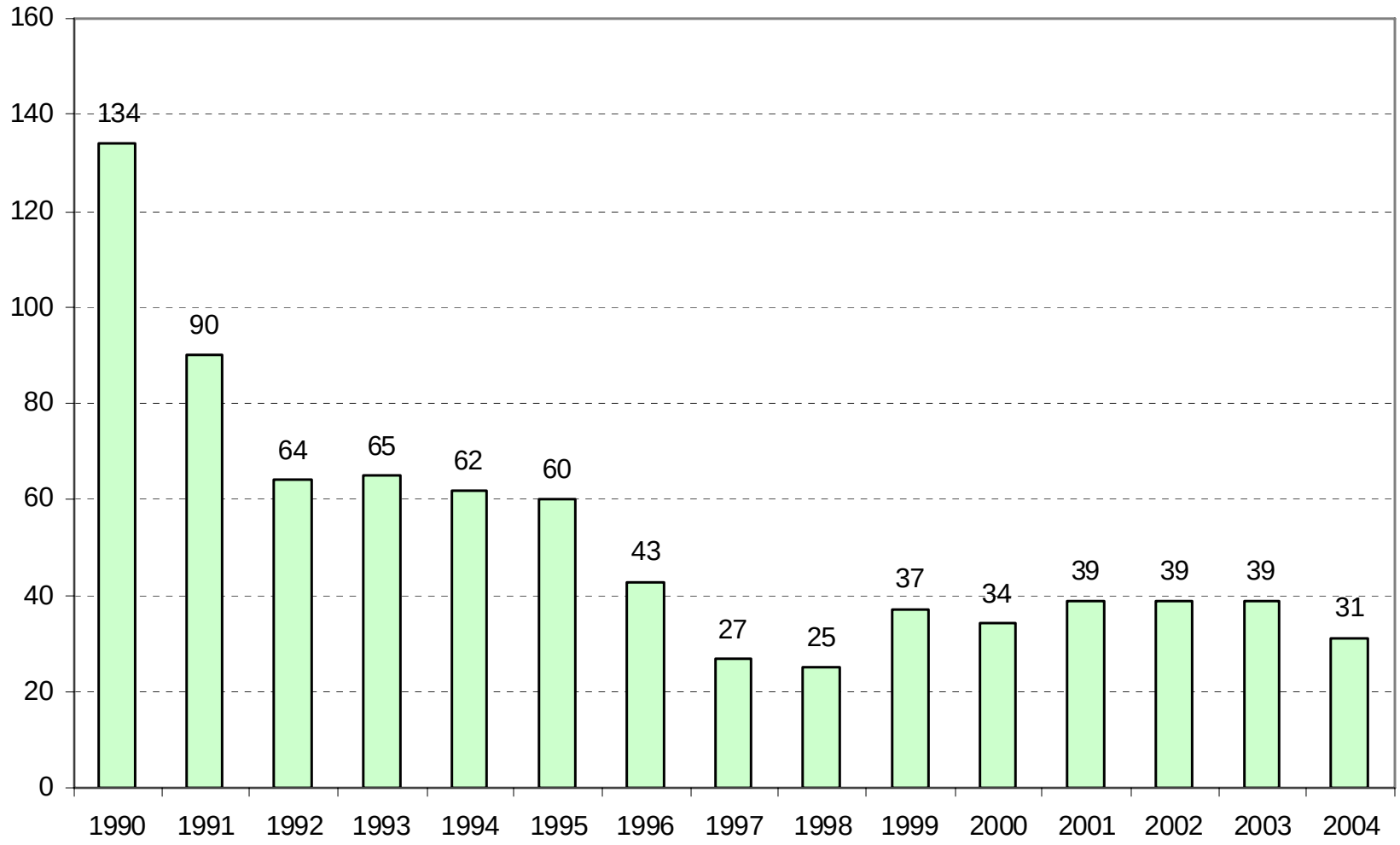
- The Brazilian scientific production is growing in a very fast pace.
- Seven times faster than the world average during the last two decades.

Intellectual property protection (1)

- Deregulation of the technology transfer process (Revocation of “Ato Normativo nº 15, de 03/09/1975” of the INPI, the Brazilian patent and trademark office, by “Ato Normativo nº 22, de 1990” and “Ato Normativo nº 120, de 1993”.)
- Internalization of TRIPS (Lei da Propriedade Industrial, Lei nº 9.279/96; Lei de Cultivares, Lei 9.456/97; Lei de Direitos Autorais, Lei 9.610/98, e Lei de Programas de Computador, Lei nº 9.609/98.)
- One of the most important objectives of the 1990’s changes in intellectual property rights was to create an environment that would encourage technology transfer, its results in terms of patent licenses, however, seem to have worked in the wrong direction.

Intellectual property protection (2)

Number of patents licensed to Brazilian enterprises, 1990-2004



Source: INPI (www.inipi.gov.br, January 17, 2007)

Foreign direct investment

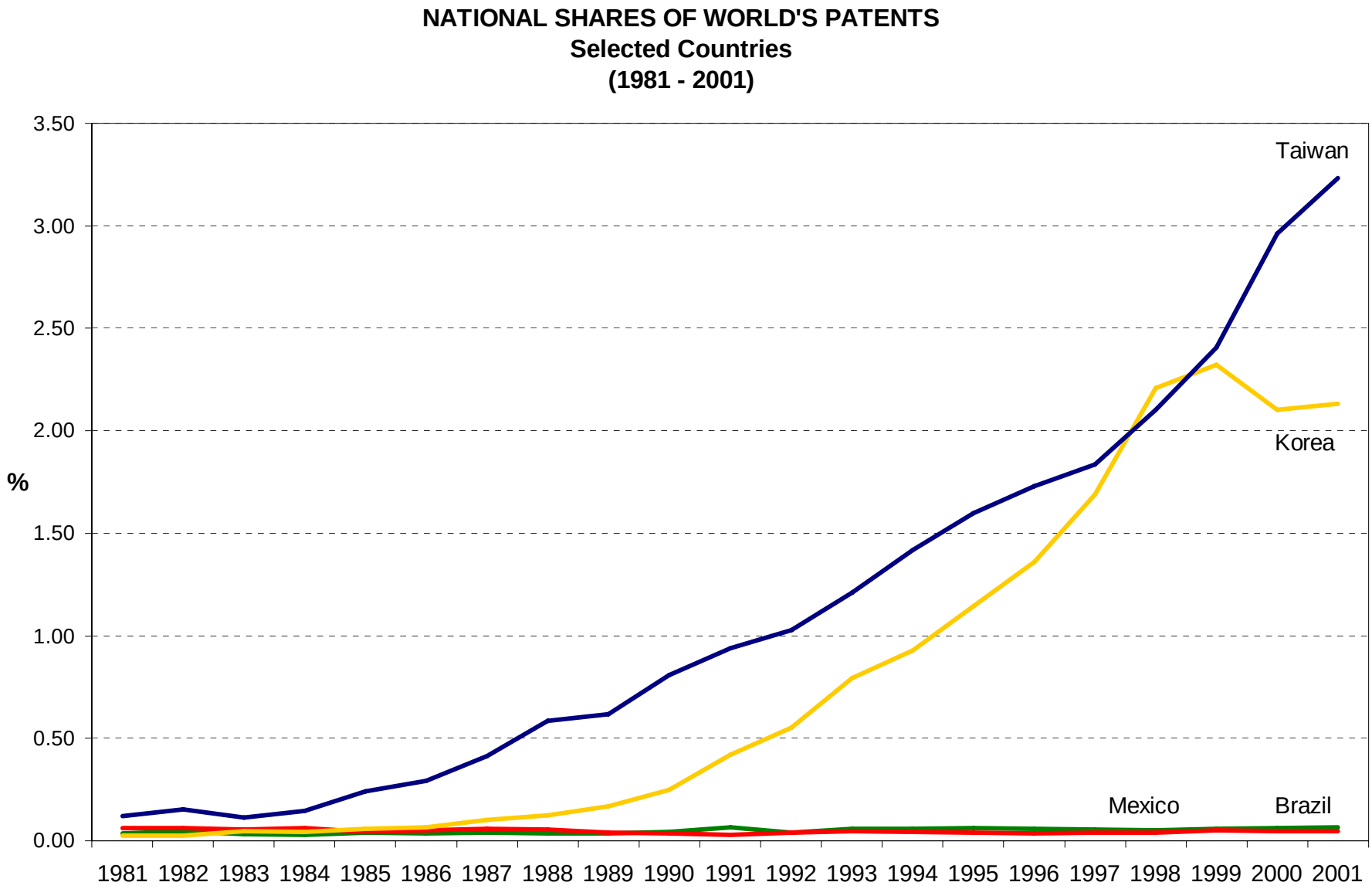
- Foreign capital has enormous weight in the industrial structure of Brazil.
- Although not that expressive in terms of the total number of enterprises, it is extremely significant in the higher size classes and accounts for an exceptionally high share of turnover.
- Foreign corporations are responsible for nearly one third of the Brazilian manufacturing turnover.
- Surprisingly, an econometric exercise performed using data from the Brazilian innovation survey found that, in comparison to domestic enterprises, foreign enterprises are seen to invest a significantly smaller share of their revenues in R&D when factors such as enterprise size and sectoral distribution are controlled for (Araújo 2005: pp. 150 and 165).

Competition (economic openness)

- During the 1990’s, tariff and non-tariff barriers were lowered substantially or removed at all, a strong process of privatization and deregulation took place, state monopolies ended, and discrimination between domestic and foreign corporations became illegal.
- Imports as a share of GDP increased substantially.

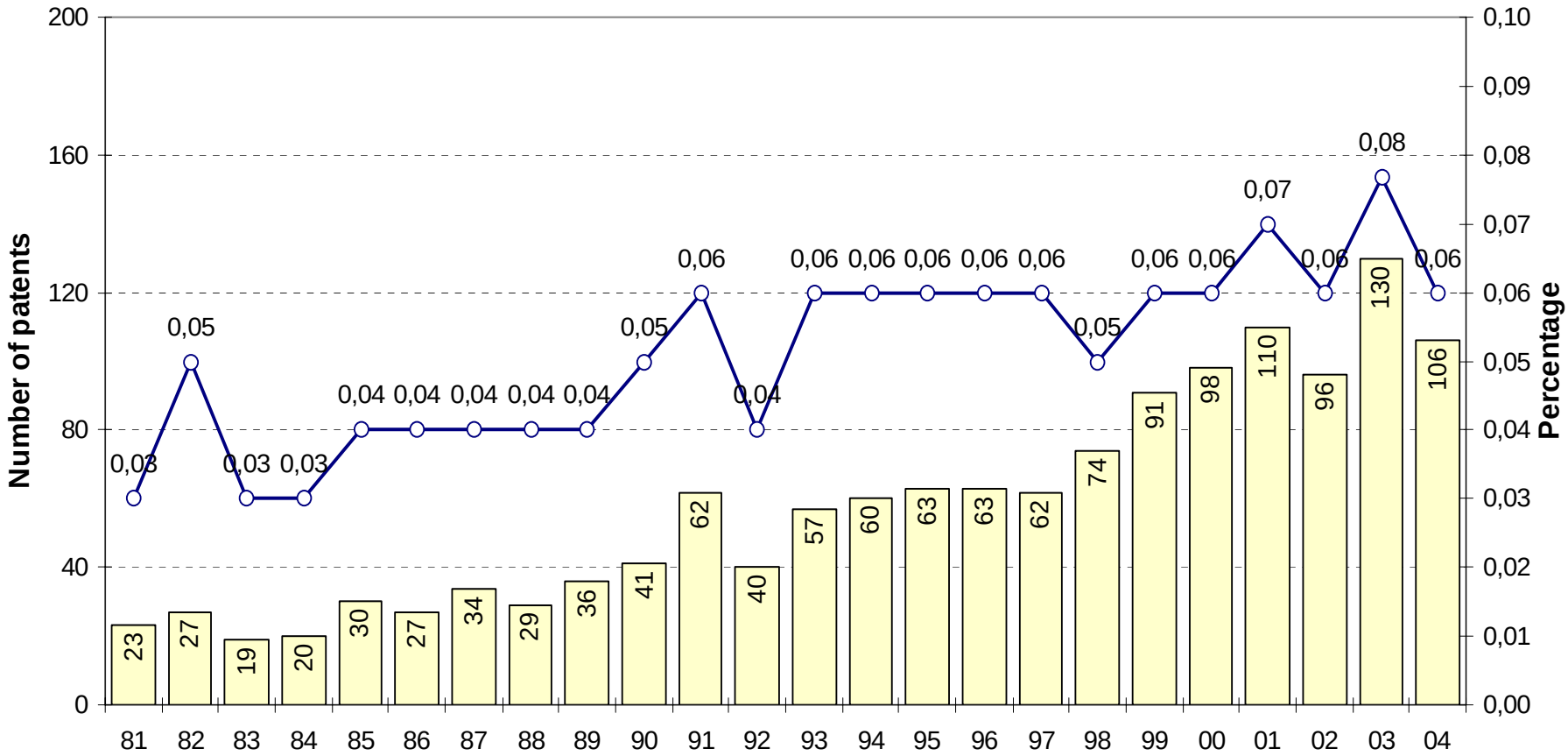
What were the consequences of conventional S&T policy in terms of technology production?

Technological Production (US patents 1)



Technological Production (US patents 2)

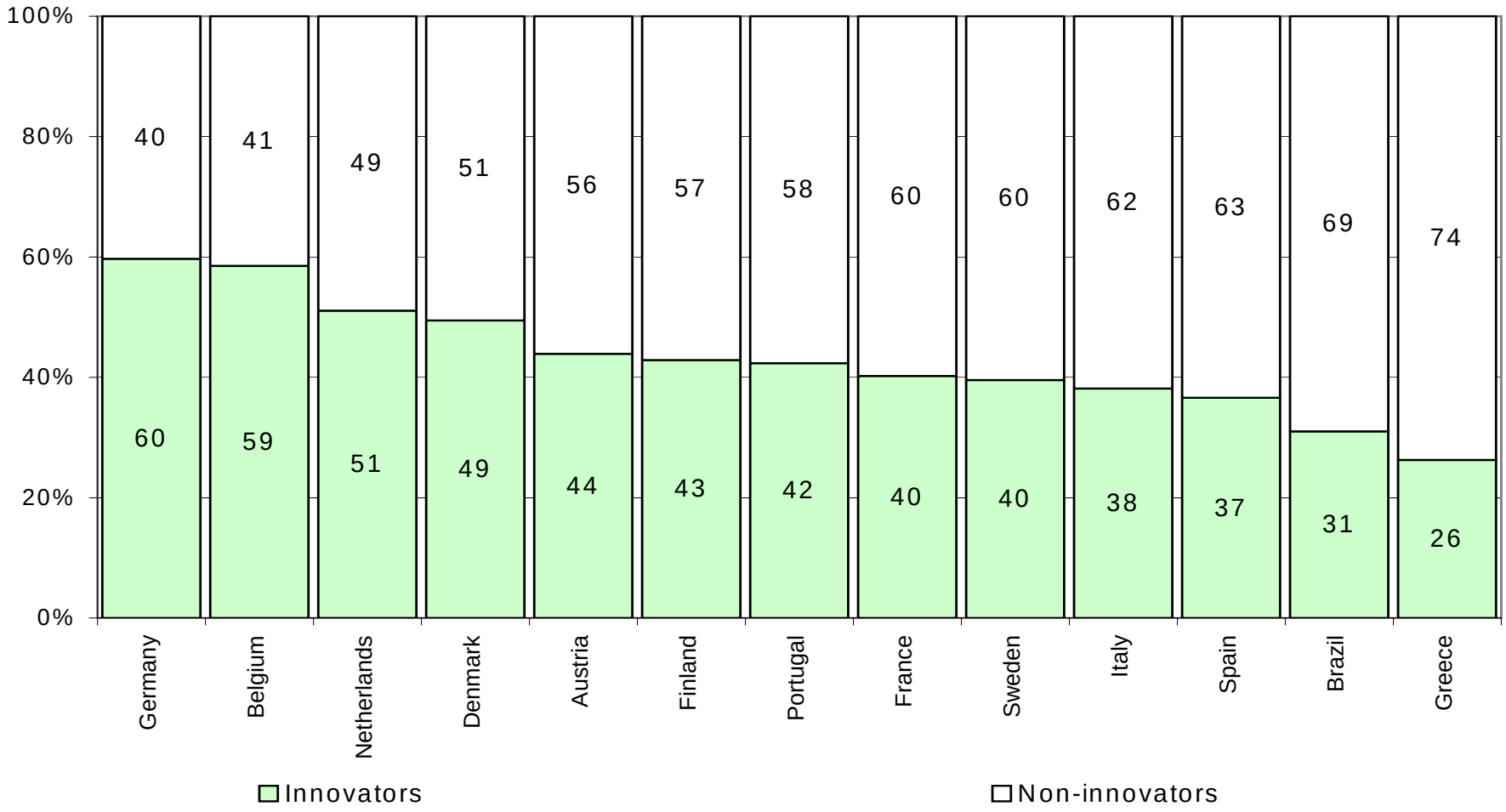
Number and percentage of US patents granted to Brazilian residents, 1981-2004



Source: USPTO

Technological Production (Innovation in manufacturing 1)

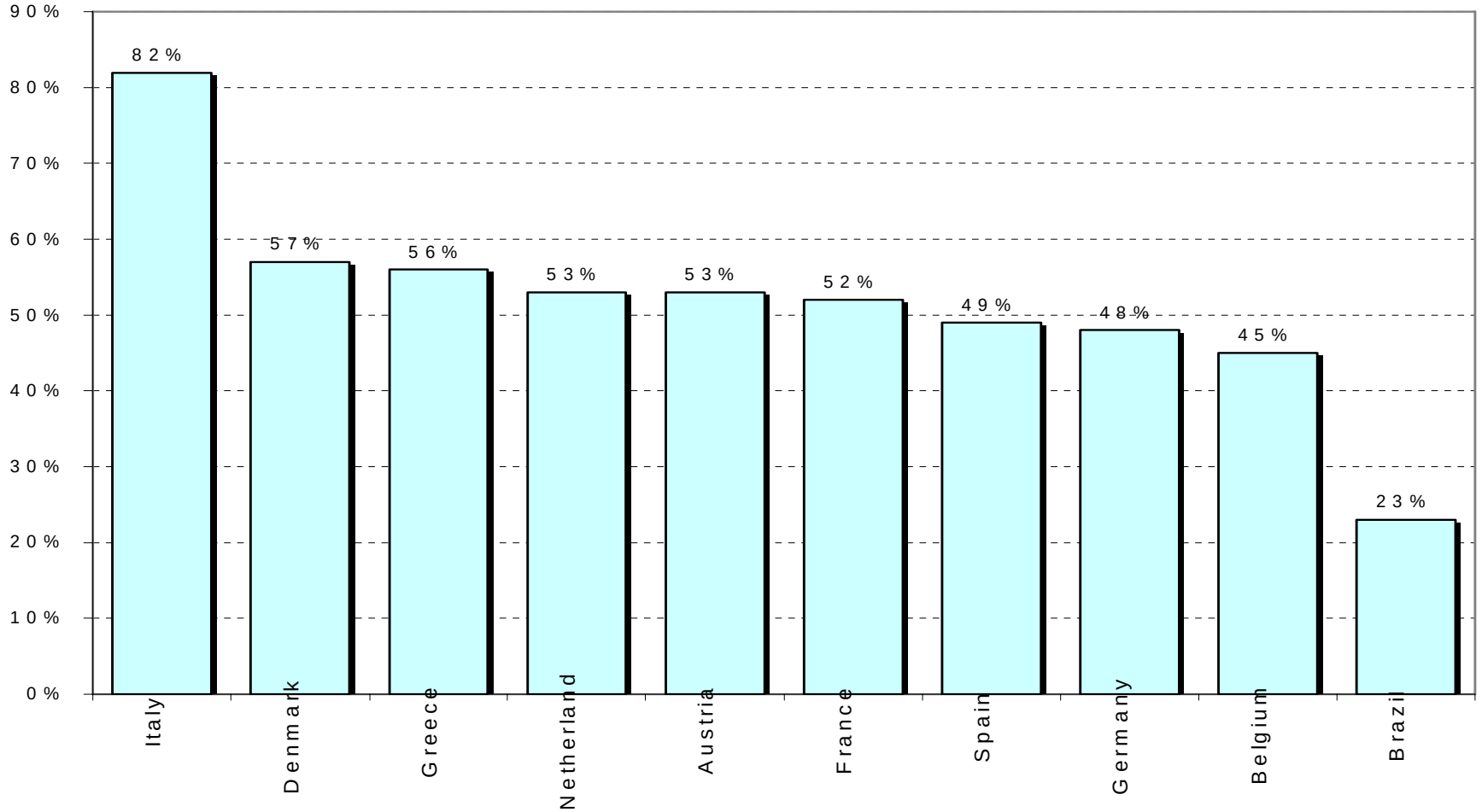
Proportion of successful innovators and non-innovators among industrial enterprises during the period 1998-2000. Selected economies.



Source: EUROSTAT, 2004 and IBGE, 2004. (authors' elaboration)

Technological Production (Innovation in manufacturing 2)

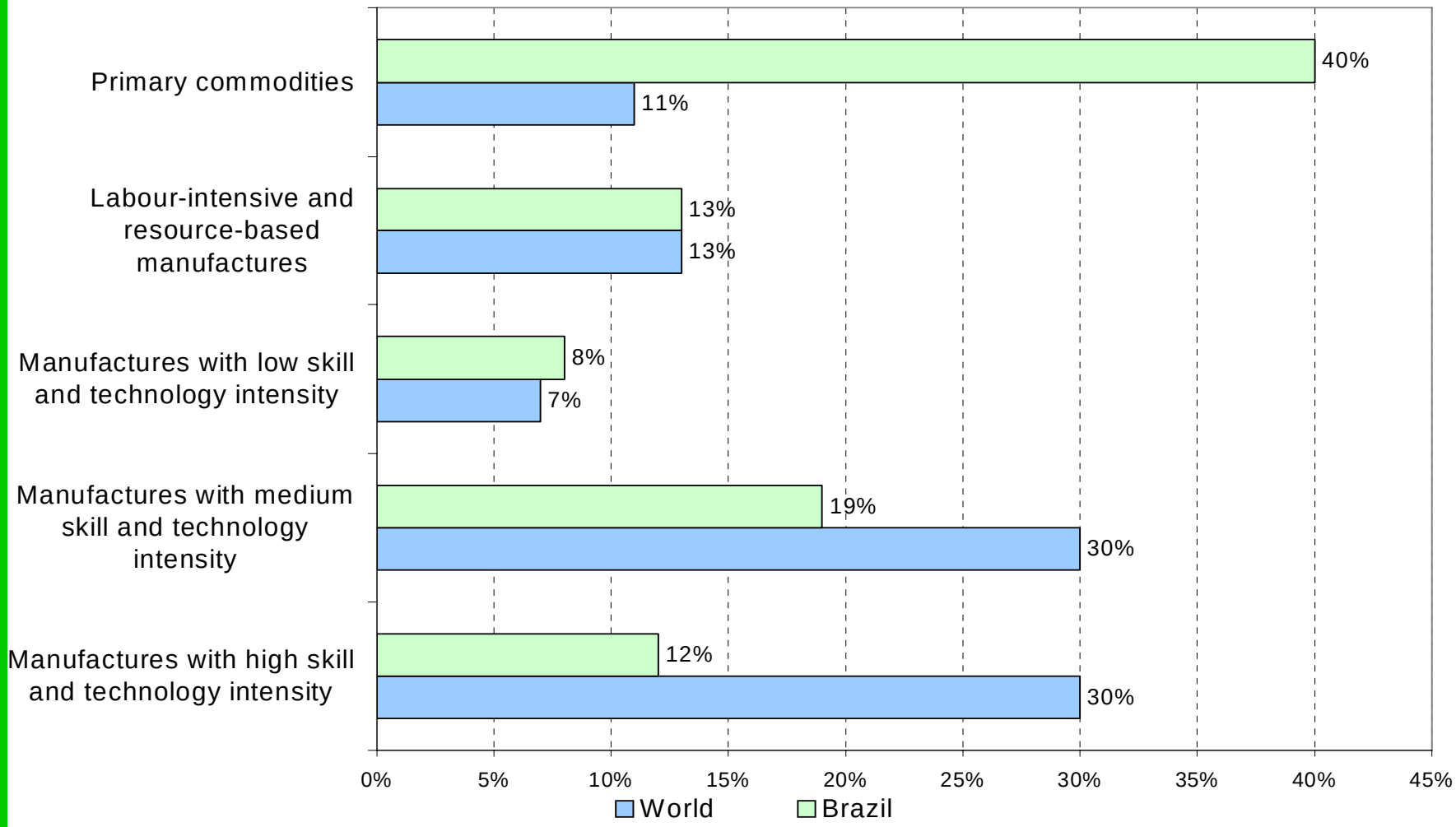
Proportion of product innovators that introduced new or improved products to the market during the period 1998-2000. Selected economies.



Source: EUROSTAT, 2004; EUROSTAT, 2004 and IBGE, 2004. (Authors' elaboration)

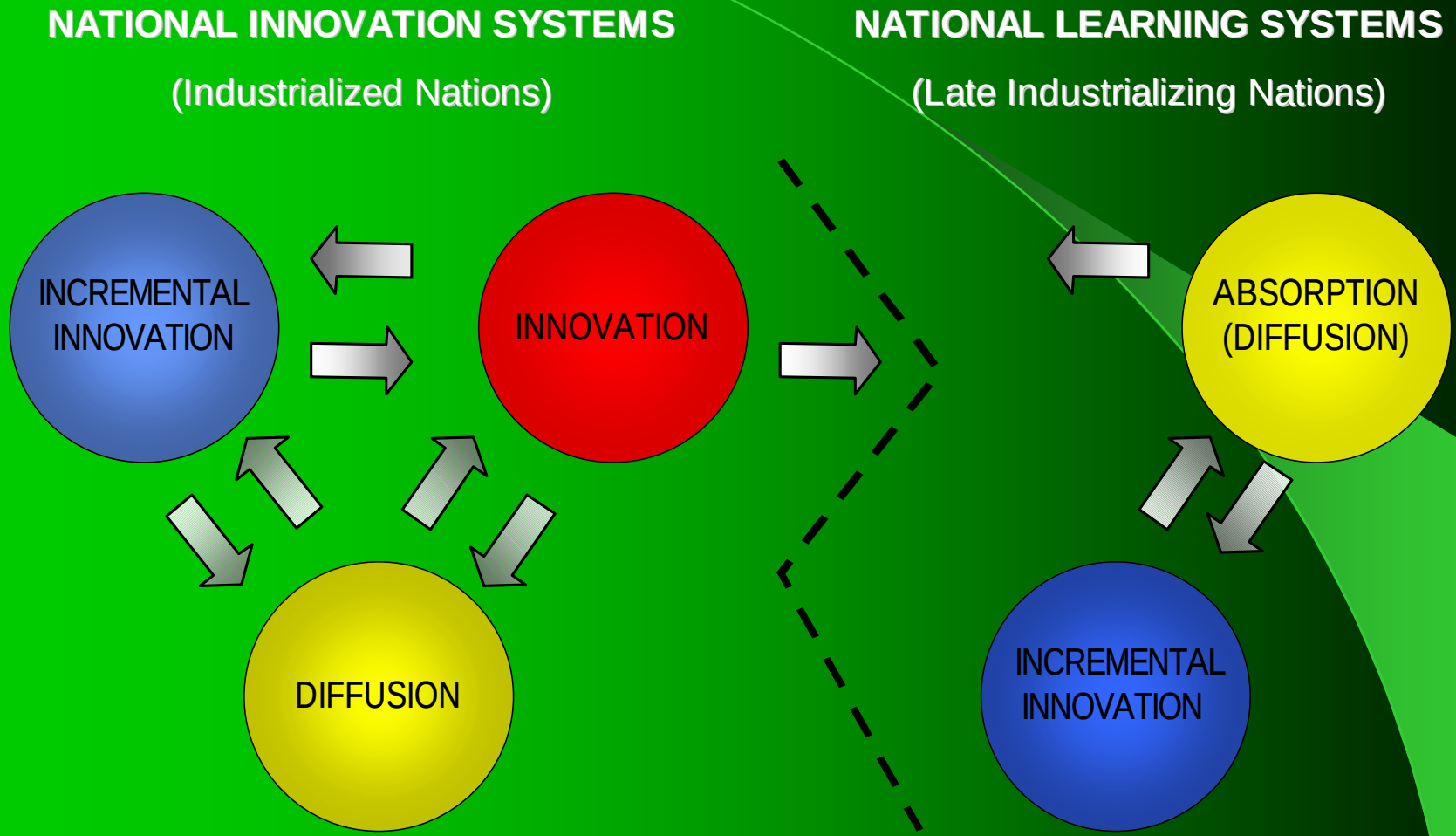
Technological Production (Technological intensity of exports)

Structure of Brazilian and world exports classified by technological intensity of products
Brazil 2003, world 2002



Sources: Data from SECEX and UNCTAD. (Elaboration Fernanda De Negri, 2004).

Why conventional S&T policy seems to perform so poorly for developing economies?



Source: Viotti (2002)

Technological Learning Systems (1)

- 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.

Technological Learning Systems (2)

- 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.
- The surplus 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.

Technological learning systems (3)

- 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.
- Its high cost must be offset by compensatory 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 equity.
- Higher wages, for instance, could jeopardize one of the few sources of competitiveness of these economies.

Technological learning systems (4)

- 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.

What is the relationship between learning, competitiveness and development?

Learning, competitiveness and development (1)

PASSIVE LEARNER	ACTIVE LEARNER	INNOVATOR
Technical change basically limited to the type of incremental innovation that is a kind of free by-product from carrying on with production, like *learning-by-doing*, and the type of technological absorption that follows the pathway of minimal technological effort, the *black box* approach, like turnkey projects.	Technical change dominated by those forms of incremental innovation that are consequence of deliberate technological effort, like *non-doing-learning*, as well as the forms of absorption that require a more intense technological effort, like *reverse engineering*.	Technical change dominated by innovation, products or processes new-to-the-world.
Technological capabilities		
Production	Production + Improvement	Production + Improvement + Innovation

Learning, competitiveness and development (2)

PASSIVE LEARNER	ACTIVE LEARNER	INNOVATOR
Price competition		**Technological competition**
Low wages, natural resources depletion, and state subsidy or protection.		New or improved products, processes or services.
Spurious Competitiveness		**Authentic Competitiveness**
Ability of a country to sustain and increase its share of the international markets only at the cost of jeopardizing its (present or future) population's standard of living.		Ability of a country to sustain and increase its share of international markets in the medium and long run, and, simultaneously, enhance its population's standard of living.

Learning, competitiveness and development (3)

PASSIVE LEARNER ACTIVE LEARNER INNOVATOR

Spurious Competitiveness → Authentic Competitiveness

→ DEVELOPMENT →

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

Policy implications for latecomers (1)

- Conventional S&T policies, stressing basic research, tough competition and strong protection for 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 immediate objective should be to foster a strong active learning process.
- It is necessary to build the right set of institutions and incentives 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, simultaneously, should focus mainly on some specific fields that are promising for the future 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.

Policy implications for latecomers (3)

- R&D for adaptation and improvement, manufacturing extension, technical assistance, demonstration and diffusion, networking of producers-suppliers and labs, and benchmarking, all become essential elements of S&T policies and strategies.
- 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.
- Macro-economic, industrial and educational policies should be appropriate for active learning.

Policy implications for latecomers (4)

- Picking the right sector or technology becomes crucial. The less mature the technology is, the higher the technological opportunities for active learning and innovation, the higher the rates of market growth and the prospects for high profit margins.
- Tough competitive pressure alone, achieved by means of open and liberalized domestic markets, usually induces price competition and specialization in industries which are intensive in labor and natural resources or which employ mature technologies. As a consequence, it favors passive learning and spurious competitiveness.

Main references:

VIOTTI, E. T*echnological Learning Systems, Competitiveness and Development* ,Texto para Discussão Nº 1057, Brasília, IPEA, 2004. (www.ipea.gov.br/pub/td/2004/td_1057.pdf)

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