

# The Role of Non-Government Enterprises in National Innovation

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# A Preview

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- ◆ The Importance of Innovation
- ◆ The Process of Innovation
- ◆ The Role of the Government
- ◆ The Role of Non-Government Enterprises
- ◆ Concluding Remarks

# The Importance of Innovation

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- ◆ Why is innovation important? Innovation is important because it enables an economy to produce more output with the same inputs and/or the same output with less inputs.
- ◆ With innovation, output can grow even if inputs do not grow (e.g., land input cannot grow, and for millennia, agricultural output grows through increases in yield).
- ◆ Innovation increases productivity, and hence enables the growth of real output per capita.
- ◆ While the real output of an economy can grow on the basis of the growth in inputs, in the absence of innovation, such growth cannot be sustained in the long run, as diminishing marginal productivity will eventually and inevitably reduce the incremental output obtainable from the incremental inputs. Innovation is critical to ensuring long-term sustainability of the growth of real output per capita.
- ◆ There can also be innovation that generates non-pecuniary (non-monetary) benefits (e.g., in the areas of environment and public health).
- ◆ Innovation can be an important source of socioeconomic mobility.

# The Nature of Innovation

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- ◆ Innovation is not manna from heaven; innovation is the outcome of purposive investment—investment in human capital, investment in R&D, investment in information systems, investment in other forms of intangible capital, e.g., knowledge capital, goodwill, software, new business models and methods, etc.
- ◆ As an investment, innovation depends on the rate of return, which in turn depends on the economic climate and environment, including the availability of infrastructure and incentives, tax treatment, exit possibilities and the security of intellectual property rights.

# The Sources of Economic Growth of Different Types of Economies

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## Sources of Economic Growth (Percent)

	Innovation	Capital	Labour
<b>Industrialised Economies</b>	<b>50</b>	<b>33</b>	<b>17</b>
<b>Newly Industrialised Economies</b>	<b>25</b>	<b>55</b>	<b>20</b>
<b>Developing Economies</b>	<b>0</b>	<b>80</b>	<b>20</b>

# The Sources of Economic Growth-- Industrialised Economies

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- ◆ The most important source of economic growth for industrialised economies is innovation (also referred to as technical progress) accounting for more than half of the growth of output, on average.
- ◆ The growth of tangible or physical capital is the next important source of economic growth, accounting for almost a third, on average.
- ◆ The growth of labour accounts for the balance.
- ◆ The United States is the world leader in terms of innovation, but is also the world leader in investment in human capital and R&D capital.

# The Sources of Economic Growth-- Newly Industrialised Economies

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- ◆ Research of Kim and Lau (1994) and Lau and Park (2005) shows that innovation played very little part in the economic growth of the East Asian newly industrialised economies prior to 1985. Since 1985, because of the increases in investment in innovation activities in these economies, principally in R&D, the importance of innovation as a source of economic growth has gradually increased.

# The Sources of Economic Growth-- Developing Economies

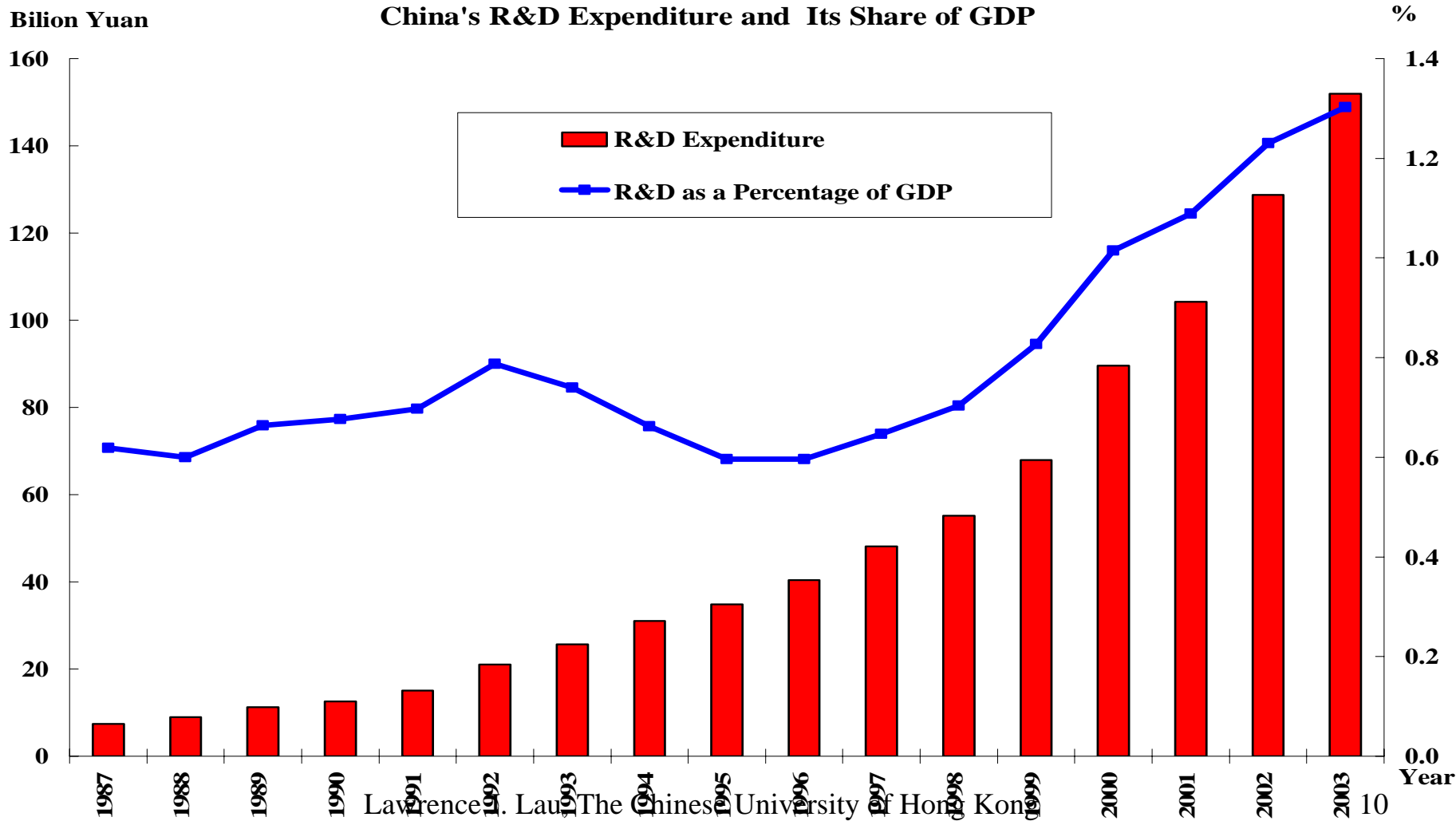
- ◆ Research of Kim and Lau (1994) and Lau and Park (2005) also shows that innovation has not been a significant source of growth in the East Asian developing economies, including China.
- ◆ The growth of tangible capital is the overwhelmingly important source of the growth of East Asian developed economies, accounting, on average, 80 percent, with the growth of labour accounting, on average, 20 percent.
- ◆ The unimportance of innovation and the overwhelming importance of tangible capital as a source of growth are typical of economies in their early stages of economic development, and has been confirmed by the experience of the United States in the 19th Century, of Japan from the Meiji Restoration of 1868 to the World War II, and of the East Asian newly industrialized economies of Hong Kong, South Korea, Singapore and Taiwan until the mid to late 1980s.

# The Sources of Economic Growth-- China

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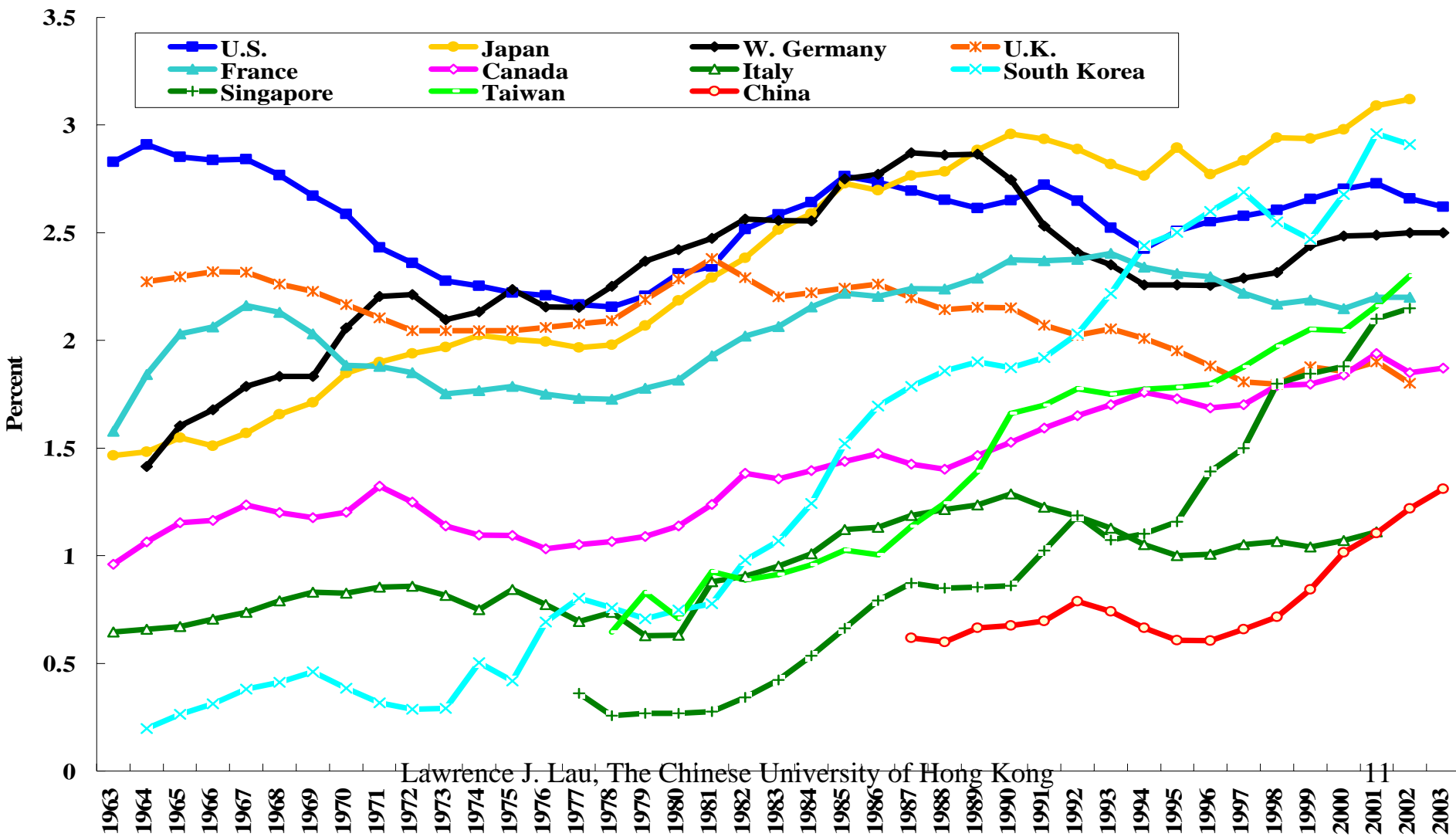
- ◆ In the aggregate, Chinese economic growth since 1978 has been mostly driven by the growth of tangible or physical inputs, principally tangible or physical capital, such as structures and equipment and physical infrastructure, and not by innovation. In particular, there has been relatively little investment in intangible capital (e.g., R&D, human capital, advertising and good will).
- ◆ The growth of tangible capital inputs accounts for the bulk (over 80 percent) of the measured economic growth in China since 1978.

# R&D Expenditures: China



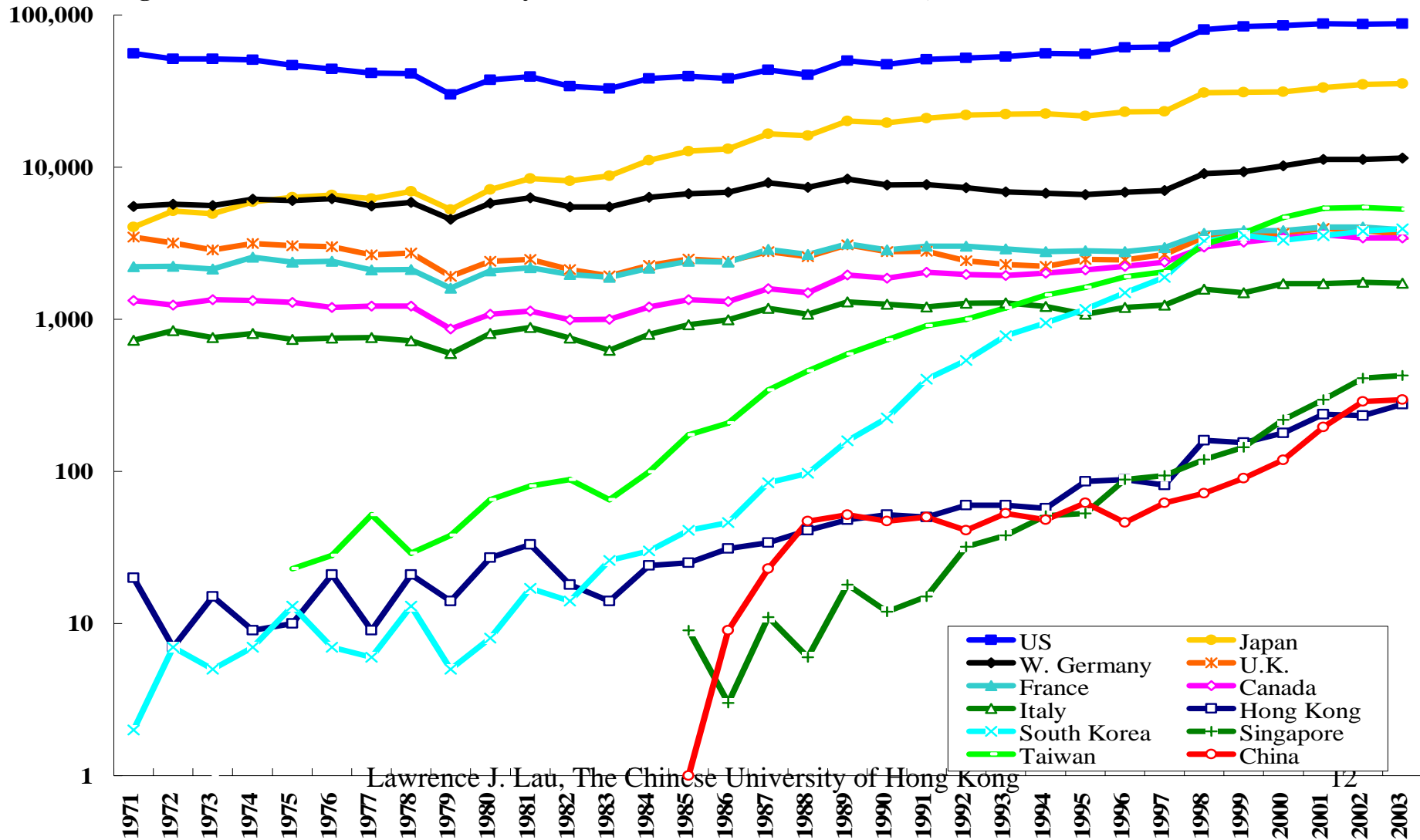
# R&D Expenditures as a Ratio of GDP: G-7 Countries, 3 East Asian NIES & China

Figure 8.1: R&D Expenditures as a Percentage of GDP: G-7 Countries, 3 East Asian NIEs and China



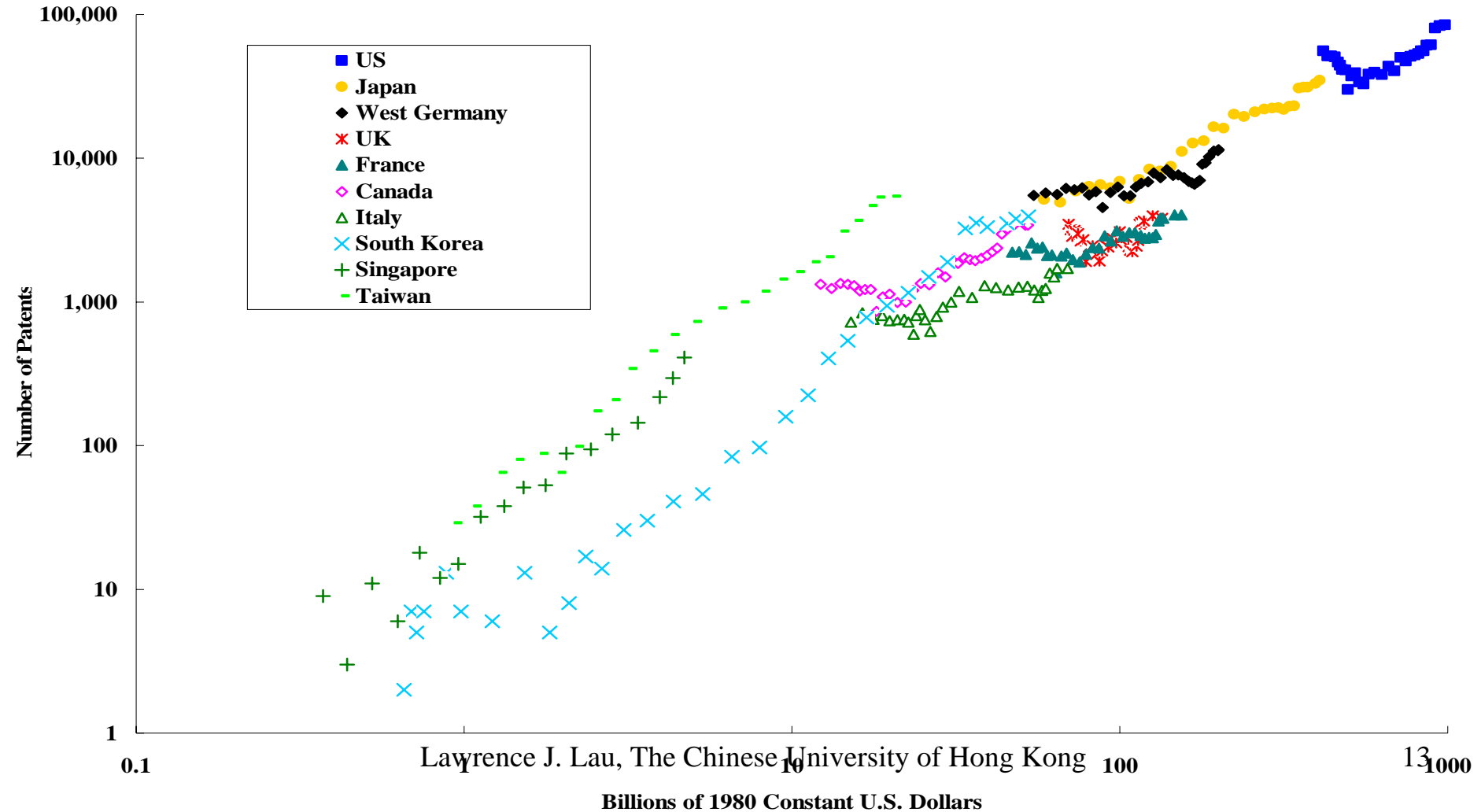
# Patents Granted in the United States: G-7 Countries, 4 East Asian NIEs & China

Figure 8.3: Patents Granted Annually in the United States: G7 Countries, 4 East Asian NIEs and China



# Patents Granted in the United States and R&D Capital Stocks, Selected Economies

Figure 8.4: The Number of U.S. Patents Granted Annually vs. R&D Capital Stocks



# The Characteristics of Innovation Activities

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- ◆ Innovation, e.g., the creation, initial application and commercialization of a patented product or process, often requires a high fixed cost, but the expanded application of such innovation, once created, has low marginal cost (e.g., introduction of existing drugs into a new market) and hence high marginal revenue and profit.
- ◆ Innovation confers a legal monopoly, albeit one with a limited duration (typically 17 years in the U.S.), which in turn enables the innovator to make significant profits without fear of competition.
- ◆ To realize the profit potential, the legal monopoly must be protected and enforced by the Government.

# The Advantages of the Chinese Economy: Large Domestic Market & Backwardness

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- ◆ A large domestic market permits the realization of economies of scale.
- ◆ A large domestic market also allows a significant influence on the development and setting of technological standards for the domestic as well as the world markets.
- ◆ A large domestic market also enhances the returns to R&D and other forms of intangible capital. Economies of scale in the creation and utilization of intangible capital imply that the rate of return increases more than proportionally with the size of the market. The fixed development costs of innovative technologies can be more easily recovered from a large base of domestic demand.
- ◆ The advantages of backwardness—the ability to learn from the successes and failures of other economies; the ability to leap-frog stages of development; and the possibility of creation without destruction.

# What Does It Take to Fully Exploit the Advantages of a Large Domestic Market?

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- ◆ Availability of infrastructure (transportation and communication, including the internet)
- ◆ Maintenance of a domestically open economy (the equivalent of the “interstate commerce” clause of the U.S. constitution)—no inter-provincial tariff or non-tariff barriers
- ◆ Maintenance of an internationally open economy--the role of the "open door" (WTO)
- ◆ Affirmation of tangible and intangible property rights and the rule of law in the economic sphere--a national commercial and tax court empowered to settle and enforce all commercial and tax disputes, including intellectual property rights, on a nationwide basis

# The Process of Innovation

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- ◆ Basic Research—conducted in academic and research institutions such as universities and Chinese Academy of Sciences, typically supported by the government and foundations. No direct financial returns are expected.
- ◆ Applied Research—conducted in academic institutions as contract research sponsored by the government and enterprises and also in government-supported research institutions such as the system of National Laboratories and Sematech in the U.S. and the Industrial Technology Research Institute (ITRI) in Taiwan, and in laboratories in larger enterprises themselves. Little or no direct financial returns are expected except for applied research carried out at the enterprises.

# The Process of Innovation

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- ◆ Development—conducted in either existing enterprises or in start-up enterprises, typically supported by the internal funds of enterprises or by venture capital. The objective is a new product/process/service that may be patented or copyrighted. Financial returns are expected. Failure rates can be high, especially for stand-alone start-up enterprises but large enterprises normally have a number of parallel development projects.
- ◆ Commercialization--conducted at the level of the enterprises, including start-up enterprises
  - ◆ Pilot Project/Prototype
  - ◆ Incubation
  - ◆ Trial manufacturing/servicing
  - ◆ Efficient scale manufacturing (learning by doing), servicing or distribution
  - ◆ Success in commercialization is the key to translating innovation (patents, copyrights, know-how, trade secrets) into increases in real value-added or GDP.

# The Process of Innovation

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- ◆ Without development and commercialization activities at the level of the enterprises, including start-up enterprises, the benefits of innovation resulting from the government investment in basic and applied research cannot be fully realized. The results of the research must be translated into commercially viable activities.
- ◆ Military or national defence-related R&D are different because there the objective is not to make a profit and very often cost is not a consideration and one does not have to achieve efficient scale production. However, national defence-related R&D often has significant spillover to the civilian sector (e.g. the Arpanet became the internet).

# Adoption as Innovation

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- ◆ Adoption means the implementation of a concept already proven and executed elsewhere.
- ◆ Relative innovation, e.g., introduction of branded fast food outlets and restaurant chains; introduction of logistics management.
- ◆ Dissemination and diffusion of new ideas, concepts and business models.
- ◆ The possibility of leap-frogging (telex machines and videotape players are virtually unknown in China; the high usage of mobile telephone service versus fixed-line telephone service).

# The Incentives for Innovation

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- ◆ The returns to innovation depends on the creation of a monopoly or quasi-monopoly (patents, copyrights, trade secrets and know-how). The ability to do so depends on the degree of protection of intellectual property rights.
- ◆ They also depend on the existing producers/suppliers. Can there be creation without destruction? Existing producers/suppliers with their sunk costs may prevent or retard the introduction, diffusion and adoption of innovation (e.g., VHS videotapes in the U.S. are still being used; fixed line telephone service).
- ◆ The degree of protection of intellectual property rights in turn depends on whether a country is a producer of intellectual property. With the growth of domestic production of intellectual property in China, the protection of intellectual property will be vastly enhanced and improved.

# The Role of Government

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- ◆ Support of basic and applied research.
- ◆ Establishment of industrial research institutions if enterprises are not large enough in scale to support such research (e.g., the Industrial Technology Research Institute (ITRI) in Taiwan).
- ◆ Provision of financing for major and highly capital-intensive research projects with long gestation periods, e.g., coal liquefaction, super-conducting electricity transmission lines.
- ◆ Registration, protection and effective enforcement of intellectual property rights (e.g., patents and copyrights), with compulsory licensing when socially justified and necessary.
- ◆ Provision of infrastructure for information, communication, and transportation, as well as physical infrastructure such as science and technology industrial parks with low facility costs.
- ◆ Support and conduct of national defence-related R&D.

# The Role of Government

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- ◆ Developing and setting national standards and participation in the setting of international standards.
- ◆ Assuring the supply of an educated labour force; supporting higher education.
- ◆ Maintaining the advantages of a large domestic market.
- ◆ Provision of tax benefits for R&D and other forms of innovative activities and for venture capital (e.g., the expensing of R&D expenditures; an R&D investment tax credit; the possibility of venture capital losses as a deduction against current income of individuals).
- ◆ Provision of a social safety net to accommodate the “destruction” that accompanies “creation”.
- ◆ Promotion of Government-Industry-Academia cooperation.
- ◆ Facilitating exits on stock exchanges by small and medium-sized enterprises (a Chinese Nasdaq?)—but in the Chinese environment it is best to require a track record of profits before initial public offering (IPO).

# The Protection of Intellectual Property Rights (IPR)

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- ◆ Without the vigorous protection and enforcement of intellectual property rights, venture capital is unlikely to take off in China.
- ◆ The protection and promotion of intellectual property rights should not be viewed as a purely legal enforcement problem. It is also an ethical and educational problem, with roots in long held traditions, customs and conventions, for example, the copying of paintings by older and established artists by aspiring artists (almost always with attribution). But it is above all an economic problem.
- ◆ Is there some way to craft a Pareto-Improving (i.e., win-win), but not necessarily Pareto-Optimal (i.e., globally efficient) solution?
- ◆ In order to enable a win-win solution, one must create opportunities for gains on the part of Chinese participants/players so that they will have the incentive to enforce the conditions necessary for the effective implementation of the solution.

# Protecting Foreign IPR: Price Discrimination & Market Segmentation

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- ◆ One way to design such a win-win solution is to take advantage of the fact that if the owner of the presumably exclusive intellectual property rights is allowed to price discriminate between markets, its profits are actually maximized.
- ◆ For example, in the 1950s and 1960s, there are authorized Asian editions of U.S. textbooks published and sold in India and Japan, at a fraction of the price of the same textbooks in the U.S. The books may be smaller in size, the print size may be smaller, and the paper may not be as good. But they are functionally equivalent. Of course there are also the well known pirated editions produced and sold in Taiwan.
- ◆ One can also apply the concept of authorized editions to the production of drugs.
- ◆ The problem then comes down to how to enforce the market segmentation, as one does not wish to see the same products being sold less expensively in China find their ways back to developed country markets in which the sale price is much higher.

# Site Licensing

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- ◆ The use of site licensing for software is yet another way to achieve de facto price discrimination, if desired, and to minimize enforcement costs.
- ◆ Site licensing can be used by both domestic and foreign IPR owners. In a typical site license, an establishment—an enterprise, a university, pays a flat fee for unlimited use of the software by all the members of the establishment for a fixed period of time.
- ◆ The establishment has the responsibility of enforcing the prohibition against secondary distribution by its members.

# Keeping the Markets Segmented:

## New Technologies Come to the Rescue

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- ◆ In order to prevent unauthorized exports of authorized local editions, there are many possibilities. For example, Prof. Joseph E. Stiglitz can publish an edition of his textbook in China, but using Chinese data and drawing examples from the Chinese economy. (Authorizing an older edition is another possibility.) Such a textbook will have little resale market in the U.S. and elsewhere, and therefore will not cut into the sales of his book elsewhere. (Drugs can also be particularized to the Chinese population in terms of dosage and other characteristics, e.g., birth control pills.) Software can be modified so that it only runs with Chinese commands so that for a potential user who does not read or write Chinese, the software is basically worthless, no matter how inexpensive it is.

# Keeping the Markets Segmented: New Technologies Come to the Rescue

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- ◆ However, there are also new technologies that can be harnessed to prevent exports in commercial quantities. For example, one can have an RFID identifier attached to an authorized Chinese edition so that it can be spotted easily when an attempt is made to take it out of the country.
- ◆ For another example, one can make site-license-provided software specific machine dependent, through encryption or other means, so that it cannot be transferred to another machine without authorization from the original software provider (potentially even taking advantage of GPRS capabilities to identify the location of the user). This would prevent unauthorized secondary distribution which undermines the foundation of site licenses.

# Incentives for Enforcement

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- ◆ The publisher of the authorized edition will have an incentive to prevent other unauthorized local editions from emerging and to press for rigorous enforcement of by now its intellectual property rights.
- ◆ The site licensee also has an incentive to enforce the no-transfer rules on its members because its license may be cancelled if it is found that its members engage in unauthorized transfer. This will force the site licensee to either pay much higher prices for the software or to use pirated versions and risk prosecution and law suits for damages.

# The Issue of Copyright Durability

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- ◆ Current copyright laws in developed economies which extend the rights to 70 years beyond the life of the creator seem too long.
- ◆ It is a serious impediment to digital distribution of published material. For example, Google has basically digitized all of the books at Harvard University, and one can search the entire corpus on a keyword but downloads are not permitted.
- ◆ China should enact copyright laws that either provide for shorter durations for copyrights created in China in China itself or to mandate compulsory licensing in China.

# The Role of Non-Government Enterprises

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- ◆ Division of labor between the government and non-government enterprises. In general, the government should do what the non-government enterprises cannot or will not do. These include:
  - ◆ Projects with very large capital requirements (e.g., the three gorges project)
  - ◆ Projects with long gestation periods (e.g., basic research)
  - ◆ Projects the benefits of which consist of mostly externalities and cannot be privately appropriated (e.g, environmental benefits, public health benefits)
  - ◆ Projects with very high risks of failure
  - ◆ Projects with national defense significance (e.g., the Moon-landing project)
  - ◆ Development-leading infrastructural projects
- ◆ The principle is that the government and the non-government sector should complement each other rather than compete with each other.
- ◆ There is also a distinction between projects financed through venture capital and projects financed with the internal funds of an ongoing enterprise. Their objectives are not the same.

# Characteristics of Venture Capital Projects

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- ◆ Venture capital projects by their very nature are trying to innovate, to break new grounds, hence they have potentially very high failure rates—typically only one out of ten venture capital projects will become a commercial success; eight are likely to be outright failures; one out of ten may barely break even and survive.
- ◆ Information asymmetry—investors, even venture capitalist themselves, know much less about the prospects of the project than the inventors/operators of the project.
- ◆ Failures are apparent quite early (in not being able to meet milestones); successes take longer to realize.
- ◆ A venture capitalist must therefore be able to tolerate failure, have the capacity to lose money, be decisive enough to cut off funding to projects that fail to meet milestones, and to be patient about eventual payoff.

# The Role of Non-Government Enterprises

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- ◆ Non-government enterprises and entrepreneurs can tolerate higher failure rates than the Government. I cannot imagine a Minister reporting to the Premier that 8 of his or her projects have failed, one is struggling, and there is only one left that shows some promise.
- ◆ Moreover, the failures are known early, and the successes, if any, only become apparent rather late. This does not help Government officials who have to make regular reports.
- ◆ Non-government enterprises and entrepreneurs lose their own money and do not have to account to anyone else (yes, sometimes shareholders, but in the U.S., most venture capitalists invest in their own personal capacities.)
- ◆ Government officials are loath to cut off projects even though they do not meet milestones because they regard it as a sign of their failure so they are likely to continue failed projects much longer, wasting even more resources, whereas non-government enterprises and entrepreneurs cannot afford to continue to fund failed projects.

# The Role of Non-Government Enterprises

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- ◆ Because venture capitalists typically invest their own money, the possibility of moral hazard is reduced. They win or lose depending on whether the project succeeds or fails. Government officials typically invest the government's money and so they have no loss if the project fails but possible significant gains if the project succeeds. Thus, their interests and the government's interests may not be aligned. The possibility of hidden action may also lead to funding of projects that should not have been funded.
- ◆ Significant co-investment by the original inventor/operator is essential to reduce moral hazard.
- ◆ Sometimes inventors/operators do not succeed on their first try. Many succeed on their second or third try. There must be an environment that is also tolerant of failures so that inventors and operators of failed ventures will still have second and third chances.

# The Role of Government

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- ◆ Because of the high failure rates, the Government should not permit venture capital projects to raise funds publicly. In the United States, there are minimum net worth requirements for qualified investors and a limit to how many qualified investors can be approached. This is to protect the small investors by not allowing them to invest in venture capital because of its inherent riskiness.
- ◆ The Government can be helpful when a venture capital project reaches the commercialization stage—appropriate extension of credit can be critical to a project’s eventual commercial success (e.g., Taiwan Semiconductor Manufacturing Corporation).

# The Role of Non-Government Enterprises

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- ◆ Ongoing enterprises invest in R&D projects so as to improve their product/process/service and to develop new product/process/service so that they can survive in the next cycle. Very often it will have to remake itself. (Hewlett-Packard as an example, from oscilloscopes to hand-held calculators to printers to personal and notebook computers).
- ◆ Companies like Dupont and General Electric invest a large proportion of their profit in R&D (as do Samsung and TSMC).
- ◆ Three principles: (1) Focus (invest in only a small number of projects but give each project sufficient resources); (2) Strict enforcement of milestones (be prepared to cut off support if the project fails to meet pre-set milestones); (3) Patience (profitable commercialization takes time).

# Concluding Remarks

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- ◆ The complementarity of innovation and scale favours economies with large markets. The experiences of the United States and more recently China suggest that the size of the market can greatly increase returns to investment in innovation.
- ◆ That the United States has the highest rate of technical progress in the world, even though other economies may have invested similar percentages of their real GDPs in R&D, may be explained in part by its own large and open domestic market. Additionally, its own large and open domestic market raises the expected rate of return on investment in innovation to potential private investors (venture capitalists) and hence increase the private investment in innovation in the United States.

# Concluding Remarks

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- ◆ Globalization of world markets thus further enhances the returns to innovation for the world as a whole.
- ◆ Ability and willingness for venture capitalists and entrepreneurs to take large risks and tolerance for failure are the two essential ingredients for the success of venture capital.
- ◆ Tax benefits in terms of write-offs against regular income, long-term capital gains treatment on gains and facilitation of exit are some of the measures that the Government can take to encourage and promote venture capital in China.

# Concluding Remarks

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- ◆ Protection of intellectual property rights is absolutely essential for the success of venture capital. However, it requires not only enforcement but also education and promotion. The public should understand that without protection, the incentive to create intellectual property rights will greatly diminish, to the detriment of the nation.
- ◆ The best way to promote and protect intellectual property rights is to devise win-win solutions so as to create constituencies both domestically and overseas to sustain these solutions.