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FROM DEPENDENCY THEORY TO CREATIVE INNOVATION

During the 1970s and 1980s, perceptions concerning technological advancement changed substantially as a result of the phenomenal post-war rise of Japan, followed by the four Asian NIEs — Hong Kong, Taiwan, Singapore and South Korea. Particularly for South Korea and Taiwan, they have experienced economic growth through their ability not only to manage effectively foreign technology but to also develop a dynamic indigenous base. Hence, for the Asian NIEs, science and technology have become critical catalysts for economic development. Increasingly, attempts to explain the success of rapidly growing economies have involved a technological dimension. In this work, the broad theoretical framework of the relationship between technological change and economic development is seen from two shifting paradigms — from the dependency theory and technological dependence to the theoretical concepts of catching-up and technological leapfrogging and how they are achieved through the role of the state and society.

THE DEPENDENCY THEORY AND LATE-INDUSTRIALIZATION

The dependency theory, simply stated, maintains that growth and development in the developing countries ("the periphery") is hampered by structural dependence on the advanced, industrialized countries ("the core"), although the degree of such constraints varies widely. The theory was made popular during the 1970s by the pessimistic views of Gunder Franck and Samir Amin, both of whom asserted the impossibility of peripheral development in the so-called Third World because of the ways in which the industrialized countries exploited the resources of the former.[1] In a later work and in response to the emergence of the newly industrializing countries, Frank argues that the popular strategy of export-led growth by these countries did not create genuine development because it was also largely dependent on the flow of international capitalism and foreign technology.[2] Writing in the early 1990s and when the world economy was becoming more competitive, more global and increasingly controlled by information and communication technology, Brazilian political economist Fernando Cardoso reaffirms the dependency position of many poor and developing countries. But now they faced "a crueler phenomenon: either the South (or a portion of it) enters the democratic-technological-scientific race, invests heavily in research and development (R&D), and endures the information economy metamorphosis, or it becomes unimportant, unexploited and unexploitable".[3] Cardoso further argues that even for those former Third World countries, such as the Asian NIEs, India, China and Chile, who have managed to become part of the global economy, there is the urgent task to introduce changes at the societal level. These changes include an appropriate industrial policy, an educational policy to upgrade human resources and to integrate the masses into contemporary culture, a science and technology policy capable of producing a technological leap forward in information technology, new materials and new modes of organization and technological innovation.[4] A similar view on technological dependency was expressed by the historian of technological change, Nathan Rosenberg. He maintains that because developing countries lack an organized domestic capital goods sector, they generally do not possess the indigenous capabilities to make capital-saving innovations.[5] Thus, they have to import capital goods at

the expense of not being able to develop their own technological base of skills, knowledge and infrastructure, which are the key elements for further economic progress.

By the late 1970s the dependency perspective came under criticism largely due to the "late industrialization" experienced by a number of East Asian countries. The rapid growth of South Korea, Taiwan, Hong Kong and Singapore confirmed that successful capitalist accumulation and growth of indigenous technological effort in innovation and R&D was possible in "the periphery". More importantly, the dynamic role of the state in promoting industrialization and technological change exposed the structural determinism of the dependency theory as its fundamental flaw. Subsequently, research on the concept of "late industrialization" shifted from issues relating to the cost and benefits of technology transfer to the ways in which these countries adapted and mastered imported technology. In the process, theoretical considerations of the relationship between technological progress and economic development in the developing world gravitated towards explanations of why some nations, like the Asian NIEs, were able to catch up and leapfrog technologically while many others are still struggling to achieve industrial and economic success.

The phenomenal growth of Japan after World War II and the subsequent rise of the Asian NIEs since the 1960s have given rise to a wealth of literature to explain their growth experiences. Most writers hope to provide some answers to two basic questions: Is there a definite pattern or a clear model on which the catching-up process is based? And in view of Japan's economic success, what can emerging economies learn from the Japanese experience? Some observers attribute the industrialization of the Asian NIEs mainly to Japan. This view is expressed in the so-called "flying geese" model of East Asian development.[6] In essence, this model suggests that Japan is looked on as an obvious model of successful economic and technological leapfrogging and provides the force behind the growth of the Asian NIE's. In turn, second-tier NIEs such as Thailand, Vietnam, Indonesia and Malaysia are learning and benefitting from the growth experiences of South Korea, Taiwan, Hong Kong and Singapore. The flying-geese argument gained momentum after 1985 when the appreciated yen forced the outflow of Japanese investments, especially in terms of technology transfer, to the Asian NIEs. It is argued by

the proponents of the model that the four "tigers" owe their export achievements largely to Japanese manufacturing subsidiaries operating within their economies. Singapore, for example, benefitted from Japanese companies offering technical assistance, and by the early 1990s received Japanese investment amounting to US$7.5 billion. Some scholars have also made the observation that South Korea, a former colony of Imperial Japan, had modelled its economically powerful *chaebol* on the Japanese *zaibtasu*, generally known as *keiretsu* after World War II. However, critics of the flying-geese analogy have argued that the pattern of late industrialization in South Korea and Taiwan has been dramatically different from that pursued by the original goose, Japan.[7] It also differs from the strategies adopted by countries in Southeast Asia. Export-oriented manufacturing in countries such as Malaysia and Thailand is overwhelmingly dependent on foreign suppliers of new technologies. Japanese investments are not the primary cause for the quantitative changes in the regionalization of production in Southeast Asia. Huge increases in the outflow of foreign direct investment (FDI) from the United States and, increasingly, from Taiwan and South Korea have played a no less important role in driving the process of rapid technological change in the countries of Southeast Asia, including Singapore.

TECHNOLOGICAL LEAPFROGGING

Rapid technological advances in industrialized countries are pressing on developing countries to close the technology gap. Many observers have suggested that the best hope for catching up is to leapfrog existing state of the art in the development of a new technology that is still at a fundamental exploratory stage when its commercial potential is largely untested. Such a strategy aims to achieve technological self-reliance or autonomy. However, to be successful, a country needs to have a pool of research scientists and engineers and the support of a well-planned technology policy and infrastructure.

Moses Abramovitz uses the term "social capability" to explain why some latecomers were able to catch up with the early leaders and even forge ahead while many countries fell behind.[8] Abramovitz indentifies "social capability" with a country's institutional and organizational

characteristics which develop or impede its ability to successfully exploit best-practised technology, raise the level of technical competence, promote the diffusion of knowledge and increase the mobility of resources and rate of investment.[9] Using Angus Maddison's new compilation of historical time series of the levels and growth of labour productivity covering sixteen industrialized countries from 1870 to 1979, Abramovitz maintains that "[c]ountries that are technologically backward have a potentiality for generating growth more rapidly than that of more advanced countries provided their social capabilities are sufficiently developed to permit successful exploitation of technologies already employed by the technological leaders".[10] The interaction between social capability and technological leapfrogging in the Asian NIEs was illustrated by Bernhard Heitger.[11] In all of these countries the importation of foreign technology played a strategic role in their attempts to close the technological gap. The process was sustained by favourable socio-economic conditions. Despite some differences, increasing the formation of human capital through improving the level and quality of education and ensuring a high degree of economic openness are the common high priorities for all these countries.[12] Implicit in studies on catching up and technology leapfrogging, such as Heitger's, is the role of the state and society in promoting — or inhibiting — the growth of an innovative technological culture which, in the long run, could determine the success or failure to develop an indigenous and self-reliant technological base.

Takeshi Hayashi's study on the technological development of Japan illustrates the concept of the leapfrogging strategy.[13] Hayashi and his team of 114 researchers rely heavily on the use of historical analysis and case studies of Japan's efforts at adapting and diffusing imported industrial technology over a period of 120 years (since the Meiji era). Hayashi provides a conceptual model by which Japan was able to achieve technological self-reliance. The major components are grouped under "Five-Ms"; namely, raw materials or resources, machinery, manpower, management of new machinery and markets. They are incorporated into five stages of technological development, starting from the initial stage and moving on to the acquisition of operational techniques, the maintenance of new machines and equipment, the repairs and minor modifications of foreign technologies, designing and planning, and finally domestic manufacturing. The "five Ms"

exist in different proportions in different countries, but Hayashi and his researchers insist that all components must be present in order for modern technology to be effectively integrated with the five stages of technological development. The Japanese experience has shown that all stages must be passed before a country is able to develop capacities for technological self-reliance. However, Hayashi clarifies two pertinent points related to the model. First, "[a]lthough it proved successful in Japan, it may not elsewhere, especially in countries where the system of technology management is largely based on functionalism and where job-hopping among workers and engineers is common"; and, second, "there is no such thing as a leap in technology" because technological changes are incremental rather than quantal in nature.[14] Hayashi's study highlights two important premises for developing countries aiming to close the technological gap and, in the process, attain some form of technological self-reliance. First, native engineers and technologists must play a key role in decision-making and R&D and, second, the need for a positive cultural attitude and perception of the people, in particular the engineers and creative entrepreneurs, towards technology and development. Post-war Japan, as a latecomer, caught up rapidly with the industrialized West by adapting and bringing into production a large backlog of technological innovations pioneered by the technological leaders such as Britain and the United States.

In the 1990s the literature to explain the success of Japan and the Asian NIEs saw substantial contributions by non-economists hoping to unravel the mystery through their interpretation of sociocultural influences. Their stand is that culture has a profound influence on the innovative capacity of a society. A society's sociocultural beliefs, attitudes and values provide directions to the process of technological change. They may either foster or inhibit technological development. Confucian scholars like Tai Hung-chao and Michio Morishima have postulated an "Oriental model" that stressed "cultural collectivism" and that also allowed Japan and the Asian NIEs to achieve their successful late-industrialization.[15] Another notable contributor to the discussion of the rise of the Asian NIEs is Ezra Vogel. He singles out "industrial neo-Confucianism" as a powerful motivating force.[16] By this term Vogel means a Confucian tradition represented by four clusters of institutions and traditional attitudes adapted to the needs of the industrial society. These four clusters are a meritocratic elite, an

entrance-examination system, the importance of the social group, and the goal of self-improvement.[17] The bureaucratic system played a critical role in industrialization. Some of the ablest people in the society were recruited into the civil service and assigned major responsibilities. They came to believe in the need for the government to harness the support of the private sector and to encourage it to prosper, while preserving the overall control of the state. Thus, even in Singapore, "where the old attitude of moral disdain toward the merchant perhaps remain strongest, multinational companies were given considerable leeway and government-financed companies were expected to behave like private profit-maximising corporations".[18]

An explanation of technological catching-up by latecomers is further provided by cultural historian Tessa-Morris Suzuki. Her seminal works on the technological transformation of Japan from the seventeenth century provides an alternative explanation of the country's success in technological catch-up. Notwithstanding the importance of institutional support, government policies and management techniques, Tessa-Morris argues that the most important factor is what she terms the "social networks of innovation", defined as "the network of communications which linked research and production centres in Japanese society".[19] These networks are the conduits facilitating the diffusion of information on the latest technologies developed by large corporations and research laboratories to small production firms and local communities at the periphery. Local governments during the Meiji period promoted technological diffusion through craft and technology exhibitions, by dispatching instructors to towns and villages, and by maintaining research libraries.[20] No period is this social network more significant than during the decades of what is popularly known as the "Japanese economic miracle" — the 1950s to the 1970s. Tessa-Morris writes: "Easy access to foreign technology and vigorous state intervention created a favourable climate for the rapid introduction of new techniques, but neither of these factors would have produced such dramatic results had it not been for an existing system of institutions which allowed new ideas to be readily communicated between companies and put to work in their factories and offices. In this context what matters is not so much the role of the state as a source of financial incentives for technological change, but rather its role in creating nodes in the network, through which knowledge of

new techniques could flow to many parts of the industrial system."[21] The key question then is this: Is Japan's social network of innovation uniquely a Japanese model? If not, can it be replicated in the strategies of other latecomers to close the technological gap? Tessa-Morris seems certain that "[f]or other newly-industrialising countries, however, the Japanese model is one which cannot be closely imitated".[22]

For industrialization latecomers like South Korea and Taiwan, during the assimilation-adaptation phase (broadly, during the 1970s to the 1990s) of technology transfer, indigenous engineers and technicians had opportunities to learn and understand the operations of machinery and sophisticated equipment, particularly on the shop floor and, more significantly, to indulge in imitation or reverse engineering, defined as the process of recreating a design by analysing a final product. Reverse engineering is common in both hardware and software. In the process, not just new technologies but also procedures, processes and strategies (of competitors) could be developed and adapted by companies to domestic needs. This accumulation of knowledge and skills is crucial to the growth of indigenous technological capabilities. Steven Schnaars argues that "[i]mitation is not only more abundant than innovation. It is actually a much more prevalent road to business growth and profits."[23] He proposes that "creative adaptions are the most innovative kind of copy [and companies] take an existing product and either improve upon it or adapt it to a new arena of competition".[24] Schnaars' analytical framework is further elaborated in Lim Linsu's documentation of South Korea's dynamic technological transformation in which he highlights the importance of building up indigenous technological capabilities in the country's successful shift from imitation to innovations in technological products and processes.[25]

How have Korea and Korean firms managed to achieve such phenomenal growth in technological learning? What major factors account for their rapid technological growth? Kim highlighted several key factors that influence the direction and speed of technological learning in Korean industries: the role of the government, the *chaebols*, education, export policy, technology transfer strategy, research and development policy, sociocultural systems, and private-sector strategy.[26] In his case study of Hyundai Motor as a successful "Imitation-to-innovation" story of the catching-up process, Kim stressed the importance of "crisis

construction" in achieving self-reliance in technological absorptive capability.[27] By "crisis construction", Kim refers to a situation in which workers within the organization (in this case, Hyundai Motors) have to collaborate to solve problems in a critical scenario, which, more often than not, is proactively initiated by the management. The aim is to challenge workers to achieve higher performance goals. Hence, the constructed crisis is more creative rather than destructive. And, by doing so, enhances the absorptive capacity of the workers for innovative change. Hyundai uses constructed crises to shift its learning from duplicative-imitation-oriented, to a more creative-imitation-oriented approach and finally to innovation-oriented.[28] According to Kim, a main strategy for South Korea's successful technology leapfrogging has been the reversal of the research, development and engineering stages. Starting from the years when reverse engineering was actively used to assimilate foreign technology (1960s and 1970s), new, improved products and processes were created and commercialized, and, finally, intensive research efforts were injected for cutting-edge development.[29] Korea's approach to innovation of a reversed product life cycle enabled the country's *chaebols* to leapfrog from being makers of technologically inferior products to producers of technologically superior products achieved through cutting-edge R&D.

ROLE OF THE STATE IN TECHNOLOGICAL CHANGE

Explanations of "developmentalist states" in East Asia in achieving rapid industrial and technological development invariably point to the central role of the state in creating the conditions for exploiting new technological opportunities. In the early 1980s, Hofheinz and Calder attempted to provide a systematic analysis of the complex interaction of economic, political, historical and cultural factors that accounted for the rapid growth of East Asia.[30] After weighing various factors they concluded that the economic success of Asian NIEs was based on political economy systems that seem better geared to competition than those in Western countries, and that an "East Asian development model" exists.[31] Some of the major components of this model included (a) a stable political climate through continuity in the ruling elite or party; (b) a Confucian political culture which stressed a high degree

of respect for hierarchy and order; (c) a colonial heritage; (d) heavy investment in education, and (e) export-oriented industrial policies. The importance of the state was given further attention by Chalmers Johnson. In his analysis of the linkage between political institutions and the economic performance of Japan, South Korea and Taiwan, Chalmers stresses that, while a laissez-faire type of political control has allowed countries like Hong Kong attain economic wealth, the "soft authoritarianism" style of highly interventionist and pervasive governments in South Korea and Taiwan (and Singapore) have also been able to achieve economic take-off.[32]

While the role of the state in the process of East Asian development has been noted, how does one explain the preservation of the state structure, autonomy and power vis-à-vis the domestic classes and elite? Hsiao Hsin-Huang attributes the harmonious state–society relationship to two factors. First, the "Four Tigers" shared a common colonial history before the war and colonial legacies have produced a lasting influence on the state structure after independence. Hsiao argues that "the 'over-developed' state bureaucracy that was inherited from the ex-colonial powers (Japan and Britain) and [which] was created to control the indigenous population might be a legacy that led to compliance of the populace with state dominance".[33] Second, East Asian tradition has for long socialized people to respect "authority", which in modern times is represented by the state bureaucracy. The fact that these authoritarian governments did maintain order and provided policies conducive to growth helped reinforce the willingness of the people to accept that order. Hsiao further adds one overarching, common sentiment — that of "national survival" in modern times. Responding to the challenges from the West, people in East Asia view their national survival with great urgency, and "such attitudes may also have some direct and indirect influences on pushing people to work harder under the national ideology toward the goals of national strength and wealth".[34] Such a "national survival" ideology is not uncommon in Japan. The late Akio Morita argued that the Japanese obsession with survival triggered the need to consistently develop technological gadgets that would make life more manageable.[35] Thus, within the general context of the political systems that East Asian governments have adopted and which the people have accepted, the state is able to introduce policies and strategies to produce technological change.

A seminal work on the role of the state in Asia's technological development is the late Alice Amsden's interpretation of South Korea's industrialization. She argued that behind the country's technological transformation has been the ability of the state to plan and stimulate the learning and adapting of foreign technologies.[36] Amsden developed the view that "institutional" rather than "market" factors are at work in South Korea's rapid economic development. The engine of growth was symbolized by the *chaebol*, a Korean conglomeration of modern enterprises largely powered by engineers and managers. As a result of the state's heavy investment in science and technology education since the 1960s, between 1960 and 1980 the number of engineers in Korean industry increased by a factor of ten, and the number of managers by a factor of two.[37] In a later book, *The Rise of 'The Rest': Challenges to the West from Late-Industrializing Economies*, Amsden examined the way Asian countries such as South Korea and Taiwan had helped produce growth through state-promoted industrialization.[38] By contrast, Amsden observed, some Latin American countries had accommodated a greater degree of overseas investment, leaving more economic decisions in the hands of multinational firms, not state actors. Sometime in the 1990s the global technological gadget headquarters had shifted from Tokyo to Seoul. Indeed, the South Koreans themselves voiced their concern about the nation's obsession with technology. Myung Oak Kim and Sam Jaffe have termed the country as a "Technology Nirvana".[39] By the early 2000s, "Silicon Valley and other technology hubs began noticing Korea's position in the digital universe. The country becomes the most popular testing ground for new technologies and products."[40] Again, the Korean government played a crucial role. Its "IT839 Strategy" is anchored on the belief that information technology will bring about qualitative changes in the economic and social paradigm, ultimately aiming to realize a ubiquitous world by forming a virtual cycle of developing new services, infrastructures, and growth engines.

TECHNOLOGICAL CREATIVITY AND INNOVATION

By the 1990s new thinking and new approaches about technological change and technological innovation in developing countries (and also the NIEs in Asia) began to emerge. Particularly in the new century,

"creativity and technological creativity", "innovation and technological innovation" and "creative innovations" are inseparable buzzwords in the literature relating to science, technology and economic development. Technological innovation is often referred to as the introduction of a technologically new or significantly improved product (goods or service) to the market, or the implementation of a technologically new or significantly improved process within an establishment. The innovation is based on the results of new technological developments, new combinations of existing technology or the utilization of other knowledge acquired by the establishment arising from in-house or contracted-out R&D activities. However, innovation is not entirely about the development and use of technology. Business establishments can also enhance competitiveness and business performance through implementation of new or significantly improved processes and changes to organization, workplace management and marketing strategy. Organizational innovation is regarded as the implementation of a new organizational method in a business establishment's business practices, workplace organization or external relations.

Michael Porter, in his seminal study of the competitive advantage of nations, clarifies that for a nation to develop its competitive advantage it is important that its indigenous firms are able to create and sustain competitive advantage against the world's best competitors in a particular industry or segment.[41] Central to this creation and sustaining of advantage, argues Porter, is innovation. This is achieved through three main pathways; namely, improvements in technology, better methods or ways of doing things, and product or process changes. Porter maintains that firms gain competitive advantage when the home environment of the nation is the most dynamic and challenging, stimulating firms to upgrade and widen their advantages over time, and when the goals of owners, managers, and employees support intense commitment towards innovation. As an explanation for the rise of the West and a difference between rich nations and poor nations, economic historian Joel Mokyr, in his book on technological creativity through the ages, states the conditions for a society to be regarded as technologically creative. These are the presence of a cadre of ingenious and resourceful innovators willing and able to challenge their environment for their own improvement, economic and social institutions prepared to encourage potential innovators with the right incentive structure,

and diversity and tolerance.[42] However, he cautioned that technological creativity has tended to rise and fade away dramatically at various times and places in the history of mankind. It is highly dependent on the social and economic environment and institutions. Using the analogy of a plant, Mokyr argues that "technological progress is like a fragile and vulnerable plant, whose flourishing is not only dependent on the appropriate surroundings and climate, but whose life is almost short. It is highly sensitive to the social and economic environment and can be easily arrested."[43] The medieval Islamic world and China witnessed the spectacular decline of scientific and technological creativity after being leaders in fields from mathematics to mechanical invention. A favourable societal environment, shaped by a variety of social, economic and political factors, is essential for inventions and innovations to take place and to support a high level of technological creativity. Clearly, for firms to be innovative, the role of the government is significant, as are institutional reforms to generate an environment that supports innovation.

Conceptual thinking on innovation in the new millennium shifted towards a more broad-based, dynamic technological strategy that does not depend solely on the importation and assimilation of Western technologies but also concerted initiatives to develop indigenous capabilities for creative innovation with regard to products and processes.[44] The concept of a "national innovation system" became actively debated. The development of innovation for a country is viewed as a result of the integration of a spectrum of agencies, which include enterprises, universities and research institutes. Success in coming up with technologically innovative products and processes depends on strong linkages between these various agencies and the role of the government in bringing them together and in promoting trust and collaboration among them. The strength of a country's innovation system is also shaped by the sociocultural qualities of its national communities. Of particular relevance to public policymakers interested in innovation policy are the works of Henry Etzkowitz. Etzkowitz emphasizes the importance of university–industry–government linkages — what he terms the triple helix — in promoting innovative activities in a country's national innovation system.[45] The triple helix interaction of the three institutional spheres represented by organizations such as the technology transfer office, research institutes, science parks and

venture capital firms is a necessary condition for the successful commercialization of innovations and, hence, a vital condition for economic growth. This integration is important because "[i]ncreased knowledge production does not translate readily into increased economic productivity" and the gap between research and development, the so-called "valley of death", has to be bridged.[46] Etzkowitz's "triple helix" approach is actively adopted as a model in Singapore's two main research universities — the National University of Singapore (NUS) and Nanyang Technological University (NTU). In the early stage a single helix university development model in the form of an innovation or technology transfer centre was first created to assist faculty members who were keen to commercialize their ideas. This morphed into a dual helix university–industry symbiotic relationship when the university aggressively established linkages with industry partners; a concerted effort has been in place since the late 1990s to encourage faculty and students to commercialize innovative products and processes through business start-ups. Government funding agencies are now stimulating the triple helix interactions through their convening capabilities, by providing public venture capital and inducing public–private research collaborations. In particular, NUS has started to implement major strategic change to become an "entrepreneurial" university. It has targeted the biomedical sector as a critical focus for technology commercialization.[47]

For economist Daron Acemoglu and political scientist James Robinson, innovation is also seen as the key to economic growth, and inclusive economic institutions are the keys to innovation.[48] Inclusive economic institutions secure private property, encourage entrepreneurship and, in the long-term, produce sustainable growth. The process of innovation is "made possible by economic institutions that encourage private property, uphold contracts, create a level playing field, and encourage and allow the entry of new businesses that can bring new technologies to life. It should therefore be no surprise that it was the U.S. society, not Mexico or Peru, that produced Thomas Edison, and that it was South Korea, not North Korea, that today produces technologically innovative companies such as Samsung and Hyundai."[49] Conversely, extractive political institutions stifle innovation and hence promote underdevelopment and poverty. In brief, Acemoglu and Robinson theorize that the origin of power, prosperity and poverty in the nations

of the world today lie in the existence of extractive political institutions: "The growth generated by extractive institutions is very different in nature from growth created under inclusive institutions. By their very nature extractive institutions do not foster creative destruction and generate at best only a limited amount of technological progress. The growth they engender thus lasts for only so long."[50] Extractive political institutions served to benefit the ruling elites, and their persistent presence is the cause of nations — in particular, former colonies of European powers — that were poor in their historical past to still be considered poor today. Using the development differences of North and South Nogales and North Korea and South Korea as explicit examples, Acemoglu and Robinson also dismiss the role of geography (including the environment and the presence of natural resources) in economic development.[51] They also disregard the cultural hypothesis as a valid explanation for differences in the wealth of nations: "there are of course differences in beliefs, cultural attitudes, and values between the United States and Latin America…, these differences are a consequence of [the] two places' different institutions and institutional histories".[52]

However, Acemoglu and Robinson admit that growth can be achieved within a set of extractive political institutions. The elites can simply reallocate resources to temporary highly productive activities under their control (e.g., from agriculture to industry). But the problem is that this growth is unsustainable in the long run. When the economy runs out of steam, so will rapid growth and the country will first be exposed to an economic crisis and ultimately to a political one. The example of the rapid growth of Soviet Russia illustrates this point. It was not driven by innovation, but by Communist state control. And when the foundations for growth were exhausted, nothing came to replace it. The economists predict the same thing happening to Communist China.[53] As to how nations evolved over time, that is, whether they would develop extractive or inclusive institutions, would depend on what Acemoglu and Robinson termed the critical junctures of history that exploited the initial small institutional differences and led to diverging development paths of nations.[54] In their own words, "History is the key, since it is historical processes that, via institutional drift, create the differences that may become consequential during critical junctures. Critical junctures themselves are historical turning points."[55] To Acemoglu and Robinson, political inclusiveness and the distribution of political power within a

society are the key elements that will determine the success or failure of nations. Jeffrey Sachs, however, argues that such a mono-causal argument is too simplistic and neglects a host of other crucial factors — geographical, technological and cultural.[56] A plausible explanation for the general poverty of sub-Saharan nations is geography. The region had low population densities prior to the twentieth century, a high prevalence of disease, a lack of navigable rivers for transportation, scarce rainfall, and a shortage of coal to be able to take advantage of the age of steamships.[57] However, in the case of the desert state of Botswana, the nation is endowed with the Jwaneng diamond mine, regarded by many as the richest diamond mine in the world, and has one of the highest per capita incomes in Africa. To Sachs, the major flaw in Acemoglu and Robinson's *Why Nations Fail* is that their theory "does not accurately explain why certain countries have experienced growth while others have not and cannot reliably predict which economies will expand and which will stagnate in the future".[58] In short, today's economic growth and development of nations is driven by a complexity of factors which dynamically interact to produce or hinder inclusive growth that benefits the society as a whole.

Economists interested in technological change also made a distinction between invention and innovation. Economist Joseph Schumpeter, who contributed greatly to the study of innovation, pointed out that invention does not imply innovation, and that firms must incessantly revolutionize their economic structure from within; that is, innovate with better or more effective processes and products.[59] He asserted that it was innovation that provided capitalism with its dynamic elements.[60] However, the linkage between invention and innovation is complementary. The difference between innovation and invention is that invention involves the creation of new things from new ideas while innovation is the introduction of new concepts to improve that which already exists. In the 1970s scholars were in the process of overthrowing the "Eureka" school of invention. Scholars now emphasize the evolutionary and collaborative nature of invention and the importance of failures and false starts.[61] Innovation means taking an idea through to the point where its applications are put into practice. The application may be commercial; in that case, success requires acceptance by the market. Inventions in this case may be patented, unlike innovations which are meant to be used by the

public to improve existing ideas. Invention is concerned with a specific product while innovation addresses a wide range of concerns, seeking to better them.

Must innovation go hand in hand with research? It was commonly believed that scientific research always precedes innovation. While there are successful companies which were founded by researchers-turned-entrepreneurs, this notion is no longer valid.[62] The history of technological innovations has shown that many ground-breaking innovations were developed by creators who did not have the scientific knowledge to explain why things worked as they did.[63] The steam engine worked well before thermodynamics was known to the inventors. Portnoff argues that many radical innovations are the results of "creative leaps". He explains, "What is needed is the intuition of a poet with a strong technical background combined with the skill of the engineer who can put idea into practice and that of the entrepreneur who can turn it into a viable business."[64] As pointed out by Mokyr on what makes a society technologically creative, Portnoff adds that there must be a critical mass of potential innovators who are willing to challenge the unpredictable environment and establish networks among people of different training and backgrounds.[65] For Mokyr, in the long run, technologically creative societies must be both inventive and innovative. This is because "[w]ithout invention, innovation will eventually slow down and grind to [a] halt [and] without innovation, inventors will lack focus and have little incentive to pursue new ideas."[66]

Last but not least, growth theorists have suggested that the clustering of creative human capital in cities is also a critical driving force for innovation to take place. Writing in 1969, the late urban theorist Jane Jacobs argued that cities humming with productive activities are the key to economic expansion.[67] Jacobs defined a city as "a settlement that consistently generates its economic growth from its own local economy [and] are places where adding new to older work proceeds vigorously".[68] For a city to generate wealth and hence economic development, it has to have an environment where people are encouraged to discover, or to innovate, new ways of doing things, new products and services, and where social stability and economic freedom prevails so that people driven by profit-seeking are incentivized to remain entrepreneurial. Such a city, in turn, will

attract an influx of people seeking wealth who will form clusters of social networks. In short, the concentration of creative people using and combining their full talents in urbanized cities is the underlying mechanism producing innovation and driving economic growth. Although not an economist by training, Jane Jacobs and the Jacobsian theory of economic development — how urbanized cities with clusters of talent lead to innovation and subsequent economic expansion — gained strong support from urban economists and sociologists alike.

Economist Edward Glaeser, in his *The Triumph of the City*, paints a brightly positive picture of cities as a powerful driver of wealth and development.[69] He argues that a city's success depends on its ability to innovate and reinvent itself to produce ideas and not things. Hence, it is through a concentration of talent within an urbanized and highly livable environment that cities are able to incubate innovation by connecting their inhabitants and serving as a gateway for ideas. Glaeser points to the success of Singapore in upgrading its human resources through lifelong education as an example to support his human capital theory. The city-state has attracted global talent and capital through a high quality of life and strong urban governance. Richard Florida argues that if cities today wish to rejuvenate themselves, they need to attract creative people.[70] It is what Florida termed the "Creative Class" that cities need to nurture and grow in order to harness their creative capabilities to foster innovation. He theorizes that for sustained innovation and economic growth, cities must possess "Technology", "Talent" and "Tolerance" — collectively, known as the "3Ts".[71] These are interdependent drivers of a creative economy. Florida advocates that countries should invest in developing the full human potential and creative capabilities of all citizens — from the low-wage earners to the top professionals. In the study, Florida pinpoints the rise of the creative class and how creative individuals have transformed American society from the 1950s to 2000. The homo creativus have three outstanding values: a strong preference for individualism and self-expression, a belief in championing the spirit of meritocracy, and respect for diversity and openness. His key finding highlights the pattern of geographic concentrations of the creative class in individual regions. According to his "creative capital

theory", the centres of the creative class are "more likely to be economic winners", who succeed in generating high-end jobs and economic growth.

TECHNOLOGICAL LEARNING: THE CASE OF SINGAPORE

The city-state of Singapore's efforts to stimulate technological change and to embark on a technological-based growth trajectory since the 1970s illustrates the various theoretical models mentioned above. Under British rule, as a "peripheral" colony of the British Empire in the East, Singapore's entrepôt economy was highly dependent on the development policies of the "core" administrative centre in London.[72] Economic activities were also mainly controlled by foreign trading houses and supported by local compradors. In the 1960s, entrepôt trade was still the mainstay of the economy. By the 1970s it was apparent to the leaders that to survive and then to catch up, the economy had to shift towards the development of an industrial base. Capital accumulation led to the expansion of labour-intensive industry and, at the same time, a contraction of traditional entrepôt activity. Initially, the pace of industrial catch-up was largely dependent on foreign financial investments. But as Singapore became an exporter of labour-intensive goods, domestic savings rose and the reliance on foreign savings was reduced. From the late 1970s to the 1980s, in response to global trends, Singapore's growth model shifted again, towards gaining comparative advantage through the creation of a more capital-intensive industrial base.[73] Economic restructuring now required the adoption of new technologies.

To climb the technological ladder, the model — popularly known as the FDI-leveraged model — adopted from the 1960s to the 1980s was one that depended on technology transfers by MNCs, especially those who were technological leaders in their respective fields. MNCs were urged to transfer technology and skills through their in-house and joint-venture or licensing agreements with local manufacturers. Inducing advanced technology by encouraging foreign investment had some definite advantages. It was possible to obtain, at one and the same time, both the know-how and the capital. By doing so, MNCs could provide exposure in the latest technologies to local

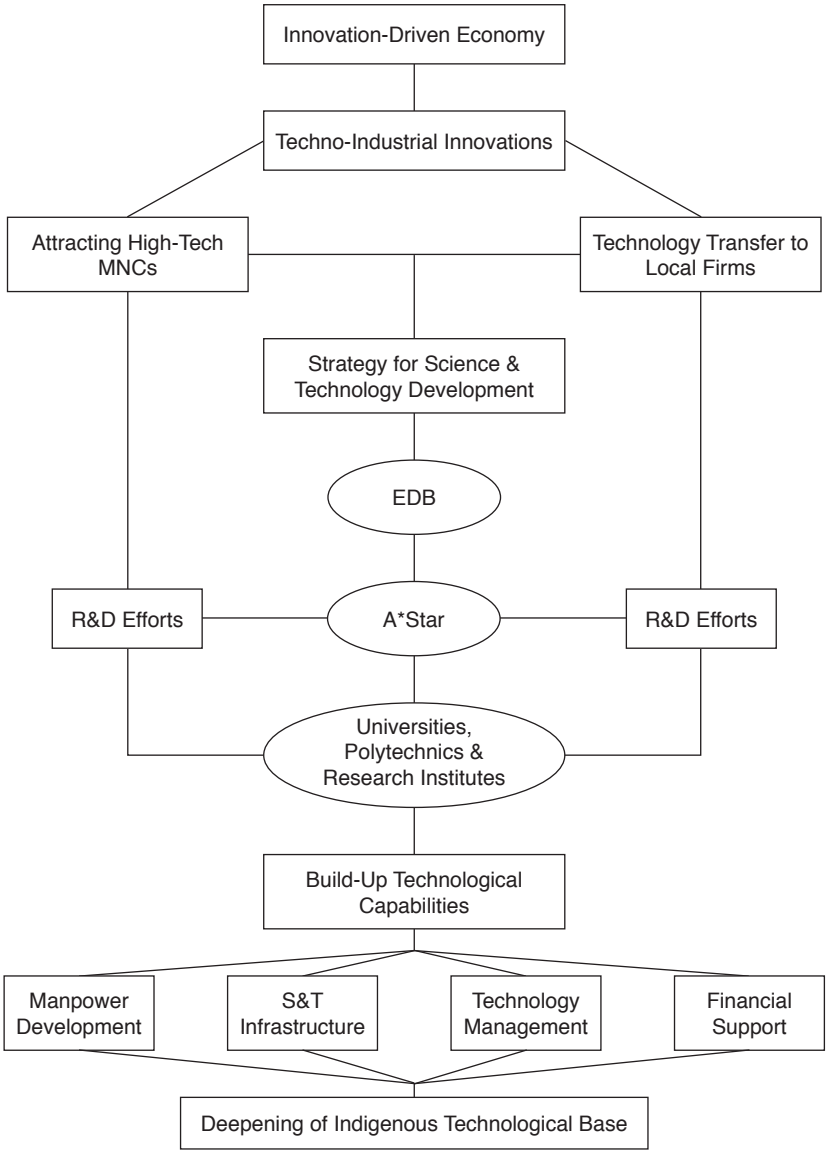
managers and workers. This would help in upgrading the country's technical competence. This traditional pathway in technological leapfrogging was seen as the most effective way for a trading country like Singapore to close the technological gap. The earlier stages of industrial catch-up were made easier because of the large pool of technology that was already in existence. As the economy absorbed the backlog, however, further transfers of technology were made more difficult. Jeffrey Sachs rightly pointed out that while many developing countries have "an easy time adopting technologies that have already been developed elsewhere", few are capable of creating indigenous technological innovations.[74] One negative impact of the MNCs-dependent, technological upgrading pathway is that local small and medium companies tend to become more risk-averse in efforts to develop their own product and process technology. Unlike Japan and South Korea where huge conglomerates accumulate competencies in advanced technologies to build up indigenous capacity and then gear towards developing an innovation-based economy, Singapore (and Taiwan and Hong Kong) businessmen take a more gradual, incremental upgrading of technology capabilities rather than a big leap forward at broad intervals. This approach also simplified the learning process since the same trained staff could be used with minor adjustments in training and re-training. In his analysis of Singapore's electronic sector, Mike Hobday shows that technology was accumulated through a gradual process of learning, rather than by leapfrogging.[75] Local small and medium firms "engaged in a painstaking and cumulative process of technological learning, rather than a leapfrog from one vintage of technology to another."[76] Local firms recruited, trained and promoted employees to senior positions in engineering, management and marketing, building up their technological and organizational capabilities in product design, process adaptation, continuous engineering, selective R&D back-up, management and direct marketing.

By the 1990s a concerted effort was made to shift from an "economy focus" to a "technology focus" as the Singapore Government realized the limitations of tapping on MNCs to develop a self-reliant, indigenous technological base. It was a crucial decision to make the shift towards nurturing indigenous capacity building in science and technology. An R&D policy within a larger S&T framework was actively promoted

in the 1990s. This R&D work is carried out in several government-funded research institutes, manned by prominent names in the world of science, technology and medicine. Since the start of the new millennium, the Singapore Government's S&T strategies have been directed towards achieving technological innovations and promoting the spirit of technological creativity, particularly in local small and medium enterprises and start-ups. In this shift towards innovation-led growth, the role of the government is critical. It now places strong emphasis on innovation and creativity, not just in the economic sector but also in schools (and higher institutions of learning), where initiatives such as "Innovation and Enterprise" to instil a spirit of entrepreneurship in young Singaporeans have been introduced.

Economic strategists and planners were reminded that Singapore had to reinvent itself in order to enjoy sustainable growth in the new knowledge-based economy. In the words of Michael Porter, who was frequently consulted by the Singapore Government, "Singapore truly is going to have to step up the pace of innovation, broadly defined, if it is going to have the productivity growth in order to continue to increase its sustainability…. Singapore is at the end of an era of economic strategy that has been very successful and it also is going to face the need to shift the strategy at this point."[77] The Singapore Government responded by putting in place institutional measures aimed at creating an innovative industrial policy and work environment. It promotes creativity and problem solving in the education system, from the schools to the universities. It champions innovation-friendly rules, regulations and legislation to provide better protection of inventions and guarantees of ownership. It rolls out initiatives to attract professional talent from all over the world. It maintains a world-class information and communication infrastructure for individuals and companies to stay connected to the world. In short, the government is attempting to create a "Creative City". Figure 1.1 illustrates the ecosystem for innovation-based growth, encapsulating the critical institutional roles of the Economic Development Board (EDB), the Agency for Science, Technology and Research (A*Star) and the universities, polytechnics and research institutes. Collectively, they plan, implement and drive Singapore's S&T policy.

Figure 1.1
A Conceptual Model of Singapore's Strategy in Technology Learning



Clearly, Singapore's S&T road map into the twenty-first century centres on the move from an investment-driven strategy to one built on innovation. The question remaining to be answered is, given its historical tradition as a nodal trading centre in the region, would the current heavy investment in research in S&T transform the small island state from a nation of shopkeepers and brokers to a nation of scientific and technological innovators?

Notes

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69. See Edward Glaeser, *The Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier and Happier* (New York: Macmillan, 2011).
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