Chapter 6
National Innovation Systems in the Asia Pacific: A Comparative Analysis

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Abstract In the final Chapter of Part One Clarke, Chelliah and Pattinson offer a comparative survey of the contrasting innovation systems of the Asia Pacific. While Asian economies have achieved rapid industrial progress, as they reach the global technological frontier they need to develop new institutional capabilities for sustaining international competitiveness. Foundational institutions including education, research, law and finance require coordination around coherent national innovation systems to sustain commitment to innovative products and processes. Technological innovation is more likely to succeed "when the elements of the broader environment surrounding firm's activities are well articulated into a system, than in situations where each element works largely isolation… The overall innovation performance of an economy depends not so much on how specific formal institutions (firms, research institutes, universities) perform, but on how they interact with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (such as value, norms and legal frameworks)" (Dodgson in Elgar companion to neo-Schumpeterian economics. Edward Elgar Publishing, Cheltenham, U.K, pp. 193–200, 2007: 592). The national innovation system essentially facilitates how knowledge is generated and accumulated in the economy to serve as the catalyst and fuel for innovation (Yim and Nath in Science Technology Society 10, 2005).

Keywords Innovation systems · Industry policy · Green growth

Introduction

Innovation is now widely recognized as the basis of new jobs, growth productivity and competitiveness, and there is a race to achieve higher levels of innovation among both the advanced and developing economies (Chandra et al. 2009; OECD

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2010, 2015). Governments internationally have become committed to advancing innovation, and as earlier chapters in this book have demonstrated innovation is at the centre of industrial policy in the Asia Pacific where the national innovation systems have proved robust (UNESCO 2016). Historically international competition is moving from a factor driven economy based largely on the costs of labour and raw materials, through an investment driven economy based on the efficiency gains of increased investment in productive processes, to an innovation economy based on competition in new ideas, products and processes in an increasingly digital international economy as Fig. 6.1 illustrates (Porter et al. 2007; UNCTAD 2017).

This chapter aims to examine what is meant by the concept of innovation, to analyze the characteristics of competing innovation systems, to review the evolution of economic theories of growth and development, to analyze the elements of competing innovation systems to investigate problems relating to the present structure of manufacturing industry, and to examine the nature of the emerging knowledge-based economies. The characteristics of different national innovation systems are highlighted, and the different modes of technological progress examined. The limits of innovation systems are explored, and the challenges facing Asia Pacific innovation strategies are investigated.

Green (2015) offers a contemporary view of the expansive nature and scope of the concept of innovation. "The innovation 'system' comprises the relationships between knowledge creating organisations (principally research and education bodies), knowledge adopters (industry and the businesses that constitute it) and government (in its policy, funding, market creation and regulatory roles). Financial institutions, including venture capital investors, innovation intermediaries, professional advisers and consultants all play an important financing, enabling and integrating role. In essence, innovation is ideas applied successfully."

This broad view of the scope of innovation covers new products, services and methodologies, scientific insights and technological breakthroughs, new perceptions in design, market behaviours, consumer preferences, business models, corporate finance, and international relations. From this perspective innovation is an 'open' system with local, national and international dimensions, reflecting the growing linkages in science, research, product development, and the globalisation of businesses—including businesses—as they participate in global markets and value chains (Green 2015).

Fig. 6.1 Stages of competitive development. *Source* Adapted from Porter et al. (2007)

A great deal of the investment in innovation by industry is in 'non-technology' innovation. Therefore Green argues, innovation policy must focus not only on the potential to apply ideas developed through research in science, technology, engineering and mathematics (STEM), but must also give attention to research in the humanities, arts and social sciences (HASS). "Innovation policy is concerned with how ideas are diffused and consumed, as well as how (and where) they are generated. The ability to sustain and grow start-up businesses and encourage established businesses to absorb ideas and capitalize on market opportunities critically shapes business success and the transformation of entire industries and economies" (Green 2015).

A taxonomy of innovation from a largely technological perspective is offered by Freeman (1987, 1992, 1997, 2002, 2004, 2008) which summarizes the patterns of the different trajectories of innovation that have occurred historically into four types:

1. ***Incremental Innovation***

Incremental innovation occurs almost continuously in any industry or service activity, though at different rates in different industries and economies, depending on the impact of demand, socio-cultural context, technological opportunities and innovation trajectories. They are associated with scaling up of plant, quality improvements to products, and increasing efficiency.

2. ***Radical Innovations***

Radical innovations are discontinuous changes the results of research and development within businesses or universities and government research. Discontinuous innovations lead to the growth of new products and markets, surges in investment, and sometimes economic booms. They bring about structural changes in aggregate demand if they are related to the rise of new industries or services, such as synthetic fibres, or semi-conductors.

3. ***Change of Technology System***

Change of technology systems involve far reaching transformations of technology involving several branches of the economy, and giving rise to new economic sectors. They combine incremental and radical innovation with significant organizational and managerial innovation. These can be conceived in Schumpetarian terms as 'constellations of innovation' for example the cluster of petro-chemical innovations, and machinery innovations in moulding and extrusion introduced in the 20th century.

4. ***Changes in Techno-Economic Paradigms***

Changes in techno-economic paradigms amount to technological revolutions, with such profound effects that they have a major influence on the entire economy. A change of this nature carries with it many clusters of radical and incremental innovation, disruptive change of existing products and services, and the development of new technology and services. The pervasive effects throughout convey the

sense that 'everything has changed.' This can amount to a new techno-economic paradigm (Perez 1983), as the changes go beyond technology, and impact cost-structures, and conditions of production and distribution—amounting to Schumpeter's long cycles of "creative gales of destruction" as a succession of techno-economic paradigms leads to a changing institutional framework and structural changes (Freeman 2008: 48; Clarke and Clegg 2000). Such long waves the early mechanization produced by the steam engine; the successive innovations associated with railways, steel and the arrival of electricity; the development of electrical engineering with automobiles, aircraft and telecommunications; the development of computers, pharmaceuticals and micro-electronics; and the information and communication revolution of the Internet, robotics, and broad band technology (Freeman 2008: 50–55).

The development of thinking regarding innovation, is a result of the deep concern of political economy with the sources of economic growth and development that have existed since the origins of industrialism but become compounded with the increasing global competitiveness of the contemporary economy. At times of limited economic growth, attention has turned to innovation as the source of ideas and technologies that may stimulate new gains in growth and prosperity.

The Evolution of Theories of Growth and Development

The emphasis of classical economic theory commencing with Smith's (1776) concern for absolute advantage derived from unique factors of production, and Ricardo's recognition of the comparative advantage specialization may bring, was reinterpreted in the Heckscher, Ohlin, Samuelson (HES) theory asserting that perfectly competitive markets, alongside free comparative-advantage-based trade, optimizes national and global resource allocation and competitiveness. These theoretical presuppositions unthinkingly applied in the contemporary global context of dominant advanced industrial countries competing with economically weaker developing countries, has often consigned many economies of Africa, South Asia and South America to lives of endless struggle with asymmetric terms of trade. As Pitelis (2009: 5) states, "The macroeconomic policy prescriptions deriving from the analytical foundations of the neoclassical perspective have been encapsulated in the various versions of the Washington and post-Washington-type policy advice to developing and transition economies (Shapiro and Taylor 1990). Their record has been at least questionable (Stiglitz 2001; Rodrik 2004; Dunning 2006)."

Confirming how a more interventionist stance has facilitated the more rapid growth of different regions in the world, Krugman (1989, 1992) highlights how in the context of imperfect competition, increasing returns, spill-over effects and first mover advantages, that strategic trade policies to support particular sectors and firms may leverage advantage. Markets are less effective at identifying new possibilities for development and innovation, than in signaling the profitability of

activities that already exist (Scott-Kemmis 2008: 63). Endogenous growth or new growth theory transcends the logic of development strategies based simply on the accumulation of physical capital, emphasizing the increasing returns to ideas as the key to growth (Sen 1994; Romer 1994; Easterly 2001). Rates of return for investment in new knowledge are consistently higher than rates of return to physical capital, and investment in human capital is equally powerful (Helpman 2004). New growth theory is complemented by institutional approaches that emphasize the importance of institutional development to long run economic growth (Hoff and Stiglitz 2001; Rodrik 2004; Acemoglu and Robinson 2005).

Illustrative of a distinctive endogenous growth approach was the success of the Japanese economy in the period from the 1960s–1980s with an emphasis on achieving market share through all forms of innovation including managerial, organizational, and human resources (Romer 1986; Lucas 1988), together with a focus on targeting strategic sectors (Krugman 1987; Shapiro and Taylor 1990). Finally of significance was the Japanese emphasis on maintaining domestic competition, as in Porter's (1990) analysis of the importance of clusters of competing and collaborating producers. Porter (1990) is associated with the stress on the importance of the coexistence of important factor conditions, demand conditions, firm and sector strategy and rivalry, and related and supporting industries.

A development of this is the systems of innovation approach with the belief that innovation is promoted best not by competitive markets alone, but by systems wide linkages involving markets, firms, governments, and social capital promoting institutions (Pitelis 2009: 12; Freeman 1995). This constitutes a more holistic conception of the innovative process relative to the linear model of neo-classical theory (Table 6.1).

In relation to the systems perspective on innovation as a basis for policy "the argument is that government has a role to play in two areas. The first is provision of capabilities in areas where firms and markets may not be able to provide accessible support, such as basic R&D, marketing infrastructures, and training. The second lies in institutions and organisations that support the operations of the innovation system as a whole—education at all levels, intellectual property rights institutions, the finance system (especially with respect to venture capital), regulatory frameworks, and so on. The considerations suggest that the public support apparatus of the innovation system cannot consist of a single set of activities. Just as innovation is a complex process, so is the support apparatus likely to be characterized by complexity: by a range of organisations, with different functions, objectives, and modes of operation" (Georghiou et al. 2003: 38).

In this context the work of Schumpeter on the role of radical innovation in driving growth has become increasingly influential. As Howitt (2009: 16) elucidates "Schumpeterian theory starts from the same premise as almost every other growth theory, namely that long-run growth is driven by productivity growth, which in turn is driven by technological progress. It differs from neoclassical theory by treating technological progress as an economic phenomenon. And it differs from other

Table 6.1 Neo-classical and systems of innovation growth theories

	Neo classical	Systems innovation
Underlying assumptions	• Equilibrium • Perfect information	• Non equilibrium asymmetric information
Focus	• Allocation of resources for invention	• Interactions innovation processes
Main policy Main rationale Government intervenes to (examples)	• Science policy (research) • Market failure • Provide public goods • Mitigate externalities • Reduce barriers to entry • Eliminate inefficient market structures	• Innovation policy/systematic problems • Solve problems in the system or to facilitate the creation of new systems • Induce changes in the supporting structure for innovation: support the creation and development of institutions and organizations and support networking • Facilitate transition and avoid lock-in
Main strengths of innovation policies designed under each paradigm	• Clarity and simplicity • Long time series of science based indicators	• Context specific • Involvement of all policies related to innovation • Holistic conception of the innovation process
Main weaknesses of innovation policies designed under each paradigm	• Linear model of innovation • Framework conditions are not explicitly considered in the model (for example institutional framework) • General policies	• Difficult to implement in practice • Lack of indicators for the analysis of the IS and evaluation of IS policies

Source Adapted from Chaminade and Edquist (2006)

endogenous growth theories in emphasising that the main force driving technological progress is industrial innovation, the same force that is central to the competitive process of any market economy."

Schumpeter also emphasized that successful technology strategies vary from country to country, depending on such factors as the state of development of institutions, geography, educational levels, environmental conditions, and particularly how close the country is to the world technology frontier. Countries that are nearer the frontier of technology tend to produce leading-edge innovations, whereas countries that are further from the frontier tend to implement technologies that have been developed elsewhere. It thus produces a context-dependent theory of what has been called "appropriate growth policy" (Aghion and Howitt 2009). In the context of the current limits to growth Schumpetarian approaches offer the dynamic alternative of open innovative economic systems (Yun 2015).

National Systems of Innovation

The diverse origins and different institutional forms of national systems of innovation are outlined in Table 6.2. Whether initiated as prestigious national research institutions, university based research laboratories, or practical industry based research workshops, these institutions possessed a common aspiration: to advance the body of knowledge that might lead to innovative change in industry, the economy and society. According to Texeira (2014) from the late 1980s onwards a new approach emerged to promoting innovation, based on the concept of National Systems of Innovation (NSI) (Lundvall 1992; Nelson 1993; Kim and Nelson 2000). Instead of focusing on various aspects of innovation in isolation, this approach involves a more holistic perspective, emphasizing the role of interaction between different actors and how this interaction is influenced by broader social, institutional and political factors (Fagerberg and Verspagen 2009).

Texeira (2014) highlights how this approach has broad applications in policy contexts including by regional authorities and national governments, as well as by international organisations such as the OECD, the European Union, United Nations Conference and Trade and Development (UNCTAD) and United Nations Industrial Development Organization (UNIDO) (Edquist 2005; Sharif 2006). According to Lundvall (2007), the diffusion of the national systems of innovation approach is impressive taking into account that 20 years ago only a few academics had discussed the concept. From this perspective national systems of innovation can be seen as an analytical framework (Sun and Liu 2010), which serves as both model and tool, focusing upon the systemic characteristics of innovation, rapid technological change and globalisation. The nationals systems of innovation approach is in this way useful as a general framework to study the differences between the productive and research systems of countries, making it possible to analyse absorptive capacities and the learning capability of individuals and organisations that take part in innovation processes and contribute to its advance (Álvarez and Marín 2010; Texeira 2014).

Table 6.2 National Systems: institutional sources of innovation

17th century	Academies of Science, Royal Society 1662, Proceedings and Journals, Internationalism of Science, Science Education
18th century	Industrial Revolution—factory innovation, Technical Education, Nationalism of Technology, Consulting Engineers
19th century	Growth of Universities, Ph.D. and Science Faculties, Technische Hochschulen, Institutes of Technology, Government Laboratories, Industrial R&D in house, Standards Institutes
20th century	Industrial in-house R&D in all industries; Big Science and Technology; Research Councils, National Science Foundation, Ministries of Science and Technology, Services industries, R&D Networks

Source Adapted from Freeman (2008: 111)

Dahlman (2009) illustrates a generic innovation system for developing economies (Fig. 6.2). The ideas for innovations may be acquired from overseas, or be acquired from other institutions in the same country. At a more advanced stage increasingly knowledge is developed within the country in research institutes, universities and within firms. There are a range of modes of knowledge acquisition and transfer internationally including purchase of technology and capital goods, securing technical assistance or education and training overseas, immigration of highly skilled people, or international knowledge networks. Locally there are similar processes for the transfer of knowledge, including incubators and spin-off firms with new technology, movement of people from universities, and local knowledge networks. Dissemination and use of knowledge occurs through firms, government departments, public institutions, and social organisations.

The dissemination and application of knowledge leads to the growth of more advanced firms, technology and people networks. However all of this innovation activity is supported and facilitated by a broader economic and institutional regime which includes macroeconomic conditions (particularly inflation, interest rates, exchange rates), the business environment (the rule of law, and effectiveness of government and regulation), and the quality of information and communication

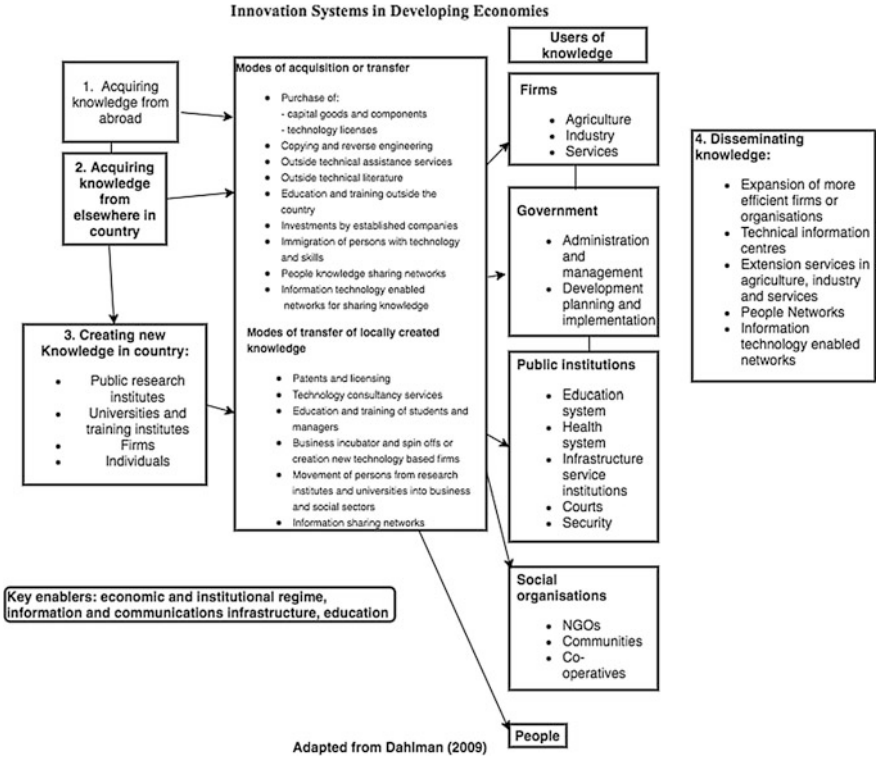

Fig. 6.2 The innovations systems in developing economies

infrastructure. Above all the education and skills of the people are critical, and the support offered by technology and institutions, particularly universities and government research laboratories, and technical and management service industries. All of these institutions and relationships encompass the innovation system and strategies of different economies.

Although advances in technology are not the exclusive source of innovation, technology transfer and absorption features importantly in many processes of innovation, and in the activity of national innovation systems. Figure 6.3 illustrates the modes of technology transfer in developing economies (Burns 2009). At the first stage the economy and its scientists are exposed to developments at the technology frontier internationally. This occurs at a personal level through education and other interactions among scientists, and at a business and economic level though direct contact with higher-technology business processes, products, and services. This can occur through foreign trade, foreign direct investment, the activities of a national diaspora, and through other forms of communication. "The larger these flows, the greater the exposure of the economy to the global technological frontier" (Burns 2009: 173). The technological sophistication of economies varies with the extent to which scientists in an economy absorb and exploit the ideas flowing from more advanced economies (Goldberg et al. 2008).

However exposure to new ideas and techniques is not sufficient to ensure progress on the ground. The technological absorptive capacity of the economy and

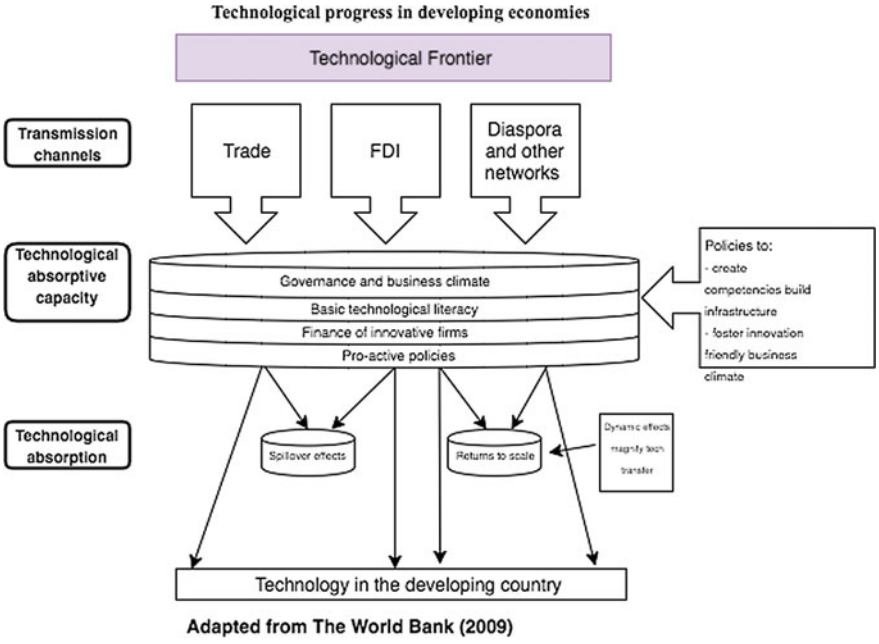

Fig. 6.3 Technological progress in developing economies

quality of the incentives for the scientific community will be critical to successful application, and in turn this depends on the quality of macroeconomic and government management, and the willingness of entrepreneurs to take risks with new to market technologies. The availability of finance for innovative companies, and the contribution of government to the provision of information and communications infrastructure, and for creating a facilitative business environment.

> Technological flows, technological absorptive capacity and technology creation influence each other, and the extent to which technology diffuses depends on various market imperfections, including increasing returns to scale and technological spillovers. Here the existence of a financial sector that intermediates between savers and innovators may be necessary to overcome the initial cost of some new technologies. In particular, access to finance may be essential if innovative firms are to reach the scale necessary to unleash a potential virtuous circle, such that the additional income garnered by the successful exploitation of one new technology permits the acquisition of another, resulting in further gains (Burns 2009: 173).

Scott-Kemmis (2008) captures the increasing sense of the complexity and interdependence of successful economic systems: "The evolution of firms and industries involves systemic interdependence between technologies and organisations and institutions, interaction involving market and non-market relationships and the key drivers from increasing returns. Just as firms increasingly outsource elements of their production system, so they also increasingly outsource elements of their innovation systems. Just as there are many more options for business models so there are many more options for firms to develop their innovation systems, and again we see a great deal of exploration with knowledge-related relationships, (for example, through open innovation) the use of intermediaries, alliances, and collaboration."

Finally there is the resource based view of the firm, focusing on the firm's capabilities, and suggesting in a more dynamic market economy firms position themselves in terms of their resources and capabilities, rather than on the products and services currently derived from their capabilities (Barney 1991; Grant 1996). The resource-based theory of the firm leads on logically to an emerging knowledge-based theory of the firm, which emphasises the role of knowledge as the critical resource in organisations. Grant (1996) reviews the essential characteristics of knowledge based business resulting from the acceleration in the accumulation and availability of knowledge in recent decades.

As David Teece argues, "The decreased cost of information flow, increases in the number of markets (e.g. for intermediate products, and for various types of risk), the liberalization of product and labour markets in many parts of the world, and the deregulation of international financial flows is stripping away many traditional sources of competitive advantage and exposing a new fundamental core as the basis for wealth creation. That fundamental core is the development and astute deployment and utilization of intangible assets, of which knowledge, competence, and intellectual property are the most significant" (2000: 3). Teece (2000) demonstrates how the flow of information, the expansion of markets, and the proliferation of alliances to access complementary assets is eroding away the traditional sources of competitive advantage. The special access to natural resources and skilled labour is

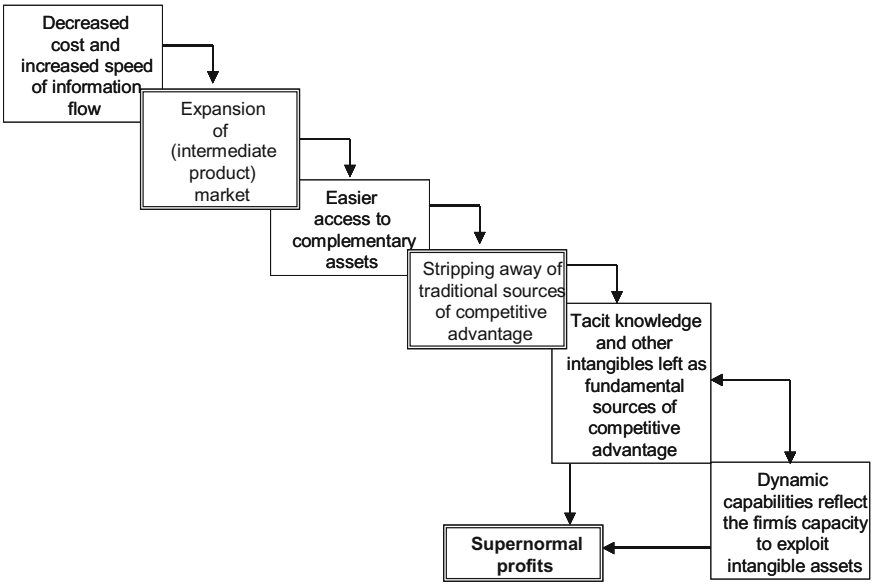

Fig. 6.4 Development of knowledge and competitive advantage. *Source* Adapted from Teece (2000: 4)

gone; scale and scope is of questionable value once you can rent physical assets or capacity on favourable terms. This leaves knowledge and competence, coupled with dynamic capabilities (the firm's entrepreneurial and strategic asset orchestration capabilities) as the foundation of competitive advantage (Fig. 6.4).

The Evolution of Industry Policy

The current concern for fostering national innovation systems, relates to the earlier strategic interventions into the economy of many governments in the 20th century, known as industry policy. The evolution of thinking about the rationale for industrial policy interventions, Warwick (2013) suggests has moved from:

- a traditional position based largely on product market interventions (production subsidies, state ownership, tariff protection),
- through the attempt at market failure-correcting taxes and subsidies operating mainly on factor markets (R&D incentives, training subsidies, investment allowances, help with access to finance),
- to a new focus on interventions that help build systems, create networks, develop institutions and align strategic and innovation priorities (Warwick 2013).

There is some evidence of a renaissance of interest in new industrial policy Warwick (2013) notes in recent literature, research programs, popular commentary and government initiatives. The World Bank has been researching in this area for some time, as in Rodrik's (2008) work for the World Bank on industrial policy and Yusuf's (2012) consideration of the experience of East Asia and its applicability elsewhere. Policy lessons from Asia have also been studied by the Washington-based Petersen Institute's Noland and Pack (2003, 2005). In Japan RIETI (2011) have launched a programme of basic research for a new industrial policy. In Brussels, Aghion et al. (2011) have been rethinking industrial policy, as has UNCTAD in Geneva (Ul Haque 2007). Elsewhere in the UN system, WIDER has been researching new challenges for industrial policy (Naudé 2010). The *Economist* (2010) ran a headline "Industrial Policy is Back in Fashion" and Ciuriak (2011) titled his recent survey the "Return of Industrial Policy" (Warwick 2013: 6).

Examples of new national industry policies in Asia Pacific highlighted by Warwick 2013: 7) include:

- Japan's industrial policy plan (METI 2010) targeting a deliberate movement away from a 'monopole' structure based on automobiles and electronics to a structure based on five strategic areas: infrastructure-related and infrastructure system exports; environmental/energy problem-solving industries (including green vehicles); culture (fashion, food and tourism); medical and healthcare; and advanced areas traditional to Japan (robotics, space, aerospace).
- Korea, a traditional proponent of active industrial policy, designated sector-specific strategies for those sectors it considers to be its flagship industries: automobiles, shipbuilding, semiconductors, steel, general machines, textiles and parts and materials. In addition Korea set out a number of priority growth engines for the future. Based on an analysis of where it believes its comparative advantage lies, Korea identifies 17 such sectors under three headings: green tech, high-tech convergence technology and value-added services (Ministry of Knowledge Economy 2011).
- The 12th Five-Year Plan of China, *The Plan for Science and Technology Development*, launched in July 2011, targeted 11 essential sectors including ICT equipment, energy technology, genetically modified foods, pollution technology, pharmaceuticals and civilian aerospace. In July 2012 the *Plan for National Strategic Emerging Industries* was published, identifying seven strategic emerging industries and 20 key projects, together with policy measures to facilitate the development of the relevant industries. Under this plan the GDP share of the strategic emerging industries was targeted to rise by 8 percentage points by 2015 and by 15 percentage points by 2020.
- In India, the Department of Industrial Policy and Promotion (DIPP) published a *National Manufacturing Policy* in November 2011, targeting an increase in the share of manufacturing value added in GDP from the current 16–25% by 2022. At its core was the planned creation of national investment and manufacturing zones (NIMZs), which enjoy planning exemptions and fiscal incentives and are developed as autonomous self-governing townships in partnership with the

private sector. The DIPP also aimed to make India a location of choice for foreign direct investment and to increase India's share of global inward FDI from 1.3% in 2007 to 5% by 2017 (Warwick 2013: 8–10).

Innovation policies have become more central as traditional industry policies have failed to stimulate growth. The development of manufacturing industry was the mainstay of the advance of Asian economies for the last fifty years, however this can no longer be relied on in the same way in future. Globally manufacturing industry has gone through a series of transformations that have made it more complex and competitive for all businesses. These transformations have included the disaggregation of value chains, and their distribution throughout the developing economies, though heavily concentrated in Asia; the introduction of automation and advanced robotics; the increased competiveness between suppliers; and the saturation of world markets. In this context manufacturing's share in GDP and employment in OECD countries has been declining for several decades, due to a number of factors (Pilat et al. 2006), including:

- Saturated demand for manufacturing products, in particular in the OECD area.
- Rapid productivity growth in the manufacturing sector, implying that despite growth in real manufacturing output and value added, less employment is needed to produce more value.
- A blurring of manufacturing with services, where manufacturing firms increasingly capture value in the associated services they provide rather than in manufacturing production itself. This also implies that certain firms initially classified as manufacturing firms are now classified as services firms.
- A growing internationalization and competitiveness of manufacturing production (Warwick 2013).

The increasing importance of services to manufacturing firms, together with growing internationalization of production, has made firms consider the position they presently occupy and seek to occupy in future in global value chains. For example as Fig. 6.5 indicates, in many industries, much of the value added in a value chain is created in the downstream or upstream stages of the value chain, where activities tend to have a strong service component (Warwick 2013: 11).

The developing disaggregation of the global value chain isolates the high value added controlling functions of finance, R&D and commercialization in the advanced industrial countries, where companies can accumulate vast fortunes by outsourcing the manufacturing of components and assembly of products to developing countries where workers are employed often on low wages and poor conditions. The fashionable products such as iphones, laptop computers, high-tech flat screen televisions, and luxury cars are then expensively marketed to the affluent customers of the richer countries. In the earlier stages of the transition to industrialism this low-value added labour intensive manufacturing was sought after in many Asian economies, but now having realized the much greater rewards available to those who control the finance, design and marketing of products, it is these higher reaches of the value chain that Asian manufacturers are increasingly reaching for.

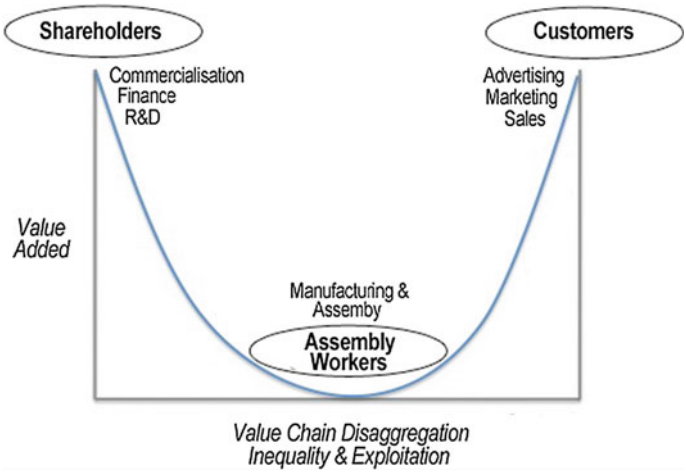

Fig. 6.5 The disaggregation of global value chains. *Source* Adapted from Mudambi (2007)

The historical progression of the location of production for lap top computers illustrates the transitions in the global value chain gradually taking place with many other electronic and manufactured products (Fig. 6.6). Early in the 2000s while the US retained control of the concept (including finance, design and marketing) and production planning, US manufacturers increasingly had disaggregated all production to developing economies. Japan initially retained control of prototype production, but soon exported this to Taiwan. Taiwan itself initially focused on mass production of manufactured goods, but by later in the 2000s had adopted a focus on design and prototype production, exporting mass production to China and the rest of East Asia. China was early in the 2000s confined to mass production but later in the 2000s had achieved a position higher in the value chain in design and prototype production, with aspirations for own brand design and production.

By 2017 Korea had led the way up to the top of the international market value chain with the remarkable success Samsung in smart phones in competition with Apple, and in televisions in competition with Japanese manufacturers, while Hyundai matched the competition in both the US and Europe in quality automobiles. Meanwhile China is looking for the same opportunities, and has enjoyed initial success with Huawei in telecoms equipment, in the auto industry with international investment in overseas production, and in the finance sector with the overseas growth of its three main banks.

Questions have been posed regarding the contribution of the different national innovation systems in the Asia Pacific to the success of industry policy and to continuing competitiveness and growth. National innovation systems literature continues to focus in terms of concepts, policy and practice on the advanced industrial economies, and less on developing economies (Lorentzen 2009;

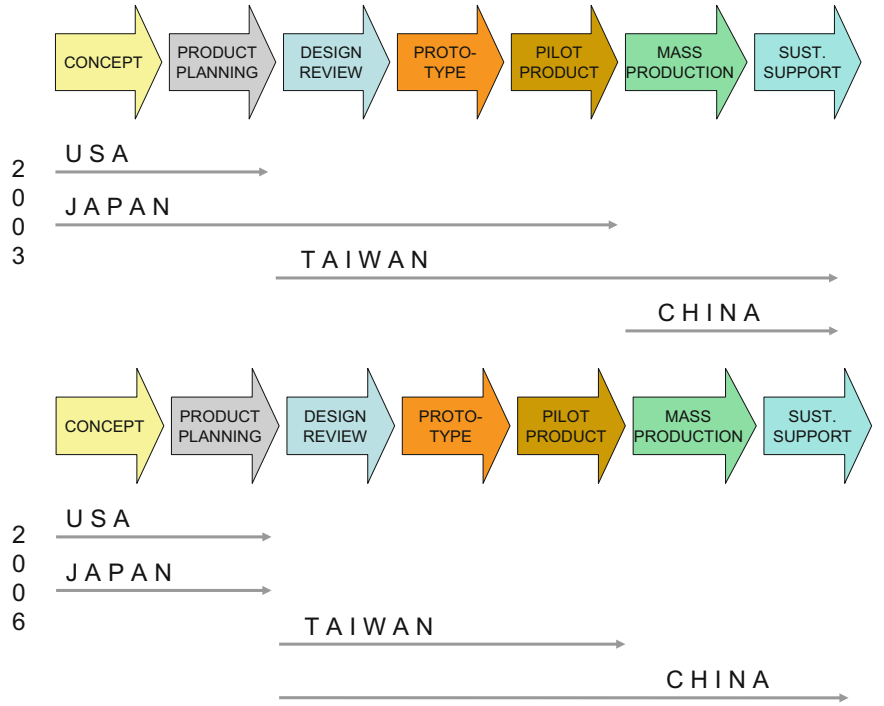

Fig. 6.6 Transition of location of product development for laptop computers. *Source* Adapted From Market Intelligence Center, Institute for the Information Industry, Taiwan

Fagerberg and Srholec 2008; Lundvall 2007; Albuquerque 2007; Lorentzen 2009). Concerns regarding the operational value and implementation of national innovation systems continue (OECD 2002; Texeira 2014). Measuring the application of innovation systems remains problematic, and performance indicators devised to reflect the effectiveness of national innovation systems remain underdeveloped (Lundvall 2002). Surveys of national innovation systems include Lundvall (2007), Godin (2009), Fagerberg and Sapprasert (2011), Texeira (2014), Carlsson (2006).

On a more positive note, Dodgson (2009: 591) analyzing the promising characteristics of Asian national innovation systems suggests, "The developing innovative capacity of some Asian nations raises numbers of questions for those concerned with understanding the relationships between business and the political economy. Firms operate in contexts shaped by national characteristics and distinctive institutions and regulations supporting innovation." Dodgson continues:

> There has been much discussion of the challenges confronting the more technological advanced Asian economies as they become global innovation leaders (Kim 1997; Dodgson 2000; UNCTAD 2000, 2017; Chen and Lee 2004; Gu and Lundvall 2006). Countries such as Korea, Taiwan, Singapore and China are developing, through increased investments in research and new institutional forms such as venture capital, more coherent national innovation systems providing the capacity to be important international sources of

innovative products and processes (McKinsey 2005; Sigurdson 2005). It is widely recognized that the capacity to be continually innovative is a key source of future competitive advantage for nations (Baumol 2002; Fagerberg 2005) and firms (Dodgson et al. 2008; Schilling 2005), and Asian countries and corporations are enthusiastically pursuing innovation as a key objective (Dodgson 2009: 590).

Strategies for Future Innovation and Growth

Looking to the future, the question is what strategies for innovation and growth in the economies of the Asia Pacific should be pursued as increasingly they compete directly with the advanced industrial economies(Dodgson et al. 2005; UNCTAD 2017) ? The OECD recognizes the multiple benefits that innovation can bring:

- Technological progress embodied in tangible, physical capital, such as better machinery, smarter equipment or greener buildings.
- Intangible, knowledge-based, capital, such as software, data, research and development (R&D), design, intellectual property, and firm-specific skills.
- Smarter, more efficient use of labour and capital to generate so-called multi-factor productivity growth (also referred to as total factor productivity).
- Strengthening the dynamics in the economy, with new innovative firms entering the market, replacing other slower, less innovative ones in a process known as creative destruction. Together, these four dimensions account for as much as half of GDP growth (Wyckoff 2016).

However there are other impacts of innovation critical to the well-being of the economy and society "Innovation is not just about supporting growth; it is also vital for addressing deep social and global challenges, like ageing, resource scarcity, disease and climate change. Innovation spurs education, skills and wellbeing throughout life too. At the same time, innovation can contribute to inequality, which is why it needs to be accompanied by appropriate labour and social policies" (Wyckoff 2016).

A long-term commitment to innovation is recommend by Wyckoff (2016), who concentrates his prognosis for the future around the impact of the digital economy, setting the following priorities:

- ***Strengthen investment in innovation and foster business dynamism***. In many OECD countries, firms now invest as much in knowledge-based assets as they do in physical capital, but these should be seen as a bundle, not separate investments. Young firms drive renewal and creative destruction in the economy. The problem is that policies too often favour incumbents, shoring up the status quo and stifling the experimentation with new ideas, technologies and business models that underpin the success of young firms and limit innovation potential.
- ***Invest in and shape an efficient system of knowledge creation and diffusion***. Public funding is needed to address the inherent underinvestment in basic

research of private firms, as this drives long-run productivity growth and facilitates the adoption of innovations across the economy.

- ***Seize the opportunities of the digital economy***. An open and accessible internet, where creativity, sharing, entrepreneurship and experimentation can flourish, is essential for innovation in the 21st century. Big data and data analytics have become a driving force in science, product innovation, processes, organisational methods and services, including healthcare. Policies are needed to promote skills in data analytics, and to foster investments in appropriate infrastructure, including data itself. At the same time, striking the right balance between the free flow of data and safeguarding personal privacy and confidence will require constant attention among policymakers.
- ***Foster talent and skills***. only one-third of workers have the required skills for a technology-rich environment, which raises a major challenge for innovation. Funding for lifelong learning and policies to encourage training are needed to address this (Clarke 1999). Women in particular should be given every opportunity to participate in science and entrepreneurship and contribute more fully to innovation. Policies should also enable international mobility among highly skilled workers as knowledge flows back and forth between countries and regions, enabling many countries to benefit.
- ***Improve the governance and implementation of policies for innovation***. A wide range of government policies affect innovation, which implies that they have to be well-aligned, not only at the level of central government, but also between the central government and regional and local authorities. There is also a need to cooperate with other countries and global institutions, including to help address common global challenges and share the costs of investment in basic research. Monitoring and evaluation of approaches and outcomes will help governments learn from experience and bolster policy performance and adaptability over time. Not every country can become an innovation leader, but every country can do better at tapping into, and developing, its knowledge-based capital and improving its position along global value chains (Wyckoff 2016).

Another approach suggests constructing advantage embracing the new dynamics of innovation and the capacity to exploit them which are essential to growth. This 'new competitive advantage' (Best 2001) highlights regional development economics, the dynamic of which draws upon constructed advantage. Cooke and Leydesdorff (2006: 7) maintain this knowledge-based construction of advantage requires interfacing developments in various directions:

- ***Economy***—the regionalization of economic development; the adoption of 'open systems' inter-firm interactions; the integration of knowledge generation and commercialization; investing in smart infrastructures; and strong local and global business networks.
- ***Governance***—the multi-level governance of associational and stakeholder interests; with strong policy-support for innovators; enhanced budgets for research; vision-led policy leadership; and global positioning of local assets.

- ***Knowledge Infrastructure***—the universities, public sector research, mediating agencies, professional consultancies, and other agencies have to be actively involved as structural puzzle-solving capacities.
- ***Community and culture***—the encouragement of cosmopolitanism; sustainability; talented human capital; creative cultural environments; and social tolerance. This public factor provides a background for the innovative dynamics in a Triple Helix of university-industry-government relations (Leydesdorff and Etzkowitz 2003).

A further strategic recipe for reviving the innovation process is offered by Criscuolo (2015), who argues future growth will involve releasing the forces of knowledge diffusion to enable businesses to adopt technological and organizational innovations. In order to achieve this what is required is:

- ***Global connections*** need to be extended and deepened, so that firms can learn from successful counterparts across the world. This requires trade, foreign direct investment, participation in global value chains, and the international mobility of skilled labour.
- ***New firms*** need to be able to enter markets and experiment with new technologies and business models. The productivity slowdown coincided with a near-collapse of overall business investment and a slowdown in business dynamism, reflected in a decline in business start-ups. These trends need to be reversed.
- ***Better*** '***matchmaking***' is needed across the economy, to ensure that the most productive firms have the resources—labour, skills, and capital—to grow. The larger the frontier firms become, the greater the extent to which their performance gets reflected in overall economic growth. The most productive and dynamic firms do not always grow to optimal scale. In some economies, the most advanced firms have productivity levels close to the global frontier, but they are under-sized relative to their peers in other countries. Inefficient resource reallocation keeps frontier firms from growing. It also slows the diffusion of best practices to other firms.
- ***Investment in innovation*** should extend beyond technology to include skills, software, organisational know-how (i.e. managerial quality). Innovation depends on the bundling of these investments, and policy initiatives (Criscuolo 2015).

Finally Mazzucato (2016) offers a new framework for innovation policy—moving from market fixing to market creating. Policies based on building systems of innovation focus on the need for nations to build a "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman 1995). As Mazzucato (2016) states "The emphasis here is not on the stock of research and development, but on the circulation of knowledge and its diffusion throughout the economy (Lundvall 1992). Institutional change is not assessed through criteria based on static allocative

efficiency, but rather on how such change promotes technological and structural change. This perspective is neither macro nor micro, but more meso, where individual firms are seen as part of broader network of firms with which they cooperate and compete. The systems of innovation approach have been crucial for highlighting deficiencies in the market failure perspective, as it regards innovation policy (Freeman 1995; Lundvall 1992). It has emphasized the inability of the market failure perspective to tackle lock-in effects and to specific types of institutional failures that arise from feedback processes along the entire innovation chain (Verspagen 2006)."

That is key innovation institutions, such as universities, will only allow the innovation system to achieve its potential if they are lined up synergistically with other institutions in the entrepreneurial ecosystem. Mason and Brown (2014) suggest "Policy intervention needs to take a holistic approach, focusing on the following: the entrepreneurial actors within the ecosystem; the resource providers within the ecosystem; entrepreneurial connectors within the ecosystem and the entrepreneurial environment of the ecosystem."

Such innovation eco-systems and networks can be national, international or global in terms of geographical span, involve multiple actors for many purposes including training, technology development, product design, marketing. These networks and eco-systems can be formal or informal, may be along a production chain, or university led. Among the conditions contributing to shaping networks and eco-systems are intellectual property rights protecting partners during collaboration; open innovation allowing partners to tap into external responses to develop modern strengths; and the globalization/fragmentation of production, which together with enhanced specialization have increased the need for cooperation to integrate different components of products, and access complementary skills. The availability of shared assets is an attraction of networks and eco-systems, but all partners will need to have valuable assets to share. Finally effective information and communication technologies are the basis of the eco-system or network sharing information and knowledge (OECD 2015, 2017; UNCTAD 2017).

Innovation for Green Growth in the Asia Pacific

The greatest innovation challenge the Asia Pacific faces, is the same challenge that is threatening the rest of the world—the imminent dangers of climate change, and the search for a sustainable economy (Clarke 2016). However much business success and economic growth has been celebrated as the means of escaping poverty and creating opportunities for the people of Asia, inevitably in recent decades, the expansion of economic activity has been accompanied by growing global environmental concerns, such as climate change, energy security and increasing scarcity of resources. Economic growth as an end in itself, without attention to the environmental consequences is no longer a viable industrial policy or business model.

In response to this impending threat, manufacturing industries have recently shown more interest in sustainable production and have adopted corporate social responsibility initiatives.

Nevertheless, as the OECD (2009a) accepts such efforts fall far short of meeting these pressing challenges. Moreover, improved efficiency in some regions has been offset by increases in consumption and growth in others. Something much more radical and effective is required if climate change is to be halted, and the environment recovered. What is required is to apply the genius of innovation to the goal of sustainability. This is now happening around the world, indeed innovation and sustainability are becoming the most powerful combined force in industrial change, providing the most promising opportunities in almost every business sector. As the OECD (2009a) insists;

"In this context, sustainable manufacturing and eco-innovation are very much at the heart of this century's policy and industry practices. These concepts have become popular with policy makers and business leaders in recent years, and they encourage business solutions and entrepreneurial ideas for tackling environmental challenges" (OECD 2009a: 8). Considerable initiatives are being launched across all industries to achieve sustainable solutions to these environmental dilemmas for example the huge commitment of Toyota motors to the development of hydrogen engines (the only emission of which is clean water). As the OECD comments:

> In recent years, the efforts of manufacturing industries to achieve sustainable production have shifted from end-of-pipe solutions to a focus on product lifecycles and integrated environmental strategies and management systems. Furthermore, efforts are increasingly made to create closed loop, circular production systems and adopt new business models… Sustainable manufacturing involves changes that are facilitated by eco-innovation. Integrated initiatives such as closed-loop production can potentially yield higher environmental improvements but require appropriately combining a wide range of innovation targets and mechanisms. While current eco-innovations in manufacturing tend to focus primarily on technological advances, organisational or institutional changes have often driven their development and complemented the necessary technological changes. Some advanced players started adopting new business models or alternative modes of provision. (OECD 2009a: 5–6).

Eco-innovation can be defined as innovation that results in a reduction of environmental impact. Various eco-innovation activities can be analysed along three dimensions:

- targets (the focus areas of eco-innovation: products, processes, marketing methods, organisations and institutions);
- mechanisms (the ways in which changes are made in the targets: modification, redesign, alternatives and creation); and
- impacts (effects of eco-innovation on the environment) (OECD 2009b).

Greening growth (GG) and moving towards a greener economy (GE) is complex and multidimensional. It entails

(i) pricing externalities and valuing natural assets for the long-run services they provide and pricing externalities;

(ii) innovation as a means of breaking with unsustainable growth paths;
(iii) the creation and dissemination of new, more environmentally sustainable technologies, goods, and services; and
(iv) sectoral shifts and changes in comparative advantage that inevitably imply winners and losers. If greening growth and a greener economy is to help move countries towards more sustainable development, the social consequences and local contexts of the transition to a greener economy must be central to managing change (GGKP 2013).

China's chief environmental objective (under its 12th Five-Year Plan 2011–15) is gradually to establish a carbon market, which represents a shift in policy attention to reducing dependency on fossil fuel and promoting higher-value added and more sustainable industries. Korea's green growth strategy takes a systemic approach to meeting sustainability goals combined with a new growth strategy. Many other OECD countries have strategies to support this transition through a dedicated green economy agenda or as part of energy and industrial regeneration strategies, and Japan's policy is (*Japan is Back, Low Carbon Technology Plan*). These policies and other commitments to innovate towards a sustainable green economy will provide the framework and systems for the growth and success of Asia Pacific economies in the 21st century.

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