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Building Networks to Harness Innovation Synergies: Towards an Open Systems Approach to Sustainable Development

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Abstract: Open innovation has become a popular approach, especially since 2003, as people began purposively managing, evolving and harnessing knowledge flows across organizational boundaries but through increasing connections with systemic knowledge nodes relevant to the innovation process. The creation and appropriation of such knowledge has evolved rapidly with digitalization and the proliferation of broadband networks. Individuals, firms and organizations now connect and coordinate to support innovations openly across innovation systems. This paper proposes an open systems model with institutional underpinnings to not only quicken knowledge flows and expand the networks to a wider range of socioeconomic agents, but also for their inclusive participation in shaping the processes of achieving sustainable development through environmental greening and egalitarian balancing of society. In doing so, using examples, the paper focuses on developments since Schumpeter's ground-breaking exposition of innovation to explain how individuals, firms, farms and organizations can participate actively in open innovation networks to connect productively with the critical knowledge nodes in society.

Keywords: open innovation; systems approach; environmental greening; egalitarian society; sustainable development

1. Introduction

The emanation, diffusion and appropriation of knowledge has undergone massive changes over time. Although the term smartification has emerged to explain some aspects of raising intelligence, we use it more broadly to capture all aspects that relate to generation, flow, diffusion and appropriation of knowledge, including the collective production, sharing and appropriation of knowledge. From the rubbing off effects of systemic knowledge flows in industrial districts, whereby by learning by looking, thinking and doing—all of which evolved interactively [1], it has subsequently evolved to a profound focus on heavy capital investment that drove R&D activity in large firms [2,3]. Schumpeter [3] referred to innovations from Marshallian knowledge spillover as incremental and the latter as radical. The argument for registering and protecting intellectual property rights (IPRs) came from Schumpeter's account for the need to stimulate radical innovations, which he argued were important to initiate new cycles of innovation, as new investments into the production of radically new knowledge was both risky and uncertain. However, since IPRs also block knowledge flows, it can both restrict incremental innovation, as well as cumulatively also slow down investments into radical innovations [4]. The increasing resort to open innovation systems is one consequence of restrictive IPR regulations. Thus, we recommend short periods for path-dependent innovations, and the use of public ownership where innovations help alleviate poverty and green the environment.

Open innovation is defined as the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand markets for external use of innovation, respectively [5,6]. In open innovation systems, organizational borders are porous, so that individuals, firms and organizations can combine their resources by cooperating with external agents. Because certain types of knowledge are a source of wealth for some and, as such, are registered under IPRs, agents cooperating in such formally defined set ups establish networks to share knowledge among members. However, since knowledge is a public good, which is neither excludable nor rivalrous, government seeking to engender the conditions for stimulating innovations must open it to all active socioeconomic agents to offer extensive synergizing opportunities for both the generators and appropriators of knowledge flows. Although digitalized smart robots are revolutionizing production and service systems, the heart of innovation capabilities has remained the human, and hence, any design of the science, technology and innovation (STI) infrastructure targeted at synergizing knowledge flows (including generation and appropriation), must attempt to link them to knowledge nodes in particular countries. However, an innovation network that is sufficiently open to stimulate knowledge flows—creation and appropriation—on the one hand, and to enable potential generators and appropriators to connect and coordinate with the knowledge nodes on the other hand, is seriously lacking. Aside from this, Chesbrough's [5] accounts of open innovation puts too much emphasis on the commercialization of knowledge when the egalitarian needs of society also require a public focus to address climate change mitigation and inequality. This new model of innovation should address the three fundamental tenets of a vibrant ecosystem built on supporting economic growth and structural change, eliminating poverty and inequality, and finally greening the environment.

Thus, this paper aims to design a framework for developing an open innovation system to act as an enabler of innovation creation and appropriation for all socioeconomic agents, and one that directs it to achieve environmental greening while improving income distribution. In doing so, this conceptual paper takes on an inductive approach of theorizing based on an evolutionary perspective of institutional changes necessary to induce purposive promotion of open innovation systems [7–11]. The next section discusses the critical developments from past work to anchor the study. The subsequent section discusses the open systems innovation model. The conclusions are presented in the final section.

2. Theoretical Considerations

Much of the extant innovation literature has focused on propelling economic growth and structural change from low-to-high value-added activities. It is only since the 1990s, especially after the turn of the millennium, that serious scholarship has emphasized the need to link innovations to support sustainable development issues. We address the three critical pillars of sustainable development, viz., economic development, environmental greening and promotion of an egalitarian society. The broad framework for achieving the three objectives requires emphasis on stimulating innovations that simultaneously drive economic growth while greening the environment and restructuring economies equitably.

This section is structured first to establish the importance of developmental rents to stimulate innovations, and their nature [2]. This is followed by spatial agglomeration of firms and innovation activity since the evolution of industrial districts in Britain, which is arguably the first documented development involving differentiation and division of labour. British industrial districts has been characterized by linkages between socioeconomic agents that connect and coordinate with one-another, including workers, farms and firms [1]. However, it is the subsequent spatial models that experienced a profound role from knowledge-producing organizations (including science, technology and innovation (STI) infrastructure organizations) and government legislative and policy instruments that stimulate them. While the development of knowledge nodes (STI organizations) is critical for the promotion of knowledge creation and its appropriation, the policy framework must also address environmental greening and achieving an egalitarian society. Also examined in this section is the role of developmental rents to promote innovation.

3. Developmental Rents

Since inventive activities carry risk and uncertainty, rents become necessary to expand the enabling environment for supporting technical change [2]. However, unproductive rents will misdirect resources to wasteful and destructive activities. Hence, the provision of rents require careful governance in the selection, monitoring and appraisal of socioeconomic agents.

The first issue that needs addressing when discussing developmental rents is its incentivizing role in innovations. Rents are associated with transaction value above or below market clearing rates [1]. Markets refer to relative prices. Instead of taking a strict definition of prices in the presence of perfect information with the assumption of all socioeconomic agents enjoying equal access to resources, we define it as the transaction value in the absence of undue intervention in support of any of the parties involved in the transactions. Neoclassical definitions consider rents that arise from interventions to be distortive, and hence, bad [12,13].

Dirigiste economists take on Schumpeter's [2,3] argument that interventions are essential to divert resources from less productive activities to more productive activities [14]. However, the pursuit of unproductive rent-seeking will give rise to clientelism [15]. Economies rife with clientelist activities in the 1980s and 1990s, which include several Sub-Saharan economies [16], Bangladesh and the Philippines [16,17], have been characterized strongly by unproductive rent-seeking activities.

Corruption is linked directly with unproductive rent-seeking activities when resources are wasted or diverted to less productive activities, thereby contributing to economic inefficiency. Also, the diversion of resources through the conduct of socioeconomic agents that create opportunities for officials to exploit unproductive rents can have a negative cascading effect on other segments of society [17–19], which leads to clientelism, whereby the rich and powerful dominate or capture the state machinery to achieve their own ends [20]. Such relationships tend to be parasitic and unproductive, especially involving collusive transfers between officials and other parties that sap economies of scarce resources [17]. Developmental rents refer to rents created that succeed in achieving productive outcomes. For that to occur, the state has to enjoy autonomy over interest groups and, at the same time, have the capability and competence to generate productive outcomes [16–18,21]. Hence, all rents targeted at supporting innovations must be accompanied by strict selection procedures, monitoring and appraising to not only prevent its misallocation into unproductive activities, but also to ensure that its misdirection is minimized.

4. Schumpeter's Innovation Initiators

Schumpeter [3] glorified the large firm, as during his time only such firms enjoyed the financial capability to support frontier R&D activities. Two key elements became central for firms' participation in R&D, which are risky and uncertain. First, Schumpeter called for the provision of protection for first movers of inventive activity. Second, Schumpeter argued that firms make deliberate attempts to raise concentration to ward off latecomers. He saw such initiation of new cycles of innovation important to stimulate business upswings. The large vertically-integrated firms, such as General Motors and Ford Motors in automobiles, and Fairchild, Intel and Motorola in semiconductors in the United States; Volkswagen, Mercedes, and Bavarian Motor Works (BMW) in automobiles in Germany; Toyota and Honda in Japan; and Siemens, Phillips and Erikson in Europe, fit this framework. The Zaibatsus that dominated industry in Japan before World War II ended, the chaebols in South Korea (e.g., Samsung Semiconductor), and large firms in Brazil (e.g., Embraer) and China (e.g., Huawei) are examples of economies where frontier firms internalize their R&D. Such innovation systems tend to be truncated in large firms, which are fairly closed as innovation systems.

5. Decentralization of Innovation Activity

The early shifts towards the decentralization of innovative activity emerged when firms (including start-ups) began clustering around critical knowledge nodes, such as research universities and public labs. Strong connectivity and coordination between firms and science, technology and innovation (STI) organizations helped connect small firms to the knowledge nodes. Hence, the Schumpeterian inventor in large firms began to decentralize into a network of firms and organizations that are shaped by institutional change. Latecomers began appropriating, much more than before, incremental innovations from inventions to undertake product proliferation.

5.1. Industrial Districts

Arguably the first open innovation system can be traced to the Marshallian industrial district [1], in which thousands of small firms agglomerated in particular geographical locations but without any significant knowledge-stimulating organizations, such as R&D labs and training centres (Figure 1). Knowledge flowed through interactions between workers without restrictive intellectual property rights (IPRs) regulations. Small firms with clothing and leather goods and their accessories, were located at proximate locations, with the division of labour between firms being high and within firms being low. Firms were specialized on the basis of scope rather than scale, and demonstrated a blend of competition and cooperation in driving productivity [22].

The industrial district became famous following its evolution in Italy as small firms with an employment size of 18 and below evolved to produce some of the most highly value-added furniture, pottery and equipment. A combination of trust and prices have been important in the institutional framework that has held together these firms in Italy (including Emilia Romagna) [23,24]. A major dimension that drove the industrial districts was the differentiation and division of labour, which ensured the constant creation of new firms specializing on the basis of scope economies. While the size of markets drove the division of labour, the division of labour drove the market size [10,25,26]. In this context, trust has been a key element in holding firms, in particular industrial districts, including in R&D activities in Norway and Taiwan [27,28].

While knowledge flows are open in industrial districts in that they are systemic, the specific distinguishing tacit elements are often embodied in humans and retained in firms so that they flow through families and relatives inter-generationally. However, while the Italian industrials have organizational support from government agencies, utility firms and training centres (including access to universities) and industrial districts, linkages with important knowledge nodes, such as R&D labs, incubators and venture capitalists, are not pronounced.

5.2. Silicon Valley and Route 128

Silicon Valley and Route 128 are two major examples where connectivity and coordination between firms, public R&D labs, universities and other intermediaries (including funding) have forged a strong network of knowledge flow to support firm-level innovations (Figure 1). Both Silicon Valley and Route 128 provide what industrial districts lacked, i.e., world-class frontier organizations undertaking R&D and incubator support. The proliferation of technology funding firms, such as venture capital, has stimulated the scaling up of start-ups in Silicon Valley and Route 128 [26,29]. Silicon Valley and Route 128 have also evolved a strong capacity to speciate new firms through differentiation and division of labour. While Best [26] discussed the evolution of new industries from the relocation of dissimilar but complementary demand from old firms to new firms, Saxenian [30] documented the movement of human capital from old firms to start new firms.

Innovation networks in Silicon Valley and Route 128 received a massive boost when government regulations helped the diffusion of innovations to a broader spectrum of society (which opened the way for private appropriation of it) when the U.S. government enacted the Bayh–Dole Act in 1980. The government of the U.S. attempted to tackle the lack of commercialization of knowledge from federally-funded projects when Congress passed the Bayh–Dole act to give control to universities to grant licenses for their use by small businesses and non-profit establishments. It overcame one major barrier that restricted university–industry linkages [31]. Also, if in the past large firms that had the capacity to undertake R&D and to scale up products created closed innovation systems, the Bayh–Dole act opened this to individuals, firms, farms and organizations to appropriate such knowledge for a small fee. Such publicly-held knowledge can also be better amortized as the same IPRs can be accessed by several agents depending on the nature of rights defined.

However, the innovation openness of Silicon Valley and Route 128 is also limited by IPRs opened by holders. For example, IBM opened its computer architecture, which saw the development of several clones, such as Compaq [5]. However, of the three technologies that have defined the PC industry in the 1980s, i.e., IBM's architecture, Microsoft's operating system and Intel's microprocessors, the latter two share their knowhow to support computer processing products but Microsoft and Intel IPRs remain closed for non-collaborators. Consequently, such a sub-system of openness cannot be accessed by society as a whole.

Also, the Bayh–Dole Act focused only on giving control to universities to appropriate innovations from federally-funded research projects. While this legislation expanded the reach of knowledge to a wider set of socioeconomic agents, thereby by casting the net of incremental innovations beyond the closed boundaries of R&D laboratories in large firms, government (including military) and universities, it did not purposively target the appropriation of innovations by individuals and organizations that function wholly to achieve social goals, as well as those unable to afford the small licensing fees. Aside from this, the Bayh–Dole act did not place any priority for supporting innovations specifically targeted at assisting the poor and for greening the environment. To ensure sustainability, a mechanism is necessary to prioritize innovations to assist the poor and to green the environment.

5.3. Vinnova Model

The Vinnova model launched by the Swedish government in 2001 has elements of the triple helix, which supports government, industry and university collaboration, but one that also brings together the different stakeholders to stimulate innovative activities (see Figure 1) [32–34]. Funding is allocated to qualifying firms and other critical members, such as universities. Extensive attention is given by the management of Vinnova to connect universities to firms, and to prioritize research on greening the environment, natural resources and agriculture. Elements of Etkowitz's [35] triple helix framework is visible here as industry, government and universities work together to stimulate innovation to drive the economy. As a concept, the triple helix of university–industry–government relationships was popularized largely by Etzkowitz [36,37], who expounded it as a triadic relationship between university–industry–government [38]. This model uses stringent criteria for selecting, monitoring and appraising the loans provided, the research undertaken and the system as a whole.

The main responsibility of Vinnova is to stimulate collaboration between higher education institutions (HEIs) and the society around them, although the focus is on firms. The Swedish Research Council is a key stakeholder in this network that attempts to lead Swedish research strategically while collaborating with other funding bodies. Forma, Forte, HEIs and companies complete the main stakeholders in the Vinnova model. Forte is a Swedish research council agency under the Ministry of Environment and Energy, while Forme is a Swedish research council agency under the Ministry of Health and Social Affairs. Although Edquist et al. [39] argued that the Swedish framework produced a low innovation return to R&D output, McKelvey [40] provided evidence to show the successful translation of funding into commercialization under the Swedish model when compared to other countries. Deiaco et al. [41] discuss how over time and across countries, universities exhibit a wide range and forms of public and private ownership, profit and not-for-profit objectives, and the degree of dependence on state funding to support innovative activity varies. Also, as Chaminade et al. [42] show, the Swedish innovation system is also internationally open, though it is strongly integrated regionally.

The Vinnova model offers room for stakeholders to organize the creation and appropriation of knowledge that focuses on commercialization and environmental greening. The stringently evaluated funding system provides scarce capital to support collaborative innovations in firms, universities and public laboratories. However, it is not sufficiently open to synergize, as well as absorb all socioeconomic agents' prospective participation in the innovation system, especially to enable the innovative faculties of individuals unconnected to farms, firms and organizations.

5.4. Taiwan's Science Parks

The R&D consortia evolved in Taiwan to support collaborative innovations is another example of innovation networks that penetrate firm and organization boundaries (Figure 1) [43]. The major contribution of Taiwan's framework of collaboration between science parks, universities and firms to a systems framework of innovation is the use of the consortia to share research, as well as to appropriate collaborative synergies. Indeed, the location of several different incubators that share common support machinery and equipment (e.g., for instrumentation and standards testing), and proximity for interactions has stimulated the proliferation of new products [28,44]. Science parks launched by the Industrial Technical Research Institutes (ITRI) in 1974 have been organized by broad sectoral categories—for example, micro-chip and micro-chip-driven products, biotechnology-based products and metal- and machinery-based products—to take account of the special structures associated with each. Each of them have a strong infrastructure to support innovation using specialized incubators.

Taiwan's STI is open to extensive adaptive learning from foreign sources of knowledge. In addition to technology acquired through manuals, imported machinery, licensing and mergers and acquisitions, institutions and interactions between experts were evolved to attract tacit knowledge embodied in human capital from across the globe to solve problems and to lead technological catch up [28,45,46]. The institutionalization of knowledge flows and continuous adaptations made Taiwan's knowledge networks innovative in providing the capabilities for developing new products and process, as well as fertilizing innovation across different industries.

The open nature of Taiwan's science parks also stimulated the coevolution of innovation activity, which allowed individuals and firms to connect with the knowledge nodes. While government-funded high-tech firms emerged through initial mergers and acquisitions—such as the United Microelectronics Company and Taiwan Semiconductor Corporation [28]—small firms, such as Phison, started by five graduates and an equity of $0.9 million USD in 2003, managed to generate sales exceeding $1 billion USD in 2009 with 200 design engineers). In an interview with the chief executive officer of Phison on 15 September 2009 by the author showed that the firm successfully used the universities and science park incubators to scale up and commercialise innovations.

The Taiwan model offers considerable room for socioeconomic agents in firms and organizations to organize the creation and appropriation of knowledge that focuses on commercialization. The matching grant funding system offers scarce capital to support collaborative innovations in firms, universities and public laboratories in Taiwan. However, like the Vinnova model, it is not sufficiently open to synergize, as well as absorb, all socioeconomic agents' prospective participation in the innovation system, especially in enabling the innovative faculties of individuals unconnected to farms, firms and organizations (Figure 1).

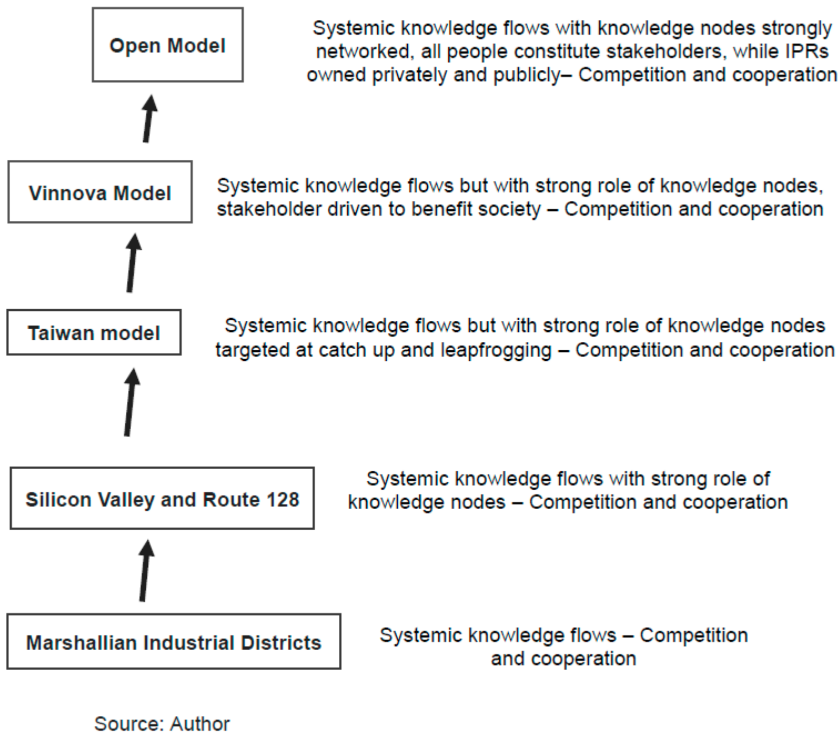

Figure 1. Evolution towards open systems knowledge flows. IPRs: intellectual property rights.

6. Innovation Systems Framework

We now turn to review the extant literature on innovation systems. From the heuristic concept of innovations systems, a range of works emerged to offer governments a framework to organize policy for promoting innovations. The broadest classification took on a loose model of national innovation systems (NIS) [47], which focused on critical instruments and organizations that deal with innovations. The use of the concept to denote links between knowledge nodes and appropriators can be traced to Freeman [48], though its crude version was articulated earlier by List [49]. However, much of the empirical works that came out of it deal with R&D, intellectual property rights, universities and R&D labs, and how firms connect to such organizations and instruments. Not only have subsequent works been overly loose, they do not take advantage of the fact that humans are the only socioeconomic agents capable of generating new stocks of knowledge, albeit other animals are known to have the capacity to evolve through adapting their routines with changes in time. Some elements of clustering and differentiation and division of labour have been captured by Lundvall [50], who discussed the critical role of user–producer relationships, which has its antecedents to Vernon's [51] scanning–coordinating relationships between R&D engineers and scientists, and consumers.

Consequently, members of NIS then went on to develop the sectoral innovation systems (SIS) concept by arguing that industries are different [9,52]. The focus was on identifying the different drivers of each of these industries, taking account of the institutional changes that are specific to locations and time [9,53,54]. The sectoral focus also allowed Chang et al. [55] to capture the nature of radical innovations in the construction sector. In contrast to the arguments of Pavitt [52], they provide evidence to show how a myriad of existing and new knowledge in areas such as seismic movements are adapted and fused together to transform construction. In fact, the construction of smart tunnels through mountains to handle both flash floods and jams, and the construction of tall buildings using construction beams, have radicalized the sector. These changes were welcome addition to our understanding of innovation systems, though much of the works on sectoral innovation systems have hardly mapped the innovation nodes and their drivers effectively.

Also, unlike in manufacturing, where much of the NIS and SIS literature has focused, the governance or institutional structures that have stimulated innovation in construction, agriculture and services have been inadequately studied. The developmental focus on agriculture, services and construction received a strong impetus when the systems of innovation literature evolved to undertake research on how adaptive learning and R&D have progressed to stimulate productivity growth in the sectors [35,53,55]. However, these works have shown little focus on how individual farms, units and firms moved up the technology ladder through a profound empirical assessment of how rents were created and translated productively. What is lacking is a direct approach to see how technological transformation has evolved in these sectors, and how the evolution of knowledge nodes has radicalized the sectors from the perspective of both generators/adaptors, as well as users. Such developments can not only stimulate structural transformation that address greening, but also support egalitarian accumulation.

Aside from this, existing NIS and SIS works have not taken advantage of advancements in systemic technological instruments, such as digitalization and Industry 4.0 tools, to conjecture the likely future institutional paths that will evolve innovation agglomerations and would enable all socioeconomic agents to participate actively in such systems, as well as embrace critical developmental measures to strengthen human societies by greening the environment and shifting the world to an egalitarian system.

Rural Innovation Systems

Since the majority of the poor among developing economies are associated with rural farming, this sub-section examines innovations that are devoted to rural developments that demonstrate how participative open innovation systems can alleviate poverty and green the environment. Socioeconomic agents' participation in innovation networks have already evolved in agriculture to address poverty and inequality and the environment. There exist considerable accounts of the state's role in poverty alleviation through land reforms, and integration of farmers and fishermen with markets (both domestically and export markets), connecting and coordinating parastatals with farmers and markets, as well as with price stabilization, in Malaysia, South Korea, Taiwan and Chile [56–59]. To check the spread of communism to South Korea and Taiwan, land confiscated from the Japanese colonial government was distributed to the poor in the late 1940s and early 1950s [57,60]. The state of Malaysia also introduced land and fisheries reforms through the launching of the Federal Land Development Authority, Rubber Industry Smallholders Development Authority (RISDA), Federal Land Consolidation and Rehabilitation Authority (FELCRA) and the Malaysian Fisheries Development Authority (MAJUIKAN) [59]. To prevent a return to socialism in Chile, the United States' government supported the Pinochet government to alleviate poverty in the country by funding the development of economic activity in locations where the poor lived [61].

While land reforms were important, two major channels of innovation were critical in the catch up experienced by poor farmers in South Korea, Taiwan, Chile and Malaysia. In the first channel, adaptive innovations were developed using largely foreign sources of knowledge (such as in the use of fertilizers, double-cropping paddy seeds and plant and fish species from abroad). Farms in all four countries raised productivity rapidly by raising yields. Whereas parastatals in Sub-Saharan Africa failed [62], effective institutional change made them a success in South Korea, Taiwan, Chile and in Malaysia until the 1980s [56,59].

Secondly, the evolution of the STI infrastructure through the development of STI infrastructure helped raise agricultural productivity in South Korea, Taiwan, Chile and Malaysia [63]. Innovation in agriculture deepened a lot more in South Korea, Taiwan and Chile than in Malaysia, owing to the three former nations' continuously evolve domestic innovation capabilities to stimulate technological upgrading. Rural farming in Malaysia, associated with the poor, began to face a decline, owing to a combination of reduced focus from the government, as well as the debilitating Dutch disease effects of an overvalued ringgit over the period of 1989 to 1997 [59]. In addition, the science and technology parks, launched to support innovation deepening, neither connected with the poor farmers, nor focused on their crops and fish.

The Saemaul Undong programme, launched in 1972 in Busan, was successful in not only supplying food to the whole economy, but also in helping to raise yields to ensure a strong rise in agricultural and manufacturing real wages in South Korea. Small farm-based agriculture has continued to enjoy productivity improvements as a consequence of technological deepening with strong support from university research and public labs, despite the sector's share contracting [56,59].

The industrial technical research institutes (ITRI) were launched in Taiwan in 1974 to spearhead technological transformation [28,44]. Agricultural biotechnology became a key channel through which the productivity of the food industry was raised, including staples, fish and crustaceans [57]. Smart robots and disc processing machines have helped reduce demand for workers and improve quality, precision, efficiency and delivery time. Smart robots in dairy farms handle feeding, milking, health monitoring, cow parturition, breeding management, manuring and cleaning [58].

Institutional innovations have been critical in stimulating environmental greening and stabilizing food production. For example, Taiwan encouraged farmers to use environmentally friendly measures for the production of quality paddy through the adoption of the Council of Agriculture's (COA) dual system of direct payment policy and guaranteed purchase on rice in six townships since 2016 [58]. The direct payment area took up 49% of the declared rice cultivation area, which was subsequently expanded to 20 trial areas in the first crop season of 2017, accounting for 63% of the declared trial paddy area to reduce farmers' dependence on guaranteed purchase. The second crop season of 2017 recorded an increase to 50 trial areas with 66% of declared paddy areas, and in import-substituting development-priority crops.

Fundacion Chile (FC) and the Chilean Economic Development Agency (CORFO) have played a critical role in adapting technologies to support incremental innovations in agriculture. Research stations, focused on adapting both local and foreign plants and animals for raising yield, were launched in several parts of Chile. One such research station, which continues to be supported by scientists from the University of Chile managed to successfully adapt salmon, corina and the Pacific hark for cultivation in Puerto Mont. Indeed, these institutional developments helped Chile become the world's second chief exporter of salmon [61]. Environmental greening has also evolved in Chile, through it started primarily in salmon farming, which was targeted at stemming the outbreak of infectious salmon anaemia (ISA) that seriously undermined farming [64].

In short, the innovation systems framework has evolved enormously to resonate in the policy frameworks of government officials who have actively promoted the development of STI infrastructure, cluster relationships and incentive structures to stimulate innovation activity. However, although education instruments have increasingly promoted open innovations (including problem solving teaching), little has manifested to stimulate the generation (including incrementally) and appropriation of innovations. Nonetheless, the advent of broadband infrastructure and digitalization, as well as Industry 4.0 tools, offer governments the potential to extend open innovation systems to all humans, regardless of their capacity to pay. Such a development also gives the opportunity for governments to regulate better environmental greening and egalitarian development. We address this in the next section. The Nordic countries have increasingly started to focus on these public goods issues [65]. The analytical focus of this paper, then, relies on an inductive methodology that draws on the empirical underpinnings that supported the evolution of dynamic knowledge-based systems targeted at stimulating innovations, and as with the Vinnova model, eventually the participation of stakeholders in shaping the requisite institutional processes. This paper not only presents an integrated model from such a historical evolution, but also seeks to explain how and why such an open innovation system should be organized, as well as on how to evolve the institutions that are essential for the inclusive involvement of all socioeconomic agents in society in the processes discussed.

7. Towards a Model of Open Innovation

Juxtaposing the different innovation systems and looking at the propellants and direction of innovations, three schematic generation/adaptation, incentivization and appropriation of knowledge flows can be considered to meet the objective of enabling all humans to connect and coordinate with knowledge nodes that provide the policy pillars to engage them. Despite the argument that protection helps innovators participate in risky and uncertain investment, the open system offers the appropriation of public goods benefits by all members of society. Hence, IPRs involving innovations that benefit the poor should be publicly held and financed to ensure its spread to all. Such publicly held IPRs are not uncommon, but need institutional acceptance on a national and international scale. Public innovation funding should focus on the needs of the disadvantaged, including diseases, farming assistance, transport systems and services of the poor and elderly.

Two major theoretical elements are important in the formulation of an open innovation system. Firstly, knowledge has to be shared in the production process, as well as in its appropriation. This is not only because knowledge is a scarce resource, but it is also because public goods are both non-excludable and non-rivalrous. In addition, knowledge is a dynamic public good that enables exponential possibilities for further innovation when its flows connect all socioeconomic agents.

Secondly, innovation stimulation requires governance to achieve sustainability that is targeted at achieving reasonable rates of growth and structural change, greening of the planet and, finally, one that supports innovation participation for all segments of society. Consequently, IPRs require deregulation to remove their undue limitations that restrict the progression of knowledge, including their periodization [4,66], with public ownership of IPRs promoted to support goods and services that help the disadvantaged, the poor and the environment.

Figure 2 shows a model of how incremental and radical innovations (including interactive learning) support technological upgrading in successful economies. In such a framework, embodied knowledge—both from abroad and domestically—is continuously appropriated through adaptation to raise industrial productivity in successful latecomers. The organizational set up can vary between countries as initial conditions and economic structures matter in the way they are shaped. However, unlike the relatively closed innovation systems, open innovation systems should be defined by strong inter-firm connectivity and coordination, and links with innovation centres (such as incubators in science parks) and markets, beyond the Taiwan experience, to include the active participation of all socioeconomic agents.

Institutions should be structured to pursue macroeconomic policies that provide the financing (incentives and grants) to support critical economic activity, for sustenance and developmental reasons, as well as to insulate from external shocks when involving small economies. Institutions should also be strengthened to meet stringent appraisal standards to check unproductive rent-seeking. Amsden [67] and Kim [68] provided a lucid account of innovation appropriation and economic catch up from foreign sources in South Korea and Taiwan. What distinguishes Korea and Taiwan from many other developing countries in stimulating innovations (including Singapore and Malaysia) is the focus on leapfrogging achieved in critical high technology industries through the development of a strong STI infrastructure. Hence, Samsung Semiconductor (in memories) and Taiwan Semiconductor Manufacturing Company (in logic chips) became world leaders by 1995 and 2005, respectively. The public good characteristics of knowledge creation and appropriation (innovation) was harnessed effectively in Taiwan and South Korea. However, while Taiwan, Sweden (Vinnova), the U.S. (Silicon Valley and Route 128) and Chile have evolved a fairly open model, South Korea's internalized innovation activity is largely closed, especially in manufacturing.

A significant channel through which developing countries appropriate and adapt knowledge new to them is through the Internet and other forms of communication, as well as through imports of goods and services, including machinery and equipment, and the licensing and acquisition of firms. Such adaptive learning is further enhanced when tacit knowledge embodied in human capital relocates from superior innovation systems or when related expertise interacts over the web to solve problems. The innovation system should be open to attract such embodied and systemic knowledge.

The critical organizations relevant to institutionalize knowledge creation and appropriation on a national scale, such as universities, public labs, standards organizations and incubators at science parks, must play an active role to stimulate incremental and radical innovations. Institutions supporting them should not only evolve a strong STI infrastructure, but also establish strong connectivity and coordination with socioeconomic agents. Legislation to support strengthening of greening initiatives, engagement of as many socioeconomic agents as possible and to promote an egalitarian remuneration system, will be important to promote sustainable development, taking account of the tacit dimension of technology [35,69].

While first movers initiate cycles of innovation, latecomers engage in incremental innovation [3]. As economies move from least developed countries (LDCs) to middle-income countries (MIC), governments should ensure that the gross expenditure in R&D (GERD) gradually rises, with a focus on R&D targeted at generating new stocks of knowledge. Instead of simply seeking a gradual displacement of government expenditure of GERD with business expenditure in R&D, the focus should include non-business public expenditure to address funding towards achieving environmental greening and alleviating poverty.

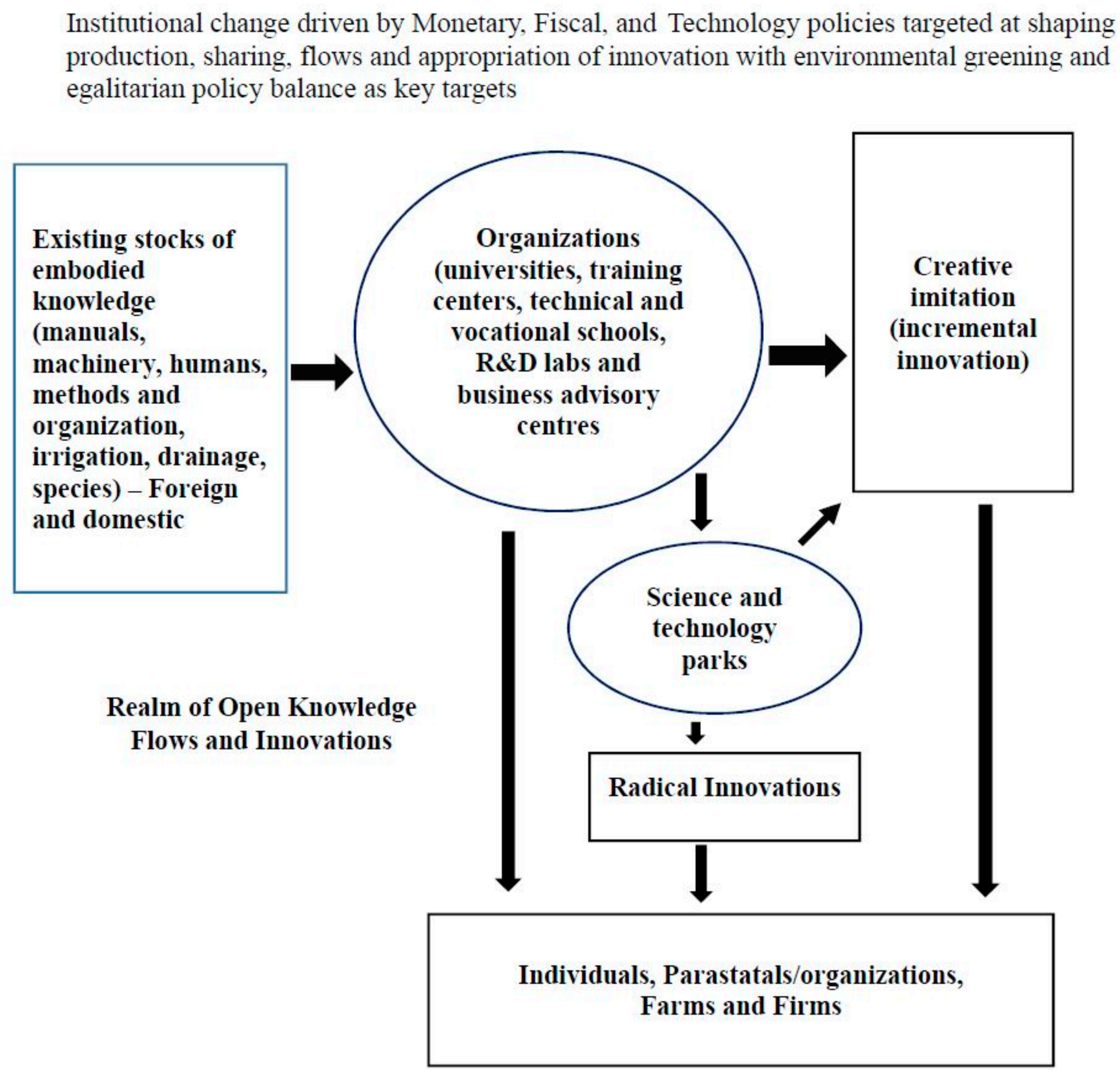

Figure 2. Open system of innovations.

While Figure 2 shows the specific links related to knowledge flows that are critical in transforming economies of the United States, Germany and Japan from low-to-high value-added activities, poor underdeveloped economies seeking to follow the economic catch up path must focus on four critical pillars, viz., basic infrastructure, STI infrastructure, network cohesion and global integration. The four pillars constitute the systemic quad, which, when promoted simultaneously alongside an open innovation systems framework, can synergize the transformation of underdeveloped locations to a developed status.

8. The Systemic Quad

Figure 3 shows the overall broad systemic framework that provides the building blocks for the modernization of economies, including its strong integration into global export markets [54]. The evolution of four pillars and the linkages between them are critical to evolve underdeveloped locations to developed status, viz., basic infrastructure (BI), STI infrastructure, network cohesion and global integration. Appendix A provides a detailed set of instruments, organizations and activities required to transform its achievement using an action plan.

8.1. Basic Infrastructure

Basic infrastructure constitutes the provision of public utilities, viz., power, water, basic education, health, transport, telecommunications and other services. These services are essentials that socioeconomic agents must access but are excludable and rivalrous. They are important to provide access, essential utility and raise efficiency. Since basic amenities must reach everyone, it is important that governments ensure their effective provision. Agglomerations of such services at urban locations, including cities, typically lowers coordination costs, yet their efficient allocation requires careful review through stakeholder coordination [70–75].

The basic infrastructure should ensure adequate provision of water, power, transport and telecommunication networks, finance, customs coordination, security, healthcare and basic education to prepare as well as support socioeconomic agents in the systemic quad (Appendix A). These agents should be able to compete in a level playing field so that the focus will be on continuous upgrading towards better species among individuals, firms and organizations.

In addition, basic infrastructure has to evolve to compliment developments in the remaining two pillars, as the quality and efficiency of services they provide is critical in stimulating innovations and their spread to all socioeconomic agents.

8.2. STI Infrastructure

Science, technology and innovation (STI) infrastructure is essential to provide public goods, which are non-excludable and non-rivalrous. They are also different from other public goods, such as security, in that they are far more dynamic and provide the paths for new knowledge creation, the extent of which varies with the capacity of socioeconomic agents and the eco-system they inhabit to generate, appropriate and expand knowledge into innovation synergies. The crystallization of different stocks of knowledge helps the development of new products, processes and services. Incremental innovation through adaptation has seen massive exports of salmon, wine and timber forest products from Chile [61], a wide range of manufactured and agricultural products from Taiwan and Malaysia, as well as manufactured exports from South Korea [17]. Radical innovations have driven state-of-the-art manufactured exports, such as memories and mobile phones from South Korea and logic chips from Taiwan. The articulation of the impact of the STI infrastructure on innovation synergies is shown in Figure 2 above.

Knight [76] defined localized knowledge-based development as the transformation of knowledge resources into local development, which should then form the basis for sustainable development. The proliferation of open innovation in platform ecosystems and its impact on regional development is a good starting point to formulate an extensively open innovation system [74,75]. The discourse on the spread of regional knowledge synergies in the past has largely focused upon urbanization and the mushrooming of cities [70,72,74–76] demonstrated the challenges of implementing a successful triple-helix model in regional university towns using evidence from Australia and Iceland. Drawing on policy and stakeholder assessments, they present the challenges of regional university towns by focusing on suitability, implementation and effectiveness of knowledge-based development policies.

STI infrastructure should experience the creation of specialized education, technical and vocational training, university education and research and digital infrastructure that connects all knowledge nodes and smart schools. Also important are skills and development centres, standards certification organizations, R&D laboratories, bodies governing IPRs, science and technology parks, R&D incentives and grants, venture capital and regulatory organizations entrusted with monitoring and appraisal (see Appendix A).

The STI infrastructure should connect with the digitalized infrastructure to reach all socioeconomic agents. With a people-oriented and environmentally friendly IPR system that advances its public goods features, the STI infrastructure will be able to integrate the open innovation network extensively to operate without excluding all active socioeconomic agents.

8.3. Global Integration

Open innovation-driven locations should be integrated in global factor and final product markets with strong connectivity and coordination between socioeconomic agents, parastatals and markets. Global integration also offers scale and competitiveness to shape innovation. A significant source of salmon farming species, farming and harvesting methods, and machinery and equipment that were originally imported from Norway, Scotland, Canada and the United States were adapted and re-innovated in Chile. The extent of final market connectivity and coordination had, by the turn of the millennium, evolved to include tele-monitoring by big supermarket chains. Saxenian [45] documented the interactive flows of knowledge between engineers in the United States and engineers in China, South Korea, Taiwan, and India. However, her evidence was largely closed to particular industries and particular groups of people. Even more impressive is the cross-diffusion and fertilization of knowledge from different disciplines and sectors in the rise of productivity in Taiwan's science park-supported farms. Farm productivity in Taiwan, including among small farmers, has risen by leaps and bounds, following the generation and appropriation of such innovation synergies [58].

The global integration pillar should increase linkages with input and product markets globally, connecting human capital and research universities with leading firms driving global value chains (Appendix A). Global developments have wide implications for governing technical change among developing economies. Best farm practices, including double-cropping using a high yielding variety of grains from research institutes, were imported and adapted for raising productivity in the developing countries [59]. Adapted knowledge inflows from abroad include imports, inter-boundary cyber-exchanges, licensing and acquisition, which have been a major channel driving incremental innovations [14,28,67].

Global policy directives from the United Nations Framework Convention for Climate Change (UNFCCC) on mitigating climate change and global warming have played a major role in strengthening their capacity to support food self-sufficiency and environmental greening (UNFCCC, 2017). The landmark Paris Accord of 2015 set milestones to reduce carbon emissions through both domestic initiatives and technology transfer from abroad to cap temperature rise to 1.5 degrees Celsius over the next century. Individual countries subsequently submitted targets to the UNFCCC Internally Nationally Determined Contribution (INDC) [77].

Meanwhile, greening initiatives, such as the Euro 4, which drastically reduces particulates and other hazardous emissions, are increasingly penetrating assemblies in Asia [78]. International initiatives to induce climate change mitigation include the efforts of developed countries, such as Denmark and the Netherlands, to root mitigation capabilities in the developing world [79,80].

8.4. Network Cohesion

The focal point of innovation in a dynamic cluster is essentially the interdependent and interactive flow of knowledge and information among people, enterprises and institutions. It must obviously include coordination between the critical economic and technological agents across value chains who are needed in order to turn an idea into a process, product or service in the market. In Silicon Valley and Route 128, innovations evolve from a complex set of interrelationships among actors located in a range of enterprises, universities and research institutes. The execution and appropriation of these innovations inter alia expand further the range of economic agents and institutions in dynamic clusters to intermediary organisations, such as suppliers, venture capitalists, property rights lawyers and marketing specialists. The government is a major player, providing a significant share of the funding public goods, although the National Science Foundation [47] has warned about a decline in its influence over the last decade. Government funding comes in the form of research supported in the military, support of research undertaken in firms and other laboratories.

The co-location of critical knowledge nodes, such as research universities, public labs and science parks around socioeconomic agents, is not enough to ensure that there will be connections and coordination to stimulate knowledge flows and appropriation [81]. While this work deals extensively on R&D linkages, network cohesion requires that individuals, firms, farms and organizations are effectively connected with strong coordination between each other.

Clustering should go beyond co-location to connect socioeconomic agents with buyers and suppliers, firms, farms and organizations, and regulatory instruments (Appendix A). Strong network cohesion should be built between firms and farms—especially in complimentary but dissimilar technologies, products and services, and between them and organizations, such as training centres, standards organizations, incubators and R&D centres. For evolving locations, institutional change should play a critical role to strengthen those links. In an open innovation system, individuals should enjoy the same access to firms, farms, organizations and other individuals. The digitalization of STI infrastructure offers tremendous potential to intensify such linkages.

An integrated—intra pillar and inter-pillar—systemic quad would shape the conduct of all socioeconomic agents to participate as creators and appropriators in the innovation process, but also could be moulded to observe greening and egalitarian practices.

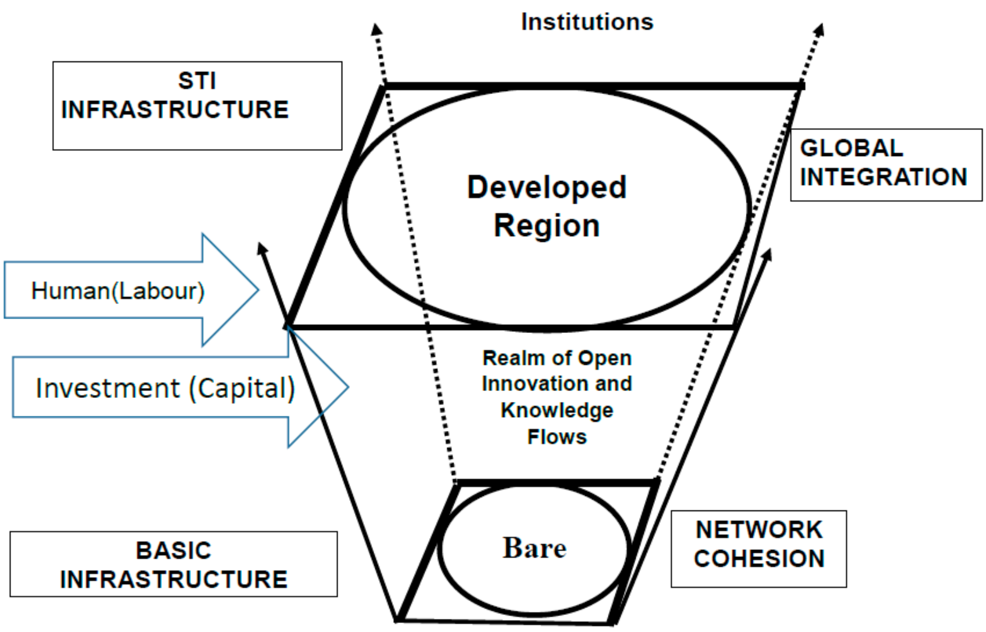

Figure 3. The systemic quad. Source: Extensively adapted and developed from Rasiah [17].

Overall, the four pillars of the systemic quad should be evolved simultaneously to appropriate maximum knowledge creation, flow and appropriation synergies. Institutional change should not only focus on quickening the development of these four pillars, but also on strengthening elements of greening and equitable distribution of income.

9. Conclusions

Despite corporate motives to protect new knowledge, constituencies calling for opening it to appropriate its public goods characteristics have been snowballing. While scientific knowledge has largely been generated in developed countries, sustaining humankind requires increased emphasis on greening and access for all socioeconomic agents, as well as ensuring that its financing takes care of the interests of both the haves and have-nots. Consequently, it is pertinent that policies to stimulate growth and structural change are integrated with environmental greening and poverty alleviation initiatives. Technological advancement has enabled the development of STI infrastructure that offers connectivity to individuals, firms, farms and organizations with the critical knowledge nodes. This paper developed an open innovation model that took account of evolving knowledge networks to offer socioeconomic agents the opportunity to participate in knowledge networks—both as generators and appropriators.

In doing so, the paper traced the evolution of open systems networks from the industrial districts of Britain and Italy, and subsequently the unique developments in the United States, Sweden and Taiwan. The specific rural experiences of Chile, Malaysia, South Korea and Taiwan were also included to construct an open innovation model that extends knowledge creation and appropriation to embrace environmental greening and egalitarian societal balance as equally important national targets as growth and structural change. For the inclusive participation of all socioeconomic agents, we extended access from firms, farms and organizations to include all socioeconomic agents. The evolution of technology (including digitalization, big data analytics and smart machines) has raised the potential for attracting the participation of all socioeconomic agents in innovation networks. While the incentive system should continue to finance economic growth and structural change, we call for a review of the IPR system to shorten protective periods to remove undue impediments to path-dependent innovation routes, and for the financing of greening and societal goods and services through public support and public ownership of IPRs.

Two important stylized models were built through the extensive adaptation and development of previous models to show how institutional, macroeconomic and innovation policies should be formulated to promote the evolution of an open innovation network that is geared towards driving both incremental and radical innovations, as well as its links to individuals, firms, farms and organizations. The open innovation system with an institutional framework that is geared towards stimulating innovations to power economic growth, environmental greening and balancing income distribution should enable the participation of entire societies in knowledge adaptation, creation and appropriation. However, given that the future is always uncertain, and that policies can fail, the governance of such a system must be subjected to stringent and accountable appraisal with a view towards recalibration to ensure that the direction of its steering is right.

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Appendix A

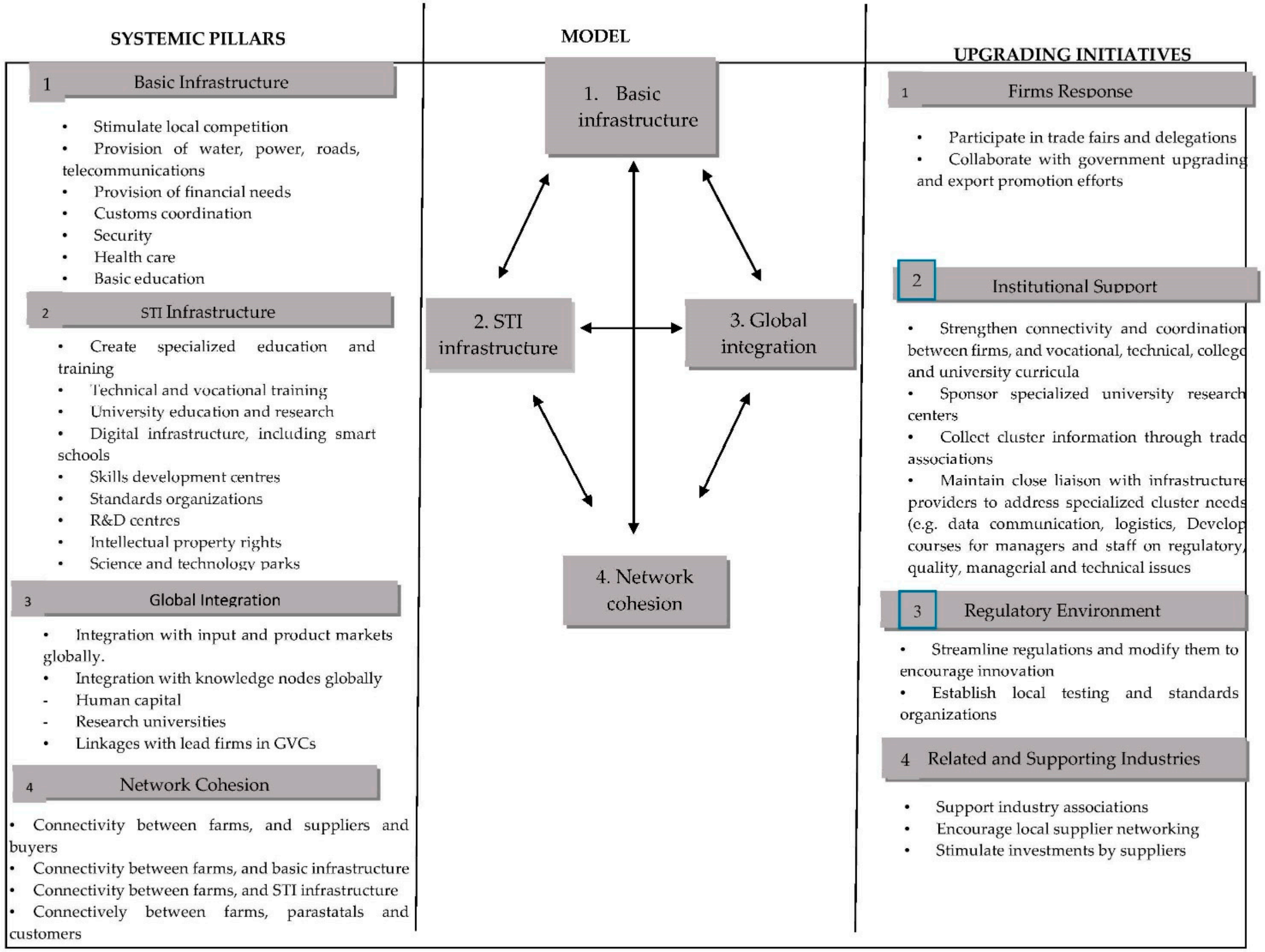

Figure A1. Upgrading action plan. Source: Adapted from Rasiah [54].

References

1. Marshall, A. *Principles of Economics*; Macmillan: London, UK, 1890.
2. Schumpeter, J.A. *The Theory of Economic Development*; Harvard University Press: Cambridge, MA, USA, 1934.
3. Schumpeter, J.A. Capitalism, Socialism and Democracy. 1942. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1496200 (accessed on 3 September 2019).
4. Correa, C. Can the TRIPS Agreement Foster Technology Transfer to Developing Countries? In *International Public Goods and Transfer of Technology under a Globalized Intellectual Property Regime*; Maskus, K.E., Reichman, J.H., Eds.; Cambridge University Press: Cambridge, UK, 2005.
5. Chesbrough, H. *Open Innovation: The New Imperative for Creating and Profiting from Technology*; Harvard Business School Press: Cambridge, UK, 2003.
6. Chesbrough, H.W.; Appleyard, M.M. Open Innovation and Strategy. *Calif. Manag. Rev.* **2007**, *50*, 57–76. [CrossRef]
7. Nelson, R.R.; Winter, S. *An Evolutionary Theory of Economic Change*; Belknap Press of Harvard University Press: Cambridge, MA, USA, 1982.
8. *National Innovation Systems: A Comparative Analysis*; Nelson, R.R. (Ed.) Oxford University Press: New York, NY, USA, 1993.
9. Nelson, R.R. Economic Development from the Perspective of Evolutionary Economic Theory. *Oxf. Dev. Stud.* **2008**, *36*, 9–21. [CrossRef]
10. Smith, A. *An Inquiry into the Nature and Causes of the Wealth of Nations*; William Strahan and Thomas Cadell: London, UK, 1776.
11. Veblen, T. Imperial Germany and the Industrial Revolution. *J. Race Dev.* **1915**, *6*, 231. [CrossRef]
12. Bhagwati, J.N.; Brecher, R.A.; Srinivasan, T.N. DUP activities and trade theory. *Eur. Econ. Rev.* **1984**, *24*, 291–307. [CrossRef]
13. Krueger, A.O. The Political Economy of the Rent-seeking Society. *AER* **1974**, *64*, 291–303.
14. Amsden, A. *Asia's Next Giant: South Korea and Late Industrialization*; Oxford University Press: New York, NY, USA, 1989.
15. Khan, M. Corruption, Clientelism and the Capitalist State. Ph.D. Thesis, Cambridge University, Cambridge, UK, 1989.
16. Evans, P. *Embedded Autonomy: States and Industrial Transformation*; Princeton University Press: Princeton, NJ, USA, 1995.
17. Rasiah, R. Innovation Policy, Inputs, and Output in ASEAN. In *Innovation Policy in ASEAN*; Ambashi, M., Ed.; Economic Research Institute for ASEAN and East Asia: Jakarta, Indonesia, 2018.
18. Poulantzas, K. *Political Power and Social Classes*; Verso Books: New York, NY, USA, 1973.
19. Rasiah, R.; Smidt, J.D. *The New Political Economy of Southeast Asia*; Edward Elgar: Cheltenham, UK, 2010.
20. Miliband, R. *The State in Capitalist Society*; Weidenfeld & Nicolson: London, UK, 1969.
21. Jessop, B. *State Theory: Putting the Capitalist in its Place*; Pennsylvania State University Press: University Park, PA, USA, 1990.
22. Wilkinson, F.; You, J.I. Competition and Cooperation: Towards Understanding Industrial Districts. *Rev. Political Econ.* **1994**, *6*, 259–278.
23. Becatini, G. *The Marshallian Industrial District as a Socio-Economic Notion*; Pyke, F., Becatini, G., Sengengerber, W., Eds.; Industrial Districts and Inter-Firm Cooperation in Italy; International Labour Organization: Geneva, Switzerland, 1990.
24. Brusco, S. The Emilian model: Productive decentralization and social integration. *Camb. J. Econ.* **1982**, *6*, 167–184.
25. Amsden, A.H. The division of labour is limited by the rate of growth of the market: The Taiwan machine tool industry in the 1970s. *Camb. J. Econ.* **1985**, *9*, 271–284. [CrossRef]
26. Best, M.H. *The New Competitive Advantage*; Oxford University Press: Oxford, UK, 2001.
27. Narula, R. Innovation systems and 'inertia' in R&D location: Norwegian firms and the role of systemic lock-in. *Res. Policy* **2002**, *31*, 795–816.
28. Rasiah, R.; Lin, Y. Learning and innovation: The role of market, government and trust in the information hardware industry in Taiwan. *Int. J. Technol. Glob.* **2005**, *1*, 400. [CrossRef]

29. Bahlmann, M.D.; Huysman, M.H. The emergence of a knowledge-based view of clusters and its implications for cluster governance. *Inf. Soc.* **2008**, *24*, 304–318. [CrossRef]
30. Saxenian, A.L. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*; Harvard University Press: Cambridge, MA, USA, 1994.
31. Mowery, D.C.; Nelson, R.R.; Sampat, B.N.; Ziedonis, A.A. *Ivory Tower Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh-Dole Act*; Stanford University Press: Stanford, CA, USA, 2004.
32. VINNOVA. *Effective Innovation Systems and Problem-oriented Research for Sustainable Growth, Vinnova Strategic Plan 2003–2007*; VINNOVA: Stockholm, Sweden, 2002; Available online: www.vinnova.se (accessed on 17 January 2003).
33. VINNOVA. Vinnova and Its Role in the Swedish Innovation System—Accomplishments since the Start in 2001 and Ambitions Forward, Presentation by Per Ericsson. 2006. Available online: http://www.rieti.go.jp/en/events/bbl/06090501.pdf (accessed on 19 September 2007).
34. Vinnova: Developing a New Funding Model for Increased University-Business Cooperation. 2019. Available online: https://www.ub-cooperation.eu/pdf/cases/N_Case_Study_Vinnova.pdf (accessed on 21 May 2019).
35. Dosi, G. Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. *Res. Policy* **1982**, *11*, 147–162. [CrossRef]
36. Etzkowitz, H. Technology transfer: The second academic revolution. *Technol. Access Rep.* **1993**, *6*, 7–9.
37. Etzkowitz, H. *MIT and the Rise of Entrepreneurial Science*; Routledge: London, UK, 2002.
38. Etzkowitz, H.; Leydesdorff, L. *The Triple Helix—University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development*; Social Science Research Network: Rochester, NY, USA, 1995.
39. Edquist, C.; Bitard, P.; Hommen, L.; Rickne, A. Reconsidering the paradox of high R&D input and low innovation: Sweden. In *Small Country Innovation Systems: Globalisation, Change and Policy in Asia and Europe*; Edquist, C., Hommen, L., Eds.; Edward Elgar Publishing Limited: Cheltenham, UK, 2008; pp. 237–280.
40. McKelvey, M.; Holmen, M. *Learning to Compete in European Universities: From Social Institution to Knowledge Business*; Edward Elgar: Cheltenham, UK, 2009.
41. Deiaco, E.; Hughes, A.; McKelvey, M. Universities as strategies actors in the knowledge economy. *Camb. J. Econ.* **2013**, *36*, 525–541. [CrossRef]
42. Chaminade, C.; Zabala, J.M.; Treccani, A. The Swedish national innovation system and its relevance for the emergence of global innovation networks. In *Working Paper No. 2010/09, Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)*; Lund University: Lund, Sweden, 2010.
43. Mathews, J.A. The origins and dynamics of Taiwan's R&D consortia. *Res. Policy* **2002**, *31*, 633–651.
44. Tsai, T.; Cheng, B.S. *The Silicon Dragon: High-Tech Industry in Taiwan*; Edward Elgar: Cheltenham, UK, 2006.
45. Saxenian, A.L. From Brain Drain to Brain Circulation: Transnational Communities and Regional Upgrading in India and China. *Stud. Comp. Int. Dev.* **2005**, *40*, 35–61. [CrossRef]
46. Saxenian, A.L. *The New Argonauts: Regional Advantage in a Global Economy*; Harvard University Press: Cambridge, MA, USA, 2006.
47. NSF. The Role of Science Foundation in the Innovation System. 2010. Available online: https://www.nsf.gov/eng/iip/innovation.pdf (accessed on 3 September 2019).
48. Freeman, C. *Technology and Economic Performance: Lessons from Japan*; Pinter: London, UK, 1987.
49. List, F. *The National System of Political Economy, (translated by Lloyd, Sampson S)*; Longmans, Green and Co.: London, UK, 1885.
50. Lundvall, B.A. User-Producer Relationships, National Systems of Innovation and Internationalisation. In *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*; Lundvall, B.A., Ed.; Pinter Publishers: London, UK, 1992; pp. 45–67.
51. Vernon, R. International investment and international trade in the product cycle. *Int. Exec.* **1966**, *8*, 16. [CrossRef]
52. Pavit, K. Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory. *Res. Policy* **1984**, *13*, 343–373. [CrossRef]
53. *Economic Development as a Learning Process: Variation across Sectoral Systems*; Malerba, F.; Nelson, R.R. (Eds.) Edward Elgar: Cheltenham, UK, 2012.
54. Rasiah, R. The systemic quad: Technological capabilities and economic performance of computer and component firms in Penang and Johor, Malaysia. *Int. J. Technol. Learn. Innov. Dev.* **2007**, *1*, 179. [CrossRef]

55. Chang, Y.F.; Rasiah, R.; Chan, W.M. Understanding innovations in Malaysia's construction industry: A study of four large national firms. *Asian J. Technol. Innov.* **2016**, *24*, 1–18. [CrossRef]
56. ADB. *The Saemaul Undong Movement in Republic of Korea: Sharing Knowledge on Community Development*; Asian Development Bank: Manila, Philippines, 2012.
57. Huang, M.T. Republic of China. In *Integration of Agricultural Research and Extension*; Sharma, R., Ed.; Asia Productivity Organization: Tokyo, Japan, 2003; pp. 118–130.
58. Lui, W.Y. An Overview of Agricultural Policies in Taiwan. 2018. Available online: http://ap.fftc.agnet.org/ap_db.php?id=867 (accessed on 15 June 2018).
59. *Driving Development: Revisiting Razak's Role in Malaysia's Economic Progress*; Rasiah, R.; Salih, K. (Eds.) University of Malaya Press: Kuala Lumpur, Malaysia, 2019.
60. Cho, L.J.; Kim, Y.H. (Eds.) *Economic Development in the Republic of Korea: A Policy Perspective*; Hawaii University Press: Honolulu, HI, USA, 1991.
61. Rasiah, R.; Vinanchiarachi, J. Institutional Support and Technological Upgrading: Evidence from Dynamic Clusters in Latin America and Asia. *World Econ. Rev.* **2013**, *2*, 24–47.
62. Sender, J.; Smith, S. *The Development of Capitalism in Africa*; Routledge: London, UK, 1986.
63. *Universities in the National Innovation Systems: Experiences from the Asia Pacific*; Krishna, V.V. (Ed.) Routledge: Abingdon, UK, 2017.
64. Asche, F.; Hansen, H.; Tveteras, R.; Tveteras, S. The Salmon Disease Crisis in Chile. *Mar. Resour. Econ.* **2009**, *24*, 405–411. [CrossRef]
65. UNESCO. *Science Report: Towards 2030*; United Nations, Educational, Scientific and Cultural Organization: Paris, France, 2015.
66. Williams, H. Intellectual Property Rights and Innovation: Evidence from Human Genome. *J. Political Econ.* **2013**, *121*, 1–27. [CrossRef]
67. Amsden, A. Diffusion of development: The late-industrializing model and greater East Asia. *Am. Econ. Rev.* **1991**, *81*, 282–286.
68. Kim, L.S. *From Imitation to Innovation: The Dynamics of Korea's Technological Learning*; Harvard Business Review Press: Cambridge, MA, USA, 1997.
69. Rasiah, R. *Foreign Capital and Industrialization in Malaysia*; Macmillan: Basingstoke, UK, 1995.
70. Cooke, P.; Leydesdorff, L. Regional Development in the Knowledge-Based Economy: The Construction of Advantages. *J. Technol. Transf.* **2006**, *31*, 5–15. [CrossRef]
71. Krugman, P. *The Self-Organizing Economy*; Blackwell: Oxford, UK, 1996.
72. Yigitcanlar, T.; Lonnqvist, A. Benchmarking knowledge-based urban development performance: Results from the international comparison of Helsinki. *Cities* **2013**, *31*, 357–369. [CrossRef]
73. Yigitcanlar, T.; Edvardsson, I.R.; Johannesson, H.; Kamruzzaman, M.; Ioppolo, G.; Pancholi, S. Knowledge-based development dynamics in less favoured regions: Insights from Australian and Icelandic university towns. *Eur. Plan. Stud.* **2017**, *25*, 2272–2292. [CrossRef]
74. Yun, J.J.; Cooke, P.; Park, J. Evolution and variety in complex geographies and enterprise policies. *Eur. Plan. Stud.* **2017**, *25*, 1–10. [CrossRef]
75. Yun, J.P.H.; Won, D.K.; Park, K.B.; Yang, J.H.; Zhao, X.F. Growth of a platform business model as an entrepreneurial ecosystem and its effects on regional development. *Eur. Plan. Stud.* **2017**, *25*, 805–826. [CrossRef]
76. Knight, R.V. Knowledge-based Development: Policy and Planning Implications for Cities. *Urban Stud.* **1995**, *32*, 225–260. [CrossRef]
77. Rasiah, R.; Al-Amin, A.Q.; Habib, N.M.; Chowdhury, A.H.; Ramu, S.C.; Ahmed, F.; Filho, W.L. Assessing climate change mitigation proposals for Malaysia: Implications for emissions and abatement costs. *J. Clean. Prod.* **2017**, *167*, 163–173. [CrossRef]
78. Sadoi, Y. The impact of Euro 4 automobile emission regulations on the development of technological capabilities in ASEAN. *J. Asia Pac. Econ.* **2018**, *23*, 279–296. [CrossRef]
79. Geels, F.W.; Berkhout, F.; Van Vuuren, D.P. Bridging analytical approaches for low-carbon transitions. *Nat. Clim. Chang.* **2016**, *6*, 576–583. [CrossRef]

80. Mol, A.; Sonnenfeld, D. Environmental Reforms in Asia: Comparisons, Challenges, and Next Steps. *J. Environ. Dev.* **2006**, *15*, 112–137.
81. Narula, R.; Santangelo, G.D. Location, collocation and R&D alliances in the European ICT industry. *Res. Policy* **2009**, *38*, 393–403.