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NATIONAL SCIENCE AND TECHNOLOGY INITIATIVES FOR ESCWA MEMBER COUNTRIES: LESSONS FROM THE SOUTH AND EAST ASIAN REGION

by

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Introduction

The full paper[1] reviews the experience of countries in the South and East Asian region that have trodden the path of intensive S&T-based industrialisation in recent decades, with a view to drawing some 'lessons' to assist the ESCWA member countries. The paper gives an overview of the development of the science, technology and innovation systems in the region and their relation to other national policies, especially industrialisation. The 'modalities' of S&T initiatives (such as technology parks and incubators, tax incentives, 'linkage' mechanisms, and support for training) commonly used in South and East Asia are described and the main S&T initiatives and policy concerns that have arisen in each of the selected countries in recent years reviewed.

Two case studies are presented. The first concerns the application of taxation and other fiscal incentives for R&D and technology transfer that have been a common feature of the S&T strategies of many countries. The second concerns experience with technology incubators, S&T parks and technology cities in Asia. Examples include problems with the development of incubators and parks in the Philippines (one of the lower income countries in the region), and the attempt to translate the Japanese experience with 'technopoles' into Australia's existing system of S&T parks.

While widely-used, common S&T initiatives can be identified, most are strongly context-dependent and their detailed expression is a product of the country's 'national innovation system'. Notably, initiatives within the East Asian countries are strongly linked to policies and 'visions' for national development that emphasise building up a national environment for systematic science and innovation. The experience of the region offers many 'solutions' to particular policy issues, like encouraging technology development in small local companies.

While the main message is that it is not a simple matter to imitate national S&T initiatives that appear successful elsewhere, the paper indicates the kinds of measures that may be helpful in the context of the ESCWA region; and suggests where to look for successful examples of particular initiatives.

The Development of Science, Technology and Innovation Systems in South and East Asia

There are clear lessons - both of success and failure - to be learned from East Asia in the application of S&T policies and initiatives in furtherance of industrial and national development. The East Asian 'latecomer' strategy focusing on 'the acquisition of technological competences' and a 'national system of economic learning' (Mathews and Cho, 2000) is a common industrial technology strategy among the countries of the region. Notable, however, is the great *differences* that exist among the countries of the region in what may be termed the 'national innovation systems' and in their socio-economic development more broadly. NSTIs evolve with the dynamism of the national development path of the country and its S&T and innovation system.

A Framework for the National S&T Initiatives in the Asian Context

In describing and analysing interventions in particular countries, it is helpful to have as a framework a conceptual model of the rationale and objectives of particular initiatives. Generally, S&T initiatives can be categorised in terms of the following:

- The overall government *strategy* or objective (eg, intervention; attracting foreign investment; promoting human resource development); encouraging intersectoral or international linkages;

[1] This document is a summary of a study prepared by the author for ESCWA. This study will be published at a later date as part of an extensive ESCWA contribution on the subject.

- The *target* or subject of the initiative (eg, industry as a whole; particular technology or industry sectors; government laboratories; universities; SMEs etc); and
- The type of policy *instrument* involved (eg, legislation; organisational changes; grants or financial incentives; construction of facilities or equipment).

Any selection of NSTIs should consider the overall national strategy that they are intended to support, the sectors and/or organisations to be targeted for the initiative, and *only lastly* the particular form of the intervention or instrument used.

Lall and Teubal (1998) recognise 'vertical' policies and initiatives (i.e., targeted at particular industry or technology sectors) and 'horizontal' (i.e., promoting an activity across all sectors). Table A shows particular examples of 'horizontal' and 'vertical' policy initiatives in the East Asian countries.

Table A: Examples of 'Horizontal' and 'Vertical' technology policies used in East Asia

Horizontal Technology Policies	**Examples**
• Grants for enterprise R&D	Israel, Singapore, Korea
• Support of R&D personnel in SMEs	Germany in the 1980s
• Teaching company scheme	UK
• Broad technology support to SMEs	Most advanced countries, NIEs, and many developing countries
• Promotion of technology transfer	Korea, Japan
• Support of cooperative pre-competitive consortia	Israel, EU, Japan and several other advanced countries
Vertical Technology Policies	**Examples**
• Infant industry promotion of new activities	Japan, Korea and Taiwan
• Subsidization and credit allocation for capital-intensive investments	Japan, Korea and Taiwan
• Restricting FDI to build up local capabilities	Korea and Taiwan
• Guiding or subsidizing MNCs to enter targeted activities or conduct R&D	Singapore, many developed countries
• Targeting strategic technologies for promotion in national laboratories	Japan, Singapore, Korea and Taiwan
• Financing private R&D in selected technologies	Korea and Taiwan
• Targeting enterprises for R&D support in particular technologies	Korea and Japan
• Subsidizing joint R&D by enterprises and institutions in specific areas	Korea and Taiwan
• Building R&D institutions in selected activities	Most developed countries and NIEs
• Providing subsidized credit for upgrading selected activities	Korea and Taiwan
• Intervening in technology transfer processes to build specific capabilities	Korea and Japan

Source: After Lall and Teubal (1998), Tables 4 and 5.

Even the most technologically advanced firms in developing countries are committed to be 'imitators'. NSTIs relating to technology transfer are thus particularly important. The cumulative, localised 'learning processes' that occur through innovation within firms in industrialised countries appear to be reproduced in developing countries. However these processes are not automatic. They require organisation and resources within the firm, and appropriate external institutional conditions. Failure of 'learning processes' is more

common in developing countries, and this failure can be addressed by public policy initiatives (Cooper, 1994).

S&T initiatives must be appropriate to the stage of S&T development. Early stage initiatives may focus on general skills development and diffusion of technologies; later stages (as with Japan and increasingly Korea emphasise promotion of R&D in industry, basic research in the universities and government institutes, and open international cooperation in scientific programs. But these stages are not mutually exclusive, and the later stage initiatives are built on the foundation of the earlier stage.

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Case Study: Taxation Incentives for Industrial R&D

Taxation concessions for R&D represent one amongst a portfolio of policy initiatives that are used for promotion of a country's national innovation potential across most industrialised economies, and which have been adopted increasingly by South and East Asian countries.

R&D taxation concession initiatives appear to be most effective where two basic conditions apply: (1) the concession is targeted towards specific R&D development and sectoral objectives; and (2) the R&D incentive is situated within a consistent package of other incentives that address the role of R&D in the particular national development and innovation context.

Case Study: Science and Technology Parks, Incubators and Cities

The Philippines experience with technology incubators illustrates the importance both of a well thought out policy *framework* and sound program *implementation* for such initiatives. The framework issues include defining the role and objectives of the initiatives, their integration with other programs, their funding, and criteria for selection of tenants and sites. Implementation issues include ensuring the provision of infrastructure, appropriate skills in providing technology/management services, arrangements for monitoring the performance of tenants of tenants and TBIs, and recruiting successful firms as 'demonstrators' for others.

The costly Australian experience with a large 'technopole' - the 'Multifunction Polis' - underscores the difficulty of firstly defining (or rather negotiating) achievable objectives for such large S&T development regions and, secondly, engendering the commitment required for their implementation. In this case local federal/state jurisdictional issues were overlain by the attempt to import a Japanese concept, incorporating a different national view of appropriate 'solutions' to the problem of promoting innovation.

In industrialised countries, S&T parks are usually developed on an already substantial research and innovation base, built up over decades. In developing countries, the allure of S&T parks for tenants is likely to be the availability of facilities and expertise not readily found elsewhere.

Conclusions: Lessons from the South and East Asian Region

What general conclusions can be drawn from the above discussion about successful NSTIs and policies in the East Asian countries? And which of these findings about NSTIs are likely to be relevant to the particular circumstances of the ESCWA member countries? The following section draws 11 key 'lessons' from the region, and suggests how these might be useful to ESCWA members.

1. **Wide differences exist in the structure of national innovation systems and national institutions and in the 'development status' of the countries of South and East Asia that influence the NSTIs and strategies chosen.**

NSTIs are context dependant and dynamic. Policies and initiatives are geared to the scientific and technological 'endowments' of each country, and to their government and business capabilities. Both socio-economic development and a country's 'national innovation system' are dynamic. Therefore NSTIs evolve over time, as national capabilities change. Japan and Korea provide vivid examples of how S&T policies and initiatives have evolved in this way.

- ***Countries in the region have each used different S&T strategies and initiatives that have evolved over time.***

- ***It is no simple matter to imitate NSTIs that appear successful elsewhere. Initiatives cannot be used 'off the shelf', but must be tailored to local circumstances - as the case study of R&D tax concessions shows.***

- ***East and South Asia provide many varied and instructive examples of apparently effective NSTIs and policies that may be helpful to ESCWA members in formulating initiatives within their own S&T strategies,* provided *that the particular national characteristics of the science and innovation system in each country is taken into account.***

2. **All the countries/economies reviewed recognise the importance of taking specific national initiatives in S&T.**

East Asian, and subsequently South East Asian, countries early on recognised the need for strategic intervention in both industrial development and S&T policy. Even those - like Hong Kong - that, in the past have been relatively 'hands-off' are now investing heavily in new S&T initiatives such as research institutes. The region provides a wealth of contrasting examples of public policy initiatives particularly for promoting industrial technology development. On the whole, the successful examples of NSTIs have involved government incentives, support, and regulation of the environment, rather than direction or control of industrially relevant S&T.

- ***The East and South Asian region's success in implementing S&T strategies and instruments successfully may provide justification for similar interventions by governments in ESCWA countries.***

3. **The most effective NSTIs are those that form part of a strategy to address particular problems within the science, technology and innovation system.**

As Lall and Teubal point out, in the East Asian context, S&T strategies have involved an appropriate mix of functional, horizontal and vertical policy initiatives that vary with the context of the country. Vertical initiatives imply selecting clusters of technologies, industries or regions - and here many of the East Asian countries have been more explicit than countries like Australia; horizontal implies promoting learning, innovation, 'technology culture', and R&D more generally. In general, economies like Hong Kong and to some extent Australia have favoured horizontal polices, while Korea and Indonesia for example have been more selective in targeting particular technologies and industries, though with contrasting outcomes.

Effective NSTIs are integrated, both within the national S&T or innovation system, and with broader industrialisation and socio-economic development policies. This requires a broad view (and understanding) of the effect of NSTIs and other actions on the 'national innovation system'. It has also led to a focus on NSTIs that serve to encourage cooperation between various players in the national innovation system, most notably universities or research institutes and industry (Brimble and Sripaipan, 1996). Indeed, the trend to cooperation and linkage in many aspects of research, technology consultancy and training (often through

agents such as 'virtual' centres or intermediary organisations) is a clear one in Australia and across many of the APEC countries in the region that already have world class university and public research sectors.

- ***It makes more sense to frame S&T policy development in terms of a strategy, or a 'basket' of initiatives, rather than in terms of isolated initiatives. Korea and Taiwan's strategies for technology upgrading in locally-owned firms are good examples of such an integrated strategy.***

- ***A good understanding of the characteristics and particular problems of the country's 'national innovation system' must inform initiative and strategies.***

- ***Initiatives that encourage collaboration between different parts of the 'innovation system' are especially valuable.***

- ***Any selection of NSTIs should consider the overall national strategy that they are intended to support, the sectors and/or organisations to be targeted for the initiative, and* only lastly *the particular form (or 'instrument') used for the intervention.***

4. The global context of NSTIs is important for all countries, but particularly so for developing countries.

Quite different initiatives may be used to build up local S&T competencies depending on whether the prevailing strategy is to exploit existing strengths within research institutions and local firms (including SMEs), or to attract large, technology-based foreign companies to locate in a country.

Improving one's 'global position' may be closely linked to work force skills. Castells (1996) argues that the spatial division of labour is grouped on a bipolar axis. On the one hand, one finds a highly skilled, science and technology based labour force, and, on the other, a body of unskilled and semi-skilled workers engaged in routine assembly (with a group of 'skilled operators' in between).

- ***Policymakers should specifically consider the relationship between specific NSTIs and 'globalisation' processes and players in particular industries and technologies.***

5. The predominant model of S&T development in the East Asian countries has been the 'latecomer learner' or 'imitation' model.

As all analysts point out, the learning model requires both effort in acquisition of technology and the skills to use it. Imitation does not progress automatically to innovation without substantial resources both within the firm and at the national level. The 'learning process' can be positively influenced by public policy initiatives; especially those aimed at general education and human resource development, and at supplying particular technical and engineering skills. There is some evidence - though also some debate - that the NSTIs and policies required for 'imitation' are not necessarily those that will promote domestic scientific advance and radical innovation. This has led to a greater focus on support for basic research, university research and research training in countries like Japan, Singapore and Korea in recent years.

- ***East Asia is a particularly good model for strategies and initiatives in those technologies and industries where the aim is primarily to learn from international best practice through acquisition of technological competence.***

- ***NSTIs aimed at enhancing human resource development, education and 'learning' more generally, are a key to assimilating technological knowledge.***

6. **NSTIs in South East Asia are closely tied to national goals, particularly those for industrial and social development.**

A common means of articulating the connection between S&T initiatives and national goals is a national 'vision' document, 'S&T plan', set of 'priorities' or 'White Paper' that sets a course for S&T development. Such papers are often connected to broader socio-economic planning documents like 5-year national or economic plans. These have been an important instrument for many states (notably Singapore, Japan, Malaysia and Taiwan) in debating and selecting NSTIs. Several analysts make that point that, to some extent, S&T opportunities are 'created' rather than simply identified, and such a high profile national plan encourages a national will or climate for S&T development.

Formulating such plans requires appropriate planning, advisory and evaluative organisations or structures such as S&T Councils, or Government-Industry Technology forums. New organisations may be required for advice, consultation or implementation: an Academy of Science in Malaysia, or cooperative research centres in Australia, Japan and other countries, for example. Implementation of national plans also requires appropriate benchmarks or statistical indicators to track progress towards goals. Many of the South East Asian countries have initiated systems to collect and analyse S&T, innovation and human resource indicators, and other data on the national innovation system.

- ***National plans and visions, organisational arrangements and appropriate data on the S&T system are required to support the successful selection and implementation of specific S&T initiatives.***

7. **Many South and East Asian countries have pursued critical generic technologies or industries, usually explicitly.**

Overwhelmingly, countries have targeted technologies in advanced manufacturing (usually the so-called medium-high or high technology industries, as defined by the OECD), most notably in microelectronics, industrial materials and the biomedical sector. Biotechnologies related to food production or processing or natural resources, environmental technologies, defence and energy technologies are also nominated by countries in the region. Clearly, industries like microelectronics have quite a different structure and dynamic than petrochemicals, pharmaceuticals or environmental remediation.

Much of the analytical work on East Asian NSTIs has been on the electronics industry, and analysts caution about extrapolating this experience to other technology sectors.

While there are certainly differences in the types of 'vertical' NSTIs applied to particular industries or technologies, the variations appear as much a response to national institutional circumstances as to inherent differences in the requirements of particular technologies. The more 'process industry' and 'science based' technology may be less open to simple imitation than, for example, microelectronic product technologies. In terms of the regulatory and intellectual property environment, there are however very significantly different requirements, say for biotechnology than for information and materials technology (Bhaghavan, 1998).

- ***The 'global context' means that international techno-industrial structure must be taken into consideration in formulating national S&T policies in particular technology areas.***

- ***For 'vertical' NSTIs relevant specifically to the chemicals and heavy industries, the early stage of post-war industrialisation in Japan, and more recently, Korea (petrochemicals, steel and synthetic fibres) provide examples.***

- ***Useful example of NSTIs for the mineral resources, energy and agricultural industries may come from Australia, and for nuclear energy technology from Japan.***

8. South and East Asian countries have taken widely differing approaches to technology upgrading within locally owned SMEs.

The lesson of East Asia is that there can be no single 'correct' solution to NSTIs that promote technology development within industry, even when the objective is similar. Take for example the growth of the microelectronics industry in Taiwan (supporting local SMEs), Korea (focused on local large firms) and Singapore (directed at enticing MNCs to locate in the country). Each of these strategies envisaged a different role and development path for SMEs. Small companies certainly have been targeted by many NSTIs, including financial incentives for R&D, technology upgrading and export oriented production, training and technical support. It is also crucial to examine the impact of other NSTIs on SMEs, even when the small companies are not the main focus of the initiative. For example, policies requiring research institutions to obtain funding from industry may lead to SMEs being 'squeezed out' from technical advice and knowledge, in favour of larger companies.

- ***Taiwan provides an excellent example of an integrated approach to promoting innovation within SMEs in the microelectronics industry, and indeed using local SMEs as the vanguard of industrial technology development; Malaysia is encouraging local multimedia services companies by co-location with major international players***

- ***An 'SME impact statement' could be considered as part of the implementation of all NSTIs.***

9. Science Parks and other 'property-based' NSTIs are widely used in the region, with a range of different objectives and outcomes.

What emerges from the critical literature on 'property-based' NSTIs is a healthy scepticism about their effectiveness, or at least their *cost effectiveness*, by comparison with a range of alternative, non-property-based initiatives such as R&D incentives, virtual cooperative centres and other collaborative S&T arrangements.

> There are now S&T parks in many countries and it is increasingly being accepted that, in themselves, they will not provide a quick, simple or cheap way of promoting technology development in a region. ... As with TBIs, final assessment of the success of S&T parks as an economic development measure will take time (Macdonald and Joseph, 1995, Appendix B: 11)

It may be equally or more feasible to offer technology support services to companies in other ways, such as through extension networks or consultants. Science cities, and the larger S&T parks, may be undertaken for genuine reasons of national prestige or visibility, as much as for a real requirement to co-locate S&T activities.

Certainly there have been notable successes, with Taiwan's Hsinchu Science-Based Industry Park and Japan's Tsukuba and Kansai S&T cities commonly lauded. But, S&T parks may risk becoming 'science ghettoes' with inadequate connection to the broader innovation system. In relation to Korea's Taedok Science Town, Linsu Kim (1997:49) for example, comments:

> Despite almost 20 years of existence, it has neither built a reputation for attracting world-class scientists, as Tsukuba has in Japan, nor become a bustling industrial park with technology-based SMEs that have large shares of world markets for personal computers and peripherals, as Hsinchu has in Taiwan.

- ***Technology incubators are a universal and relatively low cost means to provide business and technology support particularly for SMEs and for start-up high tech companies in manufacturing or services. They can be very effective if properly run, especially if business support facilities (like telecommunications or technical services) elsewhere in the country are poor.***

- *The experience with S&T parks has been mixed, perhaps reflecting their diverse objectives. They certainly require top class research institutions and universities as a core, and a long-term budgetary commitment. Taiwan provides an example where S&T parks have returned profits for investment in new parks.*

- *Technology corridors/zones and cities are clearly a major national undertaking, and require the strongest commitment and support from central and local government, domestic companies, communities and, often, international business.*

- *All 'property-based' NSTIs must be integrated with other supporting measures such as financial incentives for R&D, S&T infrastructure and leading research and training institutes etc.*

10. Successful NSTIs require adequate resources, and effective management and implementation

It is difficult to make general observations about the resources required for particular NSTIs - some examples are given in the paper. Obviously NSTIs vary enormously in scale and the investment required. Some are 'one-off' budget commitments, but usually there is a requirement for continued public funding. Increasingly the larger NSTIs (particularly large facilities or technology zones/cities) are designed from the outset with a combination of government and private funding in mind - not only to defray the cost on the public purse, but also to cement cross-sectoral commitment and cooperation. Increasingly, for the same reason, governments have required their S&T agencies to seek commercial contracts from industry and other users. Some governments have experienced problems with 'open-ended' 'horizontal' NSTIs, notably tax concessions for R&D that are available for all eligible companies, since it is impossible to predict the demand for the concession and therefore its cost.

NSTIs do not automatically 'take root'. They are applied through existing or new institutions and organisations in the particular country. Some of the most important NSTIs are aimed at mediating this application. For example, the removal of impediments to cooperation within Japanese universities, or the restructuring of government research and technology organisations in Australia and Malaysia. While implementation issues vary with particular NSTIs, clarity of goals/objectives, transparency of criteria for selection of participants, explicit monitoring and evaluation criteria, and a management structure that supports all of these are obviously critical. For broader initiatives, consultation and recruitment of 'stakeholders' could be added to this list.

Lastly, but extremely importantly, a crucial impediment to the successful implementation of many S&T initiatives in the NIEs of South East Asia has been the shortage of skilled people. Lacked of a skilled work force, for example, has caused India's information technology development zone to relocate.

- *NSTIs differ little from other public or commercial projects in their resource and management success factors. They all require clear objectives, adequate financial and human resources, sound management and monitoring and assessment. Lack of any of these has led to NSTIs failing to achieve their objectives.*

- *NSTIs aimed at human resource development have been critical in the developing phase of all the countries in the region.*

11. International cooperation in S&T is limited but growing in the South and East Asian region.

There is evidence of expanding international collaboration around particular S&T initiatives. National and regional 'technology foresight' and other activities are starting to occur around such issues of regional concern such as megacities, disaster prevention and water quality. Japan is promoting international

collaboration in its basic research activities. There is also cooperation on cross-border industrial zones, for example between Malaysia, Singapore and Indonesia.

Multilateral organisations such as APEC and ASEAN are involved in programs on the social and environmental application of research and human resource and other policy issues. With UNESCO/STEPAN they also provide a sharing of experience with S&T policies and initiatives. It is also important to remember that MNCs are an important medium for the transnational transfer of technology and skills within in the region.

- ***We do not see in Asia the level of collaboration in generic industrial technologies that apparently occurs, for example, in the European Union.***