Managing Technological Transformation in the Developing Countries: Lessons from East Asia and Challenges from the Uruguay Round

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ABSTRACT

MANAGING TECHNOLOGICAL TRANSFORMATION IN THE DEVELOPING COUNTRIES: LESSONS FROM EAST ASIA AND CHALLENGES FROM THE URUGUAY ROUND

Is convergence in the technological distance between nations possible? This has been one of the defining questions in the economics literature over the past few decades. Scholars and practitioners alike have explored and analysed this question through elaborate firm and industry based empirical analysis of sectors in both the economies of the North and South. They have come to the unanimous conclusion that such a convergence is possible, under certain circumstances and utilising certain strategies. Although such a consensus does exist, however, it is also recognised that the likelihood that such convergence in technological capacities can take place at all is a function of the degree to which a nation has an elaborate and well planned science and technology (S&T) policy/plan in place. In fact, the industrialisation experiences of East Asia have reinforced and complimented such arguments

However, history has shown us that such an S&T policy framework has been seriously under-prioritised in the South countries. There are several reasons for this, the most important of which is the lack of understanding amongst policy-makers in the South of the significant importance of S&T in a nation's development. While many nations of the South, that have given little priority to S&T, struggle to grapple with the various development obstacles they face, we find that countries that have prioritised S&T have a consistent record of achieving high growth rates in a relatively short period of time. Again the industrialisation experiences of East Asia are salient here and would appear to reinforce this statement. This thesis attempts to examine how nations can plan for their technological transformation using an S&T policy framework. We accomplish this by examining the strategies South countries can employ to master the transferred technology, and progressively build industry competitiveness at an international scale as a result of those strategies. The analysis pays particular attention to what we can learn in this regard, from the experiences of East Asian countries, specifically, Japan and Korea. In drawing lessons from these growth experiences, attempts are made to extract best-practice strategies for S&T planning in the South.

However, while the thesis advances the role of S&T in the South's development, it argues that significant obstacles threaten the degree to which certain strategies in an S&T policy can be implemented in a South country. These obstacles are associated with the international trading environment. Of particular interest to us, in this regard, is the effect of the most recently completed round of multilateral negotiations - the Uruguay Round (UR) - conducted under the purview of the General Agreement on Tariffs and Trade (GATT). The thesis seeks to identify the implications of this Round for effective S&T planning strategies and their implementation in the South. We will establish whether S&T planning strategies that can be pursued by the South countries, will be at all undermined as a result of this Round of negotiations - and if so, how and in what ways? If it is the case that the Round places new restrictions on the access to and use of technologies by South countries and undermines their ability to implement such S&T strategies and industrialisation paths employed by certain countries in the past - particularly in East Asia - the thesis will highlight the limited role the East Asian growth experience has for the South countries.

In dealing with these issues and questions, the thesis attempts to contribute to the on-going development debates on S&T, the international trading environment, the dynamics of the international political economy (IPE), and its effects on the technological transformation and industrialisation of the South. On the other hand, this thesis was prepared in the hope that it might encourage debate in this direction and deal with the central questions it poses in a substantive manner offering, above all else, policy recommendations and guidelines for an S&T effort in South countries. By giving further attention to the challenges to the South as regards its attempts to plan for its technological transformation, we hope to further an understanding of the critical role of and limits to S&T policy planning in the developing countries.

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"Hardly anyone today fails to recognise the importance of the impact of both technology choice and technology change on growth as well as on the employment and income distribution and other important dimensions of development. Both the academic and policy-making world recognise the wide range of options faced by entrepreneurs, public and private, in the third world with respect to both the static process and product attribute choices as well as the dynamic direction for technology change, i.e., the alteration of existing choices in both the process and product dimensions. The recognition of the overwhelming importance of this dimension of development relative to the more conventional inputs of capital, labour and land renders science and technology policy a most vital area for further research as well as action"

(Evenson and Ranis, 1990: 1)

Chapter 1 - INTRODUCTION

1.1 Statement of the Problem

Technology, and issues related to it, have remained a focal point in the majority of the economics literature since the seminal writings of Schumpeter. This is largely because of the revolutionary impact of technology on the economic/commercial systems of a nation. Hence, the manner in which technologies influence the behaviour of firms and whole industries and hence, the economic growth of a nation, are diverse and complex. No wonder, then, technology and issues surrounding it have been described as complex phenomena that have an immense impact on the structural transformation of products, production processes, industries and whole economies. Indeed, it is precisely for this reason that various scholars writing on technology have focused on its complexity, interpreting "technological phenomena as events transpiring inside a *Black Box*" (Rosenberg, 1982: 29).

This perception of technology operating within a Black Box has been perpetuated by the complexity and revolutionary impact of the concept on the economic and technological capacities of a nation. Kuhn (1962), in his monumental and inherently pedagogic work, attempted to prove that science and the accumulation of knowledge revolutionises a nation's development and economic growth. Technology to him had infinite possibilities within the context of the transformation of a nation. He argued this because technology fundamentally impacts and structurally alters both economy and society. In fact, in reviewing Karl Marx's work on historical materialism, evidenced in his *Communist Manifesto* (1967), but more so in *Capital (Vol.1)* (1952), it would appear

Marx viewed a nation's social system to be a function of its technological system. Not surprising then, Rosenberg interprets Marx's *Capital* as implying that technology is at the root of those activities that are inherently and distinctly human. Hence, the Black Box, in this context, is representative of the complexities of technology that when utilised, has a myriad of effects that influence (and ultimately alter) the political, economic, social and cultural strata of a nation.

According to the National Science Foundation (NSF), the "advancement in science and technology is a key element of national economic success. [It is]...investments in research and development (R&D) that tend to be the strongest and most consistent positive influence on productivity growth", because of its creation of national technology capacities that enable a nation to compete globally and hence, secure new markets (NSF/OSTP, 1993: 5). It is because of this recognition that leading industrial powers have historically restricted access to and use of these technologies, by South[1] countries, through an intellectual property (IP) framework developed in its modern form in 1883 with the creation of the Paris Convention. Recent developments in the international trading system have made it increasingly more difficult for South countries to pursue their technological transformation efforts in an effective and unfettered manner.

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[1]In reference to the South we speak only of the least developed countries (LDCs) and middle-income countries. We leave out any specific reference to what have been called the semi-industrialized or advanced developing countries, in this context. This conceptual clarification is critical as we make reference several times over to the *South*. Such reference to the South should be interpreted as only making reference to the LDCs and middle-income countries, despite the fact that we refer to them collectively as the South - for the sake of convenience.

The South, therefore, is being denied what mankind as a whole has enjoyed for centuries - enjoying the fruits of innovation. Upon reflection, we know that the history of the human race has been peppered by, and indeed can be described as, a quest for innovation. Since the dawn of time, man has struggled to develop, both himself and the choices available to him, by increasing the *means* by which he could do so. Irrespective of whether man stumbled across fire by chance, or intentionally revolutionised productive forces by the invention of the steam engine, he has, in the process, altered his way of thinking. Creativity, an obsession with the unknown - a drive to do things better, more efficiently, is the kind of thinking that heralded the industrial revolution however, it is also the kind of thinking that heralded slavery, and in most recent history, nuclear weapons. Hence, while inventions have expanded our horizons, providing us with infinite opportunities and possibilities, they also threaten the moral fabric and sanctity of humanity. This propensity for innovation and the application of knowledge to increase our choices for personal and national development, and yet also end our very existence, is indicative of a dialectic that is inherent in technology. Innovations have led in one form or another to revolutions in productive, social and economic forces; and most importantly, as mentioned above, in modes of thinking. As a result of these revolutions, the world has witnessed the institutionalisation of the spin-offs from productive forces, such as the steam engine - for example, textiles, diesel and train engines, refining processes, etc., into developmental and economic systems. It is these very innovations that have, in turn, paved the way for two remarkable trends, especially in regards to the application of technical knowledge. First, the spectacular developments in sophisticated technologies, *de novo*, associated with information technologies (IT), micro-electronics, recombinant DNA, revolutions in bio-technologies, etc., and secondly, a significant reduction in the interval or period of time between technological innovation.

However, we must recognise in this discussion that technology and ideas surrounding its critical importance to the growth and wealth of nations, through its applications in production systems, has been an institutionalised component representing how mankind views the development of a nation and the broadening of his/her choices in this respect. Indeed, the institutionalisation of social and economic ideas/concepts have taken place throughout history, for example, with the publishing of Adam Smith's *Nature, Causes and Inquiry into the Wealth of Nations* (1976), the independence of America, the rejection of *tier etates* (third estate) in France, the writings of Voltaire, Rousseau, etc., all contributed to the establishment of social and economic systems. However, it is radical advances in technologies that made these systems sustainable in the first place. The broadening of horizons that technology has afforded mankind is in itself an indication of the revolutions in and institutionalisation of, ideas and concepts regarding how man would live in an economic sense, but also in a political sense. In this regard, we speak to the issue of the revolutionary ideas/concepts surrounding democracy, in its most recognised form in modern history, as it appeared in the French Revolution, that argued *liberty*, *equality* and *fraternity*. Hence, it was humanity's drive in supporting processes of social change and self reliance, self sustainability, expanding his capacities, that led to the remarkable developments in human kind's history. Development then, as a concept, is not new to humankind . It is what makes humanity what it is today. More importantly, in the sphere of revolution, it is ideational concepts associated with technology that have facilitated for revolutions in our productive and economic systems, and the birth of theories and paradigms to account for those changes.

We can decipher from this account that it is revolutions throughout humankind's history, although they came from radical changes in thinking/ideas, that had two results that often complement each other. Specifically, they resulted in revolutions/innovations in productive and economic capacities, as they relate to technological changes in the application of knowledge and, secondly, revolutions in *ideas* that relate to how mankind would live. More importantly, how much control he/she would have over his/her own life, as that degree of control would naturally dictate his access to and use of technologies for his/her own benefit. Ultimately we speak here of individual freedoms, both over oneself, to do as he/she may within the confines of the rule of law and equal (or opportunity for) access to the technology of productive systems. It is to the latter concept, technological innovation/transformation, that this thesis places particular emphasis on, steering away from an examination of the former concept of democracy.

Governments of the North have linked their past, present, and future economic prosperity to an active, premeditated and in varying degrees - from country to country, proactive, S&T policy. The global race for technological supremacy is more than ever very much evident on a global scale. In fact, the birth of the World Trade Organisation (WTO) from the Uruguay Round is a testament to the importance of technology in the IPE at the close of the century. But, it is also evident that in this age of globalization and the fierce competition for global markets, new technologies and the building of national technology capacities are the ingredients providing countries of the North the edge they need to remain competitive in this global economy. As yet, though, the role of the South in this age of globalization, and even within the Black Box, is still unclear. However, it is becoming evident that the South is being left on the fringes of the process of globalization. It is a region increasingly being left behind because it has been struggling to develop its technological capabilities. This struggle is in large part a manifestation and reflection of what is increasingly becoming its failure to effectively contend with and address the larger issues of development. However, it is also a reflection of the increasing pressures and obstacles the South must now face as a result of exogenous or supranational actors such as the WTO, that with various Agreements of the UR, will inevitably make it that much harder for the South to attain high levels of economic growth and technological transformation. In an age where the South can ill afford to remain in the depths of underdevelopment and poverty, we are finding that the majority of the South, save for a few countries like the newly industrialising countries (NICs), have *not* been able to effectively deal with the problems and issues of underdevelopment and development, in large part, through no fault of their own.[2]

The capacity of South countries to plan for their technological transformation is under threat from the international trading system. While the recent formation of the

[2]It is important to highlight that exogenous actors and institutions share a disproportionate amount of the blame for relegating much of the South to an existence of misery and poverty. After all, the extent to which the South can have any sustained, long-term development is dependent on conditions in the international political economy (IPE), which, for a variety of complex reasons, have not been made available to reinforce or support the South's development aspirations.

WTO has the mandate to restructure the global system of trade, production, and the international division of labour, it also substantially weakens the South's ability to engage in S&T building strategies that many of the now industrialised and NICs employed for generations. However, the dynamic of this 'game' is not new. Consider that historically, one part of the globe has successfully extended its hegemony over entire peoples, cultures, societies and nations. The North, first through colonialism, took from the South its resources, and then through the exercise of neo-colonialism, has denied the South the tools to develop effectively. In its most recognised form, this systematic effort to deny the South the tools of development is action to deny a people the very source upon which productive economic capacity is dependent - technology. It is the life blood of a productive system that enables it to become more sophisticated, and enables an economy to become more competitive. It is perhaps no coincidence that technology proliferated throughout the North totally oblivious of IP regimes during and shortly after the Industrial Revolution, the same cannot be said to have happened or to even be currently occurring in the South.[3] All countries in the North have historically had access to technology. The South has been subject though, to an entirely different set of rules, in that while science has remained relatively free for this region, technology has been

[3] This statement must ofcourse be qualified, for while technologies did proliferate through the societies of the North in the nineteenth century and early twentieth century the process was not as unfettered as we are describing it to have been. There was heated economic and technological competition between Germany and Britain in the last century and yes, New Zealand and Australia did experience some difficulty in the acquisition of modern technology; however, South countries aspiring to industrialise in this century are experiencing significantly more impediments to acquiring technologies necessary to do so, than did these North countries, because of increasingly more stringent international IP regimes.

commodified and access to it severely restricted in the South, principally because of the terms on and methods by which technology is transferred. The system of transfer fosters dependence and the international regime governing IP strictly limits the ways in which it can be used in South countries, necessarily influencing the success to which those countries can maximise their gains from the utilisation of Western technologies.

The success of East Asia, however, brings hope to what has historically been an international economic/trading system that has rarely worked for the South. What is striking about the success of the East Asian growth dynamic though, is that it directly contradicts the central prescriptions of the Capitalist system as we know it, yet it has enabled the East Asians to achieve a level of growth that the North took twice as long to achieve. These nations' growth experiences provide important lessons for the South's development. However, East Asia aside, what can be said about the technological capabilities of other South countries? The mal- and under-development that many South countries are subject to is rather telling of what increasingly appears to be the low priority given to indigenous or local technological capability building in South countries. Even in countries where indigenous S&T capability building efforts have been pursued, the results have not been encouraging. Efforts to develop such capacities in the areas of R&D, adaptation, and diffusion of S&T have been few and far between in many countries in sub-Saharan Africa and to a lessor extent, Asia and Latin America because of the lack of development of national S&T policies, plans and institutions. Many South nations are in search of an S&T policy; while some have made policy statements in this regard, especially in response to the 1979 UN Conference on Science, Technology and

Development, which solicited countries to provide S&T plans to the conference, most South countries have not made any substantial advances in developing these statements into action. This in part is a result of the fact that although some governments may be aware of the role of S&T in industrialisation, such a realisation has limited effects, as such nations lack the necessary private sector and academic participation and capacity to construct and implement such plans in the first place.

Hence, the extent to which a South government can successfully promote and develop such a plan is limited because of the lack of consensus or networks amongst parties involved as to how to cooperate in developing such a plan. Therefore, while the political will may exist to develop such a plan, no such will is evident amongst businessmen or entrepreneurs, the scientific community, etc. By the same token the reverse is also the case in some countries, i.e. the private sector and universities may have the will to pursue an S&T effort, but government has neither the inclination or resources to operationalize such a plan. However, this account is not representative of the situation all South countries may find themselves in with regards to S&T. Generally, the state of S&T in South countries is very heterogeneous. Typically, though, there are three situations or categories that most South countries tend to find themselves in regarding S&T.

The first category comprises of South countries that have a few patents and a limited capital goods sector. These countries often have an S&T infrastructure in place, however, it is in search of an S&T policy.[4] This lack of a well established and implemented S&T policy has resulted in the disjointed nature of the S&T infrastructure, especially as regards R&D efforts/programs. Therefore, research activities are conducted on a modest level with limited commercial application. Typically, the nation's Academy of Science or Ministry of Science and Technology will oversee and administer institutes conducting such research and scientific documentation centres that are depositories for national and international research findings. However, because of the lack of an S&T plan such research often cannot be linked to the commercial sector or, in the odd case that it does contribute to industry, it does so in an ineffective or at best modest fashion. These countries typically are well endowed with a pool of scientists, engineers and technicians - who are graduates from universities, technical, vocational and engineering colleges/polytechnics; however, they may be unable to find work in companies or industry. This will often occur because of the lack of cooperation, communication or networking between universities, institutes and industry.

The second group of countries typically will have highly fragmented, scattered or uncoordinated research efforts. Instead of working together and cooperating in their use of scarce resources, the public, private and university sectors will compete for the use of those resources. In addition, where countries in the first sector have a relatively developed and scientifically based education system in place, this category of countries typically under-funds the social sector/services, especially education and health.

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[4]There are some exceptions though as in some cases a handful of countries have incipient S&T policies.

Therefore, these countries remain highly dependant on foreign experts from technology supplying transnational corporations (TNCs) to train local scientists and engineers (as a substantial portion of the technology transfer package). In fact, because of the chronic lack of a pool of scientists and engineers, incentive programs are often in place for repatriating nationals who graduate from universities overseas to create a critical mass (which is lacking) in the stock of scientists, engineers and technicians in what institutes, research centres and other similar infrastructure that does exist. However, any such S&T infrastructure will typically be old, in a state of decay and in need of upgrading/repair.

The third category of countries have very little to no science and engineering research effort. If any research is being conducted in the country, it is externally funded by foreign actors, resources and personnel. These countries have a very limited number of local scientists and engineers (especially with PhD training in the hard sciences). S&T institutions are highly fragmented and S&T policies/plans are non-existent. The country typically lacks indigenous modern technology because of the absence of any co-ordinated research effort, and is highly dependent on traditional technologies. Consequently, almost all the technology requirements of the country come from abroad to provide industry mass-production capacity. Often the industrial sector/industry in place is just emerging in what are highly agriculturally dependent economies hence, issues of appropriateness of transferred technologies is constantly an issue because of the relatively underdeveloped nature of the manufacturing industry. Because these countries fall into the category of least developed countries (LDCs) they are typically recipients of structural adjustment programs (SAPs), and so lack the necessary resources to fund primary and secondary education, let alone their tertiary education capacities. Compounding the under-investment in the social sector is the fact that much of the earnings (that come from agricultural and raw material/mineral exports) have to be directed to servicing debt obligations of these countries to various international financial institutions (IFIs). Consequently, the population in general rarely have but a few years of primary education, this is especially the case in the rural areas, because of the lack of monetary resources to be directed at the social sectors, industry and basic infrastructure, e.g. roads, telecommunications, etc. Typically, very little to no understanding exists amongst policy-makers in planning agencies and ministries about the value of S&T, save for a superficial recognition of its importance. As a result government rarely if ever, promotes fiscal incentives for industries to engage in R&D or to even develop intra-firm R&D institutes. Generally, these countries, because of their unstable political and economic environment, are victims of massive brain drain, a chronic lack of foreign investment and basic infrastructure from schools to hospitals, so critical to a development effort at large.

Common to all the countries in these three categories, excluding the NICs of East Asia and Latin America, is that they lack explicit, well developed or defined S&T policies.[5] This is the common link amongst such countries that proves to be a significant obstacle that stands in the way of them achieving their development goals. That said,

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[5]The above three categories are meant to be representative of LDC and middle-income countries and not the NICs of East Asia and Latin America. Typically, these NICs have a well identified and developed S&T plan that are an integral and comprehensive part of their five year plans.

these countries have had a wide range of experiences with and approaches to S&T. However, the fact that an S&T plan remains absent from the development planning framework of these countries is cause for concern. Rather than ask why this is the case, as this has been much talked about by authors concerned with issues of governance, democracy, etc., the thesis seeks to examine what strategies must be taken to reverse this state of affairs and develop this much needed S&T planning framework.

The thesis acknowledges that technological transformation is occurring in the South. However, it is not occurring fast and dynamically enough. The extent to which this transformation changes the structural dynamics of South country economies or contributes in a significant fashion to economic growth, though, is very much dependent on the access these countries are given to the tools needed for technological transformation. The lack of development of an S&T infrastructure and policy framework, as well as the nature of the IP system and regime of international trade, however, will continue to be obstacles to the South's access to those tools. It has long been accepted that the extent to which the South will have access to those tools is very much a function of the degree to which the North is committed to providing an enabling international economic environment for the South to continue on its path to development/industrialisation. History has shown, however, that such commitment is not evident amongst leaders of the North largely because the interests of their countries and their TNCs are at odds with those of South countries. This is regrettable, as it is widely acknowledged that there can be no success in the collective development of the South to the extent that the North does not have the collective will to see the South truly develop.

Inevitably then, the extent to which the rapid technological transformation of the South can at all be realised into the next millennia, will largely be a function not just of the attention given to S&T in the South, but also the help the South receives from the North in strengthening and building capacities in this area.

1.2 Objective of the Study

This thesis supports the view that an S&T plan is critical for the sustained economic and technological transformation of a nation. However, this is not at issue in the thesis, as it is the subject of an extensive literature that does not need to be reconsidered here. Aside from an initial explicit statement that such a policy is critical to the growth of a nation, the thesis attempts to develop a theory or general guidelines for technical change in the developing countries. We devise and articulate a framework that links the various general guidelines/strategies for and dynamics of S&T capability building in the South countries. There is a need for such a study as it is commonly recognised that an appreciation of S&T capability building is only evident amongst policy-makers and planners in North countries and a handful of South countries (the so called NICs). This statement must of course be qualified as some of the countries in the South do indeed have quite an elaborate S&T infrastructure.[6]

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[6]Egypt and Kenya, for instance, were among the first African countries to develop explicit technology policies after independence. South Africa, though, has had a consistent record of planning for S&T. In the1980s, for example, the country had over 10 000 full-time researchers -more than the number of researchers in North and sub-Saharan Africa. In addition the Council for Industrial and Scientific Research (which is at the heart of the nation's S&T policy) actively promotes S&T policy in the country and has

Nevertheless, policy-makers in South countries, despite the voluminous evidence supporting the role of S&T in industrialisation, have failed to understand the link between technological advancement and industrialisation or economic growth. Furthermore, they lack an understanding of how dynamic industry can be developed and what technological requirements are involved or necessary for this to come about. This failure to recognise and appreciate the importance of S&T in the economic maturation of a nation, by many Southern governments, has translated into an absence of any clear strategy as to how to go about promoting capacity building efforts in the area of S&T and industrialisation in general.[7] Some South country apologists may not agree with such an assessment though. Typically, they would argue that evidence of S&T capability building is apparent even in middle-income countries. However, evidence for them typically refers to various commitments that Southern policy-makers have made to S&T, such as those found in the Lagos Plan of Action. Regrettably such commitment (on paper) has rarely translated into action. Even in cases where policy-makers in the South may claim to understand the role of S&T in industrialisation, whether they understand the complexities of the process of linking scientific research through technology to the commercial efforts of firms/industries is less clear.

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been well recognized for creating a conducive environment for billions of dollars in spending a year in public as well as private sector R&D (Segal, 1984).

[7] Interview with Dr. habil D. Pilari, Division for Sustainable Development, Department for Policy Coordination and Sustainable Development, United Nations, New York, July 8, 1997, 4:00-5:30.

Consequently, the thesis seeks to present a strategy that South countries (especially middle-income and LDCs) can employ to secure and ensure their sustained economic and technological transformation into the next millennia. Such an exercise in technology policy planning must target three areas: i.) human capital (or social technology) capacities; ii.) physical capital (technology) capacities; iii.) economic/trade policy regimes that will facilitate or provide an enabling environment for and especially reinforce the effective implementation of the prior two policies. In this regard the experiences of East Asia in their industrialisation effort is especially valuable to the South and provides important lessons to the South's current and future S&T efforts. However, having argued for such a technology policy and examined or captured the dynamics of such a policy, the thesis poses the question - can such S&T capacity building efforts be implementable or at all usable in the 1990s? Such a question is posed as the new realities of the international economic environment of the 1990s, especially in the wake of the recently negotiated UR, has substantially undermined the South's ability to utilise S&T strategies that have been aggressively and successfully employed in East Asia over a very short period of time. The UR significantly changes the dynamics of how a technology policy must be formulated in South countries and the extent to which such countries can not only learn from the experiences of East Asian NICs, but actually replicate such industrialisation strategies, evident in the 'flying geese' paradigm.

We will attempt to explain why this is necessarily the case. First, by analysing and appraising specific agreements within the UR (such as the so called 'new areas', i.e. the Agreement on Trade Related Aspects of Intellectual Property Rights - TRIPS, the

Agreement on Trade Related Investment Measures - TRIMS, the Agreement on Textiles and Clothing - ATC, the Agreement on Agriculture and the General Agreement on Trade in Services - GATS) with the intention of establishing in what ways this round is an impediment to or accelerator of the South's ability or capacity to technologically transform. And secondly, we examine how and why this is necessarily the case and what must be done to respond to this. Implicit to this assessment is the assertion that the UR not only has important implications for the South's capacity to advance its technological transformation objectives, but also has an impact on the nature of the South's technological trajectory, the pace of its economic growth and its access to technologies over the next few decades.

So, on the one hand, there is a need for such a study because the understanding (especially amongst technology policy-makers in the South) of the processes of technological development is still rather vague and incomplete. This lack of understanding of the important aspects of S&T in developing countries is reflected in the absence of any clearly articulated S&T policy in the region. But also by the fact that the micro-, meso- and macro-economic policy regimes in many of these countries are not complimentary to or reinforcing of efforts to build the nation's S&T capacities. Secondly, to the extent that the UR and more especially the GATT/WTO is a watershed in international trade and global affairs, most importantly North-South relations, it is important to examine and articulate how such events have and will impact South countries. This thesis, as a result, is a contribution to the literature on such themes as it continues in the tradition of investigating how negotiated understandings like the UR will impact the nature, pace and spread of technological and economic transformation in the developing nations in the coming decades.

1.3 Thesis Statement

In addressing the issues stated above the thesis attempts to advance three arguments. The first argument maintains that it is critical that a comprehensive S&T strategy and policy framework be in place in South countries in order to secure the sustained and dynamic structural transformation of the developing countrys' technological capacities and economic growth. The thesis identifies what these strategies are and examines how they can contribute to a dynamic S&T effort. Secondly, it is argued that there are extensive lessons that can be learnt by South countries from the East Asian experience in employing S&T strategies in its bid to industrialise. The thesis not only identifies what these policy lessons are but also how and why they are important to the South and how they can be operationalized in the South. Thirdly, it is argued that there are significant impediments to the effective formulation and implementation of an S&T effort in the South countries. The greatest obstacle is the recently negotiated UR. The thesis will indicate why this is the case by engaging in a detailed analysis of five agreements in the Round and highlight why they necessarily restrict and impede on the South's ability to effectively plan for its technological transformation.

These three arguments seek to identify how an S&T policy framework can be operationalized in the South and indicate how and why the UR threatens the efficacy and capacity of South countries to operationalize such a policy framework. Such an analysis is of critical importance if we are to understand how the dynamics of international economic/trade system have such a profound effect and influence over how nations develop, under what conditions they develop and the success of their development efforts.

1.4. Structure of the Thesis Argument

These chapters are ordered and structured in such a fashion as to provide a logical succession of ideas, themes and issues surrounding the three arguments upon which the thesis is based. Each chapter provides the groundwork for the subsequent chapter, such that there is a natural progression of ideas and arguments throughout the entire text of the thesis.

Chapter 1 offers a conceptual introduction to the issues and themes dealt with in the body of the thesis. It provides an important introductory and background analysis into the themes considered in the arguments of the thesis. The chapter also reviews the objectives, thesis statement and methodology employed in research for the thesis.

Chapter 2 comprises a literature review. The review first considers some of the important themes connected to the literature on technology, and then examines the various definitions of technology. The purpose of the first part of this account is to familiarise the reader with the debates and controversies surrounding technology. The purpose of the second account is to identify the complexity of technology by highlighting the variety of definitions that have been applied to it over the course of the evolution of the literature on technology. The chapter then engages in a modular analysis of the role of technology in economic growth. The modular analysis serves two purposes. First, it attempts to empirically and mathematically argue the essential and critical role of technology in economic growth in such a fashion that there can be no doubt about technology's role in economic growth, and also, to reinforce why we are advancing the role and importance of technological transformation in the process of economic growth at all. Secondly, it attempts to lay the groundwork for the subsequent review of literature on the various theories that have accounted for technology's role in economic growth. By engaging in further analysis into an account of the evolution of the literature on technology and its connection to economic growth, the chapter has been written with the expectation that it will provide important theoretical and modular insight into the critical role of technology in economic growth and hence, set the stage for upcoming discussions on this theme.

This chapter is meant to reinforce the first argument of the thesis discussed in Chapter 3. Specifically, while the argument maintains the importance of building technological capacities to secure economic growth, it does so on the premise that we will have established why and under what circumstances technology is able to do so in the first place - in Chapter 2. By engaging in a modular analysis of the role of technology in economic growth we establish (on a theoretical level) why technology - and specifically technological transformation - is such an important component of economic growth. By engaging in a literature review, especially on the evolution of thought and scholarly work on technology - and its role as the *residual* - in economic growth, as considered by two very important schools - the endogenous and neo-classical growth schools, we attempt to further establish the premise for the first argument of the thesis. Specifically, in reviewing the various interpretations of the *residual* as they have evolved over the decades, we attempt to establish the important contributions of various theorists to providing an insight into the role of technology in economic growth and why it has become so fashionable to associate sustained economic growth with the pursuit of an S&T effort that aims at increasing the scope and role of technological transformation in the overall structural transformation of a nation.

Chapter 3 engages in a theoretical analysis of S&T planning, and then proceeds to engage in an analysis of how S&T capacities can be built in South countries. Specific attention is given to the role of technology transfer, technology assimilation techniques and indigenous R&D efforts in such an effort. The analysis draws on the experiences of East Asia, particularly the Republic of Korea. In looking at East Asian experiences in this regard, we focus attention on the critical role savings and investment policies, as well as selective infant industry protection, have as important supportive policy regimes of an S&T effort. This chapter builds on chapter 2 in that having acknowledged the role of technology in economic growth, we now have the opportunity to review the specific characteristics of an S&T policy framework and how it (once being operationalized) can be applied to a nation's bid to technologically transform. By reviewing specific techniques inherent in an S&T effort, as well as supportive economic policy regimes, we are able to set the stage for a very detailed analysis of East Asia's experiences in operationalizing such an effort and drawing lessons from this experience for the South.

Chapter 4 offers a detailed analysis of Japan's and Korea's S&T capacity building efforts. The chapter examines the institutions and policies that were a part of this effort and implicitly and explicitly hints to how South countries can learn from such strategies. This chapter attempts to build on the previous chapter's more theoretically oriented discussion of the features of an S&T policy framework by presenting the actual experiences of East Asia in this regard. So, having understood the theoretical aspects of an S&T effort, we are prepared to examine the important practical experiences of countries (selected from East Asia) in this regard. To accomplish this, specific attention is given to the policies, actors and institutions involved in the S&T effort of both Japan and Korea. In doing so, the chapter highlights the importance of the infrastructure developed to formulate and operationalize these countrys' S&T efforts. From this account we can infer that similar infrastructure will have to be built in the South countries if they are to engage in an S&T effort in a committed and comprehensive fashion. However, the chapter also maintains that while there are important lessons to be learnt from the dynamics of East Asia's efforts to technologically transform, it also acknowledges that the region's industrialisation path cannot be replicated.

Chapter 5 initially offers an introductory discussion of the evolution of the international IP system as well as the evolution of GATT. This review provides an important background for a subsequent discussion of the United Nations Conference on Trade and Development' s (UNCTAD's) efforts to reform the international IP system. In addition, the review of GATT lays the foundation for a more detailed analysis into one specific Round negotiated under the purview of GATT - the UR. Five agreements in particular are highlighted and discussed. In addition, their ramifications for the South's ability to plan for its technological transformation are also extensively reviewed. This chapter then, enables us - having examined the dynamics (at a theoretical and policy level) of an S&T effort - to review what the major impediments are to the pursuit of such an effort in the South. In analysing the international economic/trading system, more especially, the UR and the GATT, we identify the effects this regime has over the pace, spread and nature of technological transformation in the South. From this analysis, we are able to infer that the Round has extremely negative ramifications for the sustained structural transformation of the South and, as a result, we are able to validate the third argument of the thesis.

Chapter 6 constitutes a review of the arguments presented in the body of the thesis. However, it also provides a more detailed and critical analysis into the issues dealt with especially in the latter part of the thesis - specifically, the impediments to the efficacy of S&T policy planning in the South as a result of the UR. The chapter attempts, by way of conclusion, to provide a more focused analysis of the implications of the UR for S&T capacity building efforts in the South. The chapter also reflects on the larger implications that the international IP system and technology have on globalization. We advance the notion that many of the advances in technology are at the heart of globalization, so as a result, just as the South is excluded from fair access to and use of technologies, it is and will continue to be excluded from enjoying the merits of globalization as the North countries have. From this assessment, it is inferred that the international trade regime and economic system are curtailing or restricting the industrialisation options available to the South. This has very serious implications, which the latter part of the conclusion attempts to articulate.

1.5 Research Methodology

The thesis is dependent on both primary and secondary sources. The primary sources are based on face-to-face interviews conducted in the United States of America and in Canada. However, electronic mail, and correspondence through faxing and phoning were also tools for research. These interviews were directed at development practitioners in the field and policy- makers from various organs of the United Nations and from the Ministry of International Trade and Industry (MITI) in the Japanese government. Private citizens retired from various international organisations and academicians from international organisations were also interviewed. In addition, several government documents, including policy statements, from the Japanese government have been cited or referred to, in order to qualitatively substantiate views presented throughout the chapters of the thesis. Secondary sources were also a major component of the research for this thesis. They included a variety of books, PhD thesis, as well as journal articles acquired from libraries throughout Canada and the United States.

Chapter 2 - Technology and Economic Growth: A Literature Review

2.1 INTRODUCTION

This chapter is an effort to introduce the ideas of, and provide a critical analysis into the literature and debate surrounding technology. It will first review and discuss the variety of debates and definitions surrounding technology and introduce the arguments as they have evolved since Schumpeter's work in the early part of this century on the role of technology in economic growth. Consideration will be given to an analysis of the role of both physical and social technology in the economic growth process. In both cases, a modular/mathematical analysis will be employed so as to theoretically and empirically substantiate the argument of the role of technology in economic growth. The chapter will then provide a literature review of the various theories of economic growth that have evolved through the decades to account for the role and impact of technology in growth. Particular attention will be given, in this account, to the contributions of the neo-classical economists and the endogenous growth theorists to the development of this literature.

We will then examine the process by which technology is created (i.e. innovated through R&D). We will focus particular attention in this context to the theory of Long Waves first advanced by Kondratiev (1935) and then further developed by economists such as Freeman and Perez (1988). This analysis will lend a greater understanding, on the one hand, to how the literature on technology has evolved into the 1980s and 1990s, but also provide us with an understanding of why technology in economic growth is even more important now with the emergence of microelectronics and information technologies. It has been argued that it is advances in and the production of these technologies that, in large part, will result in the rapid industrial transformation of nations; the economic and technological transformation of East Asia is especially pertinent to this argument. The section on Long Wave theory will provide us with an understanding of the importance of harnessing the technologies that characterise a particular 'wave', so as to gain maximum returns from the production of that technology for export. Recognising that South countries are still very much dependent, however, for their technology needs from technology suppliers in the North, the chapter will then turn to a discussion of the role of TNCs in the technology transfer process. In undertaking this analysis, we seek to briefly review and become aquainted with the dynamics of this process.

2.2 Technology: Definitions and Theory

Research into technology in the developing countries has historically focused on issues such as the nature and unfairness of the process of the transfer of technology from North to South, as well as the choice of technology; specifically, appropriate technology in this process (Stewart and James, 1982). As of late, the focus of researchers has been directed more at examining how the technology that is acquired from TNCs is actually assimilated by South country firms and the strategies they employ in order to enhance the efficacy of this process. Researchers are also examining ways in which transferred technology can be effectively adapted, mastered and generic changes made to it at the firm level. These types of studies, however, stem from a long line of earlier studies that raised these issues, such as the work of Sen (1979). Such work was actively spurned by earlier works in the 1960s by authors such as Arrow (1961) who wrote on learning-by-doing concepts. Bell (1984) and Dahlman and Westphal (1981) further developed these concepts, by specifically looking at the importance of investment in the learning process - substantiating their arguments through firm-level case studies from Latin America. In the last fifteen years because of the contribution of scholars such as Westphal (1982), Dahlman and Westphal (1983) and Evenson and Ranis (1990), for example, focus has again shifted to a re-examination of the importance of S&T capability building policies, dealing with issues that go beyond concepts like the transfer and assimilation of technology, to what strategies - on a broader scale - can be pursued to provide an enabling environment for technological transformation in the South. Specifically, authors like Patel (1995) have talked to issues like social technology and how building on these capacities will serve to ameliorate other strategies related to building indigenous technology capabilities in South countries.

Several authors have recently begun to strenuously argue that strategies aimed at building on indigenous technology capacities in South countries is an important phase in the efforts of these countries to understand and harness the tacit features of technology. Such sentiment was apparent at a 1996 UNCTAD Meeting of Experts on Technology Partnership for Capacity-Building amongst delegates from Africa, Asia and Latin America (UNCTAD, 1996). It was widely agreed that such understanding of the innate/tacit characteristics of technology could only come from increased local R&D efforts. While this has been long recognised, there has been a resurgence in literature on such themes of technology mastery and the creation of indigenous technology strengths to accomplish this. Again such work has its origins in the writings of Nelson and Winter (1977), who wrote extensively in the 1970s on issues of the tacit features of technology and the importance of developing indigenous R&D capacities in the South to compensate for the loss of certain technical and operative information during the transfer of technology. They argued that it was critical South countries develop the capacities to research their own technologies, as the nature of the foreign technology and design features of that technology were such that they suited the firm environment it was coming from, and not the firm environment it was being transferred to.

The recently negotiated UR, though, has forced many scholars to refocus attention on issues long debated and unresolved, such as the unfairness of the negotiating process for technology, restrictions on how, where and to what end the technology can be used by the recipient firm (UNIDO, 1996). In addition more recent focus has been on efforts to articulate how technological effort can be built and the process involved in technological transformation strengthened. There is, however, a dichotomy in the literature when it comes to such a focus. For example authors examining the experiences and policy lessons from specific industries in the NICs of East Asia and Latin America engage in studies that are micro in nature paying specific attention to the dynamics of transformation at the firm level. Other studies, however, remain macro based - focused on larger sectoral issues related to technology capacity building; for example, economic policy regimes that must be in place to compliment such technology building efforts. Both types of research, though, are complimentary providing for a well rounded and more accurate assessment of S&T issues as they are apparent in the technology literature.

What follows is a brief review of how technology has been defined, and how the issues related to it articulated in the literature over the last three decades. In the rubric of the literature written on technology, a number of conceptual and definitional differences exist among the writers engaged in the field as to what technology actually means and what its implications are. We will navigate through this body of literature so as to illustrate the ways in which technology has historically been analysed and discussed.

Technology, by any standard and in its simplest meaning, hints to the utilisation of scientific/technical knowledge in production or processing methods to produce a product. What can be implicitly understood from this statement is that technology has its origins in science.[8] Technology, then, is the commercialised product of science, specifically, it has the effect of commercialising applied science. In this respect, technology is 'the interaction of person (s)/tool or machine /object which defines a way of doing a particular task'. In this sense, technology comprises a collection of not only production possibilities, but also methods as well as processes used to create outputs to meet the demands of those who employ the technologies in the first place.

Undoubtedly in our history, our ability to invent has become increasingly easier because of the knowledge we have acquired from past successes in innovation. Indeed growth rates have increased to the extent they have because of the increasing stock of knowledge on global technology shelves. Hence the rate of growth throughout the world has been commensurate to the rise in the stock of knowledge available to economies, in

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[8]In the context of this analysis, science is understood as a systematic and formulated body of knowledge.

their specific technology shelves. It is only in the past three centuries, though, that applied science has been the source of technology. This was not always the case, as Patel argues, especially in the 15 000 years since the Agricultural Revolution when man happened on technological innovations more so by chance or trial and error, than by any deliberate effort at R&D or through an understanding of scientific principles, in what were widely considered societies that relied more on superstition for explanation than on scientific understanding for explanation. This lack of scientific underpinnings for technological innovations in this period, rendered those innovations quite incremental, and never really ground breaking. This is substantiated by the fact that in the years after the Agricultural Revolution, the production capacity of humanity only increased but two times, while in this century alone growth throughout the international economy has grown at exponential rates.

All this changed as a result of the scientific revolution that brought with it unprecedented growth rates never evident in centuries past. The revolutions in science and technology (reflected in the Technological Revolution that came towards the end of the 1800s), Patel argues, brought with them new ways of looking at things that were not based on superstition, but on science.[9] It allowed for scientific questions to be asked and investigated through scientific methods. This accumulated scientific knowledge was progressively and systematically translated and commercialised into technology. As a

[9]These ideas and the ideas incorporated into this discussion made in reference to Patel are from a seminar in 'Trade, Technology and Economic Growth' taught by Dr. Surrendra Patel, as a graduate course in the International Development Studies department at Saint Mary's University, Halifax, Nova Scotia.

result of this, Patel maintains technology was comprehensively introduced or incorporated, on a massive scale into the production processes (to a large extent, in the economies of the Metropolitan powers). Once scientific discoveries and phenomena were theoretically derived technology, took a back seat to science. But also as a result of this differentiation, science maintained its place as a free public good and hence accessible to all. Technology, though, because of its role in commerce, took on very different characteristics. Implicitly, it was understood more and more as being task specific, principally because commercial transactions resulted from its use. And while science became humanity's inheritance, technology on the other hand became subject to different rules. Technology was able to be planned, and because of what was increasingly being recognised well before the turn of the century as its critical importance to economic growth, nation's who had begun to build their technology capacities around this time, sought to preserve their status in the emerging international political economy (IPE); and as such (and for various other reasons, to which we will speak to later) devised a system of intellectual property (IP) in order to guard against the widespread proliferation of technology in economies of the Southern hemisphere. This practice occurred because South country economies threatened to emerge as competitors to the Metropolitan powers if they obtained technologies as freely as they had access to science.

While we have reviewed conceptual issues related to technology, there are significant controversies surrounding technology. These controversies arise because of the various applications of technology in different fields. Technological innovation in the field of health, for instance, could prolong or better the quality of life. By the same token, technological innovation in war, for example, in bacterial and chemical weapons may actually work to compromise the longevity and quality of life. Hence, because of the numerous applications of technology to any number of fields, it is those applications that will dictate a variation in definition. However, variations in the definition and interpretation of technology are also subject to the paradigmatic and theoretical disposition of the authors concerned; hence, these factors will also influence the definitions of technology.

Turning back to a definitional analysis of technology, we know that there are an innumerable amount of definitions of it and its uses. Consider that technology is defined by Sharif (1992) as a means specifically to increase both the productivity as well as efficiency of agriculture and industry. How? By significantly reducing production costs, increasing value added and making it possible for the introduction of new products and processes to production so that the firm can effectively respond to resource scarcities and cater to the ever changing demands and size of markets. The United Nations Centre on Transnational Corporations (UNCTC) defines technology in two ways. Specifically, the organisation refers to *technical knowledge*, as that which can be applied to various *methods* and *techniques* when producing goods and services. Technology also relates to capital goods, commonly referred to as *embodied* technology: "[Technology]....means technical knowledge or know how - that is, knowledge related to the methods and techniques of production of goods and services. In this sense, it may include the human skills required for the application of these techniques, since it is difficult to separate such application from a knowledge of the techniques themselves. In the second broader sense, *technology* also encompasses capital goods - tools, machinery, equipment and entire production systems - that are themselves, the embodiment of technical knowledge" (UNCTC, 1987: 1). Technology inevitably is a means to (or ensemble of practices that make use of existing resources to meet) an end, an end that is very much specific to the goals or value ends of a particular society. Whatever those ends may be, technology remains a mechanism utilised by mankind to satisfy a set of material wants. And as such, principally because it is used to respond to an infinite number of wants/demands, technology constitutes a plethora or an entire body of information or instructions as to how to accomplish certain tasks within the context of production processes. Technology in this analysis then must be understood to as much comprise of a production process or techniques, as much as it comprises finished products of such processes.

In the broadest sense, though, technology remains at its core, even if it takes its form in a finished product, a totality of methods. These methods rest on scientific principles hence their inherently rational nature. Technology then is a systemic approach to every area and type of human activity, and in this sense, it transcends the production process. Hence, technology has widely been viewed by authors, such as Kuznets (1966), in more linear analysis, as a principle source of productivity and economic growth. Gibson takes this definition a step further, as he considers technology as "scientific, engineering and managerial knowledge, which makes possible the conception, design, development, production and distribution of goods and services" (Gibson, 1976: 24). Other scholars, such as those within UNCTAD, consider technology to signify a package that includes apparatus/physical devises, techniques/know-how, and socio-economic arrangements or relationships which are established as a result (UNCTAD, 1988: 39). Technology is also viewed as a productive asset having commercial value, a combination of which can be applied to production and marketing processes. It "is a long-term, if not perpetual, cumulative asset, requiring commensurate investments to ensure its generation, productive utilisation, maintenance and replacement" (IDB/UNCTAD, 1988: 20). Central to technology, then, is both product and technique. As a productive asset, technology could be tangible, intangible, cumulative and human, needing commensurate investments to guarantee its application and development. Such views and interpretations of technology are shared by Gruber and Marquis (1969), Vincent (1984), Galtung (1979), Leys, Fransman and King (1984), Hall and Johnson (1970). Corporate and business oriented definitions given by authors such as Hayden, on the other hand, view technology as "the quantum of knowledge, by which such inputs as patent rights, scientific principles, and research and development (R&D) are translated into the production of marketable industrial materials, components and end products" (Hayden, 1976: 23). Suffice it to say, technology is definable and specific to particular fields and applications hence, the extensive body of definitions as to what it is. However, technology is generally understood as a stock of knowledge that facilitates qualitative and quantitative *improvements* in products and processes hence, its crucial role in economic and technological transformation (UNCTC, 1988).

Although economists like Schumpeter (1928) and (1935) recognised the important role of innovations/technology as endogenous factors in the performance of industry that many neo-classical economists failed to see this. The significance of technology, especially in the micro-economic analysis of firm performance as, Scherer (1984), Romer (1990), Grossman and Helpman (1991) argue, was especially posited by the neo-schumpeterians in the 1960s, especially in their explanation of the significance of technology in enterprise growth, especially in the case where increased levels of factor proportions went to R&D. Kuznets (1959) and (1966) chose, however, to focus on the merits of applying knowledge and technological innovation to the economic system of a nation. Kuznets maintained that the applications of technology in this fashion would facilitate technological transformation in the production system of that nation (such technical transformation would be reflected in growing income per capita levels gauged by real per capita output indicators). This would inevitably result in the social and economic development/growth of a nation and increases in output per capita. Kuznets also maintained that the level of application of technological innovation/change in economic systems would dictate the extent of transformation in those very systems. These changes in technology, and especially the application of new technologies to productive/economic forces, would have the effect, Arrow (1962) argued, of altering the nature and pattern of growth in output at multi-sectoral levels, a pattern of growth that would bring about 'a more desirable organisation of society' and achievement of greater material welfare. Industrialised nations, though, do not only owe their current growth rates/levels singularly to the application of new technologies alone. Equally important are the revolutions that have occurred in organisational forms and institutional structures. Nevertheless, history has shown us that in an effort to spurn economic development and output, countries have relied primarily on creating national capacities to enable them to reap the rewards of the development and application of new technologies. Often these capacities would come about by nations imitating/adopting, sometimes creating (i.e. innovating), but more often than not, importing technologies. These practices were particularly widespread in Europe in the late nineteenth century and are the case in the South, this century .

In conclusion, we must recognise that it is the inputs of technology in production, especially the tools of production, both physical and human capital, that constitute prerequisites for growth in per capita income and significant increases in the efficiency/quality of productive resources. This describes the experience of the Metropolitan powers, especially in the late nineteenth and early twentieth centuries. The impact of technology on economic transformation cannot be viewed myopically, as singularly affecting productive/industrial forces in a nation. Technology has a profound impact on capital formation, which Baranek and Ranis (1978) maintain is in itself an extremely powerful tool in economic growth as it comprises a significant proportion of national output (GDP). Sizeable capital formation levels lay the foundation, not only for further technological and industrial development, but also independence, especially by increasing stocks of financial resources available for further *independent* R&D initiatives. Technology and the spread of a scientific revolution to the society and economy thus could be interpreted as a panacea for economic growth.

This account of the various definitional accounts of technology is not exhaustive. There are countless definitions, in most every discipline from the arts to the sciences. In the context of this thesis technology (and more specifically, production technology) is to be understood as a technique or set of techniques. It is the ***how*** and ***what*** of production. It is the knowledge, skills, methods and procedures necessary for the operationalization and optimal functioning of production systems and processes. Because the South lacks a strong capacity to produce its own technologies it must rely on foreign suppliers for technologies. Typically these technologies are transferred to the South via contractual relations between a TNC and a South nation's firm (s). The trade in technology (the subject of section 2.2.5) constitutes "the transmission of information, means, and technical services, needed to establish and to operate facilities. These transfers include: patents, licences, know-how, plans, blueprints, engineering data, training, operating manuals, capital goods, and various technical services" (Dahlman and Sercovich, 1984: 65). What follows is a modular analysis of technology's role in economic growth; it seeks to substantiate the importance of technology as a catalyst for economic growth.

2.2.2 A Modular Analysis of the Role of Technology in Economic Growth

Schumpeter's 1928 work perhaps was one of the first deliberate and comprehensive efforts by an economist to argue that technology is the driving force behind capitalism and economic growth.[10] However, although Schumpeter's pioneering work was not explicitly targeted at establishing the link between the role of technology in economic growth, its consideration of technology in the growth process laid the ground

[10]While it widely recognised in the economics literature that Schumpeter conducted the first pioneering work into the link between technology and economic growth in a capitalist economy; this view is not entirely accurate as Karl Marx in his book *Capital* (1952) was the first scholar to actively study this functional link.

work for successive analysis into the subject by Arrow (1957), Abromovitz (1956), Solow (1957), Usher (1955), Schmookler (1966), Mansfield (1968) and Brown (1968), all classic works on the subject of economic growth and technology in their own right. To Schumpeter, the nature and pace of growth, but also the extent of the disruptive nature of capitalism itself, was dependent upon the nature of the new technology introduced into a particular sector of an economy. Those new technologies would affect the economy in the short and long run; in the case of the former, causing several macroeconomic disruptions and disequilibria, but in the case of the latter, resulting in growth because new technologies bring with them new production functions. Growth then is brought on by new production functions (created because of the introduction of new technologies in production techniques/processes) that alter existing combinations of factors of production leading, as Schumpeter argues, to new ways of utilising productive resources.[11]

It is useful to have a clearer, more precise understanding of the role of technology in economic growth. So we will turn to a mathematical explanation of the technology/economic growth linkage. To accomplish this, the paper shall borrow from what is widely viewed as the classic empirical and mathematical proof of this relationship, brought into the technology literature in 1957 by Solow. In this classic work, Solow[12] was attempting to analyse a method of segregating variations in output per

[11]Additional writings by Schumpeter such as *The Theory of Economic Development* (1934) dealt more comprehensively with technological change and its linear antecedents - invention and innovation in his explanation of economic growth.

[12]The mathematical explanation of the technology/economic growth linkage, in this section of the chapter is based on issues reviewed by Solow in *Growth Theory: An Exposition* (1970).

head due to changes in the combinations of capital per head in a given economy. To accomplish this, he utilised an aggregate production function in which he analytically and mathematically attempted to decipher the effects of technical change or technological advancement in non-farm economic growth in the United States over several years - 1909 to 1949. His study illustrated that 90% of the increase in output in this period was attributable to technological transformation.[13] However, his analysis can be interpreted, if not as a standard, but general theoretical way to calculate the relationship between technical change and economic growth hence, its inclusion in our discussion.

We take the production function:

$$Q = F(K, L; t) \qquad (1.)$$

Where Q represents output, K represents capital, L represents labour and t represents technical change.

We assume that the conditions of this function imply economic growth can be measured by the net increase in aggregate output per capita, as a result of changes in the factors of production and technology, and as a result, productivity. Solow assumes technical change will remain neutral initially hence, the production function takes the form:

$$Q = A(t) \,.\, f(K, L) \qquad (2.)$$

[13]This assessment was slightly different from an equally celebrated work in economic growth advanced by Denison (1962) which concluded that around 40% of the growth in per capita income in the US between 1929-1957 was attributable to technological transformation.

A (t) is representative of aggregate shifts over time in the levels of technology A. Solow then differentiates the above equation with respect to time and then divides this by Q hence, we have:

$$\frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + \frac{A\partial f}{\partial K}\frac{\dot{K}}{Q} + \frac{A\partial f}{\partial L}\frac{\dot{L}}{Q} \quad (3.)$$

[14]

Therefore, the equation 3 can be expressed in the form:

$$W_k = (\partial Q/\partial K)K/Q \quad \text{and} \quad W_l = (\partial Q/\partial L)L/Q \quad (4.)$$

Which we can then write as

$$\frac{\dot{Q}}{Q} = \frac{\dot{A}}{A} + W_k\frac{\dot{K}}{K} + W_l\frac{\dot{L}}{L} \quad (5.)$$

Solow utilises several assumptions and discrete time intervals to establish the relationship below, which accounts for the level of technology, output and capital per man hour:

$$\frac{\Delta A}{A} = \frac{\Delta(Q/L)}{Q/L} - \frac{b\Delta(K/L)}{K/L} \quad (6.)$$

b represents the value of capital as a proportion of the value of output.

Rothwell and Zegveld (1981) go onto explain that an approximation can be made for ΔA/A p.a. to measure the proportion of the p.a. rise in gross national product (GNP) per man hour. This rise is attributable to several causes, except for changes in capital per

[14] The dots represent time derivatives.

man hour, overtime. Hence, the difference between actual percentage changes in output per man hour and the proportion of these changes as a result of capital per man hour, will establish the levels and importance technical change plays in the economy each year. Rothwell and Zegveld maintain that Solow's explanation of the effect of technical change then, can be established when we arrive at the total increase in output per man-hour in the period under consideration (in the case of Solow 1909 to 1949 in the American economy), this accounts for the level of technical change. Solow concluded from his study that in the years 1909 to 1949, the non-agricultural sector in America was greatly influenced by technical advances. In fact, as much as 87.5% of the aggregate increase in output per man-hour in his study in those 40 years was attributable to technical change. Although a landmark study, especially in its use of the aggregate production function as a measure of the effect of technical change on economic growth, there have been other methods devised since then to measure the growth/technology relationship. Rothwell and Zegveld note that total factor productivity (TFP) has been the method of choice used by many economists in measuring this relationship, however, it is a less accurate technique. TFP utilises indexes of labour and capital towards the creation of an index of total resources in a given economy. These inputs are then allocated weights; when an index of total input is arrived at, it is then manipulated under several assumptions to illustrate how output would be altered. The ratio that is established for outputs and inputs gives an index of total productivity. Hence, by arriving at the difference between growth in initial years and the most recent growth levels in inputs, will necessarily represent economic growth as a result of changing scientific, technological, and managerial knowledge.

Lucas' 1993 article in *Econometrica* reaffirmed the importance of technology in economic growth. He argued in an elaborate econometric model that improvements in national technology capacities is a significant contributing factor in growth. He noted, though, that unless improvements in physical technologies were coupled with similar, if not higher improvements in social technology, the efficacy physical technology would diminish significantly. In fact, in his model, what was at the root of economic growth for the economy he developed was human capital accumulation. Specifically, the catalyst of growth is knowledge, that manifests itself in human capital via the education variable in growth, that takes the form of primary, secondary and tertiary education, but also on-the-job-training (OJT). By far though, it is skills acquired on the job by the workforce in his model, regarding their understanding of specific production technologies, that is the most important factor for the growth of a nation. To Lucas, the sustainability of growth rests on the ability of the workforce to continually adopt and adapt new technologies and production techniques. What Lucas successfully argues is that there are dynamic factors at the root of a nation's growth. In modelling for a single and multiple economy scenario, and by manipulating various economic variables, he concludes that those dynamic forces are predominantly a nation's human capital who are extensively trained at work engaging in learning-by-doing and learning-by-using of specific technologies. He utilises this theoretical evidence to substantiate his comparative analysis into why South Korea industrialised and the Philippines did not, despite the fact that both nations had similar demographic, socio-economic, per capita gross domestic product (GDP), and trade characteristics in the 1950s.

Having said this it is clear, therefore, that the importance of human capital or social technology in economic growth is crucial, even though human capital is a function of physical capital. Nelson and Phelps (1971) investigate the relationship between investments in human capital (through increasing their skills and knowledge) and technological progress by developing two models, on the one hand, of the process of technological diffusion and, on the other, the role of education in growth. There is a common recognition in both the models they develop that the better educated the workforce, the more effective the process of technological diffusion and adoption of new production techniques/processes.

The first model states:

$$A(t) = \Im(t - w(h)), \quad w'(h) \prec 0 \tag{7.}$$

$$\Im(t) = \Im_o e^{\propto t}, \quad \propto \succ 0 \tag{8.}$$

Where: A(t) - The index of technology in practice;
$\Im(t)$ - The theoretical level of technology, i.e. best-practice technology levels;
w' - The time-lag, a decreasing function of h;
h - The degree of human capital intensity;
t - A specific time; and
$\Im o$ - The initial level of technology.

What we must infer from the model is that given that the level of technology in practice is equal to the theoretical level of technology w years ago and providing human capital intensity (h) is constant, we must accept that: A(t) grows at a level that is equal to $\Im(t)$, i.e. the growth of A(t) occurs at identical rates ($\propto$) as $\Im(t)$; in a situation where levels of technology in practice are an increasing function of the degree of human capital intensity. Hence, if the pattern of the model itself is altered, what can be surmised is that the greater the returns to education, the quicker will be the advances made in $\Im(t)$.

The second model states:

$$\mathring{A}(t) = \phi\,(h)\,[\,\Im(t) - A(t)\,] \qquad (9.)$$
$$\Delta(o) = o,\ \ \phi'(h) \succ o$$

Where: ϕ - Level of education attained (interpreted by the authors as an increasing function of h).

The model can be interpreted as stating that the rate of increase of technologies in practice is a function of the level of education attained; as well as the gap that exists between $\Im(t)$, and the levels of technology in practice. Under the condition that $\Im(t)$ is growing exponentially, we can surmise from the model that the higher the education of the workforce in question will have a direct effect on significantly increasing levels of technology in practice. Hence, a more (technically and scientifically) educated population, it can be assumed from the model, will contribute to the increased technological capacities and technological sophistication (or advanced nature) of the technologies in use in given firms, industries and entire sectors of an economy. Principally, because a more technologically adept workforce could better understand technologies in use in production techniques or processes, and be more easily adaptable to the constant changes that occur in these production processes. High skill and knowledge accumulation, Kuznets argues, can compensate for these continuous changes. In fact, innovation under these conditions will be a function of the application of such a knowledge base to the production process, via different production techniques. This, in a sense, is a responsive process; responsive, that is, to the fact that spatial and inter- and intra-sectional structural changes in different sectors of the economy will demand that new knowledge and skills constantly be amassed and learnt by the workforce (Kuznets, 1980).

Technology is the central factor in structural transformation and hence, the economic growth of any nation. Such transformation comes about principally because of the way technology alters the mix of products, firms, industries and human capital in a given economy (Schumpeter, 1934). The percentage/proportion of changes in output per man-hour was utilised by Solow to gauge the impact of technology in the American economy from 1909 to 1949. He succeeded then in illustrating how technology manipulates the productivity of human and physical capital. The chapter seeks at this point to once again mathematically explain the economic growth process, but this time the mathematical explanation will be a lot simpler, and will be a production function, commonly used in neo-classical equilibrium economics to account for economic growth. This analysis of economic growth is done to illustrate how technology impacts not only labour but capital, and hence the importance of the continuous and simultaneous introduction of new technologies into the production process. This analysis serves to build on our modular and theoretical understanding of technology in growth (reviewed in equations 1 to 9)

We assume Economy X has only two inputs, i.e. factors of production - capital (K) and labour (L) that work together to produce Economy Xs output (production - Q). Then we have:

$$Q = f(K, L) \qquad (10.)$$

We will manipulate this function so that it takes a Cobb-Douglas form (we do this because it is one of the simpler mathematical functions, hence making our analysis easier) (Anderson and Kuenne, 1986). The Cobb-Douglas form of the above function then, is:

$$Q = K^a \; L^b \qquad (11.)$$

Returns to scale in this function are constant, hence a + b = 1, therefore, equivalent levels of production occur when inputs are increasing. One primary condition in this two-factor model is that it measures output per unit of K and L in Economy X. Now we will see the impact of technology on the function when it enters the model.

$$q = ak + bl + ct \qquad (12.)$$

Where q, k, l, and t are rates of growth for Q, L, K and *technology* C.

Hence, C is the rate of technical progress/technological transformation. What occurs when technology enters the model is it acts as a catalyst for changing both the pace and nature of output, by spurning the productivity of K and L and hence, aggregate growth in Q (Kennedy, 1983). Proponents of neo-classical equilibrium economics argue that K in this model has to continuously alter in order for it to effectively assimilate new technologies. This is why substantial investment in capital is emphasised by neo-classical economists. However, because of the magnitude of investments in K that typically characterise such models, that investment of scarce resources often comes about at the expense of investments in the homogenous input - L. Because either one of the inputs K and L can increase output, neo-classical economists do not necessarily view such unbalanced investments in K to be a problem. However, by the very fact that K is over-invested in at the expense of L poses a serious problem in the long-term for the effectiveness of L in the production process. By not effectively investing in the upgrading of Ls skills (through on-the-job training, etc.), the degree of technological transformation in Economy **X** is threatened. This is the case because, as economists such as Arrow (1961) argued in his seminal work *The Economic Implications of Learning by Doing*, it is the mastery[15] of the technology of product and process, by a given labour force, that in large part brings about the technological transformation of a nation (Leontief, 1983).

It is often the case, and empirical studies like those of Denison (1967) and Jorgenson (1988) have proven this, that capital investment is credited with less than half the increase in output in any given economy. It is significant improvements at the firm level of labour quality through training/education, both formal, informal and intrafirm that result in increased growth rates throughout firms and industries that significantly facilitate for economic growth and technological transformation (Becker, 1964) and (McCrackin, 1984). What becomes apparent as a result of the previous analysis of technology in economic growth in a two-factor neo-classical equilibrium model is that with the introduction of technology in the production function, the model exhibits disequilibrium. This is represented in the unbalanced growth of the Circular-Cumulative Causation model. In this model, growth becomes self reinforcing - knowledge, expertise and capital acquired from technologies serve as endogenous endowments that are utilised

[15]Mastery of the technology of production only comes about because of the education of human capital in technical skills and expertise to facilitate for that workforce to comprehend and understand hence, effectively operate the technology in the firm environment.

for future sustained growth in technology capacities. Technology is reinforcing in this situation as a result of the Verdoon-Kaldor Law and, and as a result has a critical role to play in the process, pace and nature of economic growth.

The theoretical and modular analysis above has provided us with the tools to better understand the role of technology in economic growth. We now turn to a comprehensive literature review of the writings on technology's role in economic growth by reviewing the evolution of this literature and how it accounted for the role of technology, or what has come to be known as the 'residual' in this growth process.

2.2.3 Contributions to the Empirics of Economic Growth - The Evolution of the Technology and Economic Growth Literature

Although the following account offers a discussion of the different theories of and approaches to economic growth as they have emerged through the decades, they have one thing in common, they all discuss economic growth, how it occurs and the catalyst for this growth - the 'residual'. A few of these earlier theories, however, did not make explicit the role of technology in economic growth. For example, amongst the earliest writings on the subject of long-run growth were the works of Ramsey (1928) who wrote on optimal savings issues and (Rosenstein-Rodan, 1943) who considered the structural obstacles to economic growth using Eastern and Southern Europe as a case, as well as Von Neuman (1945), who wrote on balanced growth at a maximal rate. Domar's (1957) work was also a very important contribution to how economists interpreted and understood the dynamics of economic growth however the more celebrated writings of the 1950s and 60s on long-run equilibrium growth, were the econometrically based modelling of economies that Lewis (1954) and Fei and Ranis (1964) developed. Although these economists provided little insight into the dynamics of technological change (because these works viewed technological change as an exogenous process constantly occurring at a steady state over time), they did, however, lay the foundations for the later recognition by economists of the role of technological change in economic growth.

Only more recent writings emerging in the mid-twentieth century, such as the works of Schumpeter (1939), paid particular attention to the role of technology, particularly innovations - shifts in a firm's production function - on growth, especially at the micro or firm level . While they recognised that technology was important to economic growth, these authors also argued that technological change was in fact more significant or critical in this process. This is because "technological change is the advance of technology, such advance often taking the form of new methods of producing existing products, new designs which enable the production of products with many important new characteristics and new techniques of organisation, marketing and management" (Mansfield, 1968: 10-11).

Economic growth is generally understood as an increase in production over a time frame of a year, measured by the rate of growth, i.e. RGDP.[16] As a result, economic

[16]RGDP p.a. is typically arrived at by calculating growth in a given year as a proportion of production in the inception of that year. RGDP per capita, on the other hand, makes specific reference to the growth of production per person. As a result, economic growth rates are measured by GDP, which is the annual average value of total production in a country divided per head of population.

growth can be understood as referring "to a sustained expansion of the productive potential of the economy which - in the long run - converges with the growth of aggregate output" (Technology and Economy Programme, 1992). Historically, economists who have attempted to account for or interpret economic growth have fallen into two distinct categories. The first (and perhaps most widely known) approach has been articulated in the *Resource Theories*. These theories comprise: the Malthusian theory, the Capital-limits theories and the Neo-classical theory.

The Malthusian theory views any increase in real gross domestic product per capita as being decided by how natural resources (land) are utilised and the volume of such resources available to entrepreneurs at any one given time. In other words, the threat to the continued availability of such resources lies in the increased and uncontrolled rise in population, which must be stemmed if growth is to be sustained. The capital-limits theories view growth as being spurned by increased savings and investment. Economists, such as Harrod (1939) argued that capital accumulation facilitates sustained growth provided somewhat of a balance exists between investment and growth in labour. Harrod raised the issue of stability of the direction of growth by reviewing the warranted and natural rates of growth. He argued an economy had to strike a balance between the two rates because if it was more inclined toward the warranted rate, capacities for growth would not be utilised effectively and if it was oriented too much toward the natural rate, rising unemployment would be a significant and continuous problem. The neo-classical theory was essentially a response to what many economists, who in time came to be known as neo-classical economists, saw was a major flaw in

Harrod's theory of economic growth, i.e. it failed to recognise the importance of diminishing returns. The neo-classical theory views economic growth as being facilitated by increased capital accumulation, which, however, is constantly threatened as capital to neo-classical economists is subject to diminishing returns. The effect of diminishing returns in this context is that the marginal productivity of capital drops while capital per worker rises. The warranted rate of capital growth relative to labour is greater as compared to the natural rate. The ultimate effect is a reduction in the profitability to invest therefore, the incentive to invest decreases and with it, a decrease in investment levels themselves.

This diminishing returns principle is really a law. In order to comprehensively explain this law, we must first understand other related concepts - mainly average product, marginal product and diminishing marginal product. Average product constitutes the total product divided by however many units of the variable factor (call it labour) utilised in the production of this product. Any change in the total product though as a result of an increase in the amount of the variable factor used in its production is called the marginal product. The average product will in fact increase as more labour is used, however, it will increase to a certain point of output known as the diminishing average productivity point, after which average productivity will fall. Similarly, marginal product will also reach a level of output - call it the point of diminishing marginal productivity (i.e. product per unit of labour divided by quantity of labour) where it will no longer be increasing but rather begin to decrease. Hence, because the total productivity rises at an increasing rate and then at a decreasing rate, as a result, marginal average productivity and the average and marginal product curves also rise and decline.

Ultimately, it is the variations in output because of the application of more or less of a variable output to a certain quantity of a fixed factor that paves the conditions for what the neo-classical economists term the law of diminishing returns or variable proportions. The law maintains that increasing amounts of a variable factor applied to a certain quantity of a fixed factor will create a situation where in time, even the addition of another unit of the variable factor will in fact contribute less to total product than did additions of the same units prior to this point, principally because a decline in the marginal product of the variable factor will manifest itself. So what in fact occurs, according to the neo-classical economists explanation of this, is that more of the variable factor, in this context we can view it as being labour, is added to an amount of the fixed factor, we can call it capital, and all the while output is still increasing. What occurs is labour (which we know to be the variable factor) has less capital (which we stated is fixed) to work with, because labour is increasing but capital remains the same, at each stage of an increase in labour. Therefore, each unit of labour (as output increases and as each unit of labour increases) gets less and less of a share of capital to aid all the units of labour in the production of an increasing level of output. As a result, a point is reached where even though amounts of labour continue to increase and still capital remains fixed, increased units of labour will in fact start to add diminishing amounts to total output. This situation may in fact be compounded by and begin fairly early in the production process because of the effects of diminishing marginal product on capital and labour as well, but also the effects of diminishing average returns to the variable factor (labour) itself; which like capital may be subject to diminishing returns, however, for reasons associated with diminishing average returns, and not conditions where fixed capital in the face of each additional unit of labour, contributes to diminishing amounts of total output.

Hence, it is no surprise then that the neo-classical and to a lessor extent the Malthusian economists aggressively argued for the need for and merits of technological innovation. Consider in the case of the neo-classical economists capital remains fixed, and in the case of the Malthusian theorists land remains fixed - in both cases, however, labour units are increasing constantly and at a sustained level because of rising population levels. How then would we counteract the effect of rising variable factors on fixed factors? Besides the obvious policy prescription most widely advocated by the Malthusian theorists of curbing population growth; of great importance would be the role of technical improvements or innovations in the production process that would serve to stem the effects of the variable factor on fixed factors. Such technical innovations would satisfactorily address and counter the effects of a decline in the marginal product of each and any additional unit of labour. Why? Because the efficacy of techniques of production would be significantly improved by technological innovation, hence the levels of fixed factors would be relatively large at the outset of production so as to cope with the continuous rise in units of labour during production. This capital accumulation would be made possible through increased investment in R&D hence, improved ways of using labour as well as machines during production. As a result, to some degree the declining average and marginal products of variable factors would be addressed - but only to a certain degree. The fact is (at least in the neo-classical model) one factor is always fixed. As long as this is the case, diminishing marginal and average products for variable factors would always be inherent in the production process. Hence, the levels of output would have a tendency or greater propensity to decline. Thus for the neo-classical economists, output growth and, therefore, economic growth would be continuously threatened in any country. This decline in growth could only be addressed to a degree by the continuous and sustained additions of technical innovations to the production process of each and every firm in every industry.

So central to the neo-classical economists' argument is the idea that increases in productivity per capita is made possible by innovations and not purely investments because of the principle of diminishing returns and the effects it has on the growth in capital relative to labour. Hence, increases in marginal productivity of capital as a result of technological innovations alters the equilibrium ratio of capital to labour therefore, increasing the productivity of labour and with it the living standards of that labour force and hence, economic growth in general. So to neo-classical theorists, the extent to which that labour productivity and rising living standards of a population could be unbounded or more accurately sustained then, depends on continuous and new technological innovations to shift the marginal productivity of capital to the right and as a result, increasing the productivity of labour.

The second approach economists have utilised in accounting for economic growth is based on the Theory of a *Virtuous Cycle*, which views increased productivity as a function not only of increased division of labour, but also economies of scale, innovations and learning-by-doing. This theory has its foundation in the work of Adam Smith (1976) who first introduced the concept by articulating his views on the division of labour and its contribution to productivity growth. These theories have developed well beyond a consideration of the role of labour and market size in growth, though, to encompass theories that consider the importance of the scale of production, knowledge accumulation and various methods to facilitate for such accumulation. The cycle in this context would be continuously sustained (provided that spillover problems, monopolies and infant industries are addressed - so as not to slow growth) because increases in the scale of production would result in the more optimal use of labour in turn resulting in the increased productive capacity of this factor of production, which would then have a positive effect on the scale of production such that the cycle repeats itself.

While these various theories of economic growth paid particular attention to the role of investment in increasing the productivity of factor inputs in the production process, many economists began to realise that a significant portion of economic growth was not being satisfactorily accounted for in their analysis. In other words, long-run growth, viewed as the weighted average of increases in aggregate inputs, never satisfactorily or completely accounted for output levels. That portion of economic growth of per capita output that could not be explained or accounted for or attributed to per capita growth as a result of the contribution of labour, capital and natural resources to output became known as the Solow residual or simply *the residual*, i.e. technical progress (Mansfield, 1990). Rutton argued "technological change....designates changes in the coefficients of a function relating inputs to outputs resulting from the practical application of innovations in technology and in organisation" (Rutton, 1959: 606). The effect of this technical progress or technological change on productivity and productivity changes, Mansfield argued, could be measured either by growth in labour productivity, the ratio of best-practice to average-practice productivity and/or by the growth in total factor productivity (TFP)[17] (Mansfield, 1966). He also argued that technological change could be measured through the analysis of reductions in unit costs, both *ex ante* and *ex post* of the time in which an innovation takes place. This was because it was generally accepted that this residual constituted the role of technology specifically technological innovation in the growth process. This residual was most commonly accounted for by TFP as TFP explains residual growth in output that causes shifts in the production function not explainable by increases in the volume of inputs (Enos, 1958).

In fact, Solow (1957) and Abramovitz (1956) both contributed seminal and quantitatively critical studies to the field of economics in the late 1950s so as to establish, through a series of case studies, the role of technological progress in economic growth. Solow and Abramovitz's methodologies and time periods under analysis were different, however, both their studies (especially Solow's study of the significance of technological advancement in non-farm economic growth in the US between 1909-49) alluded to the fact that growth in per capita output was a function of the increasing productivity of resources. However, there was a residual which was apparent *ex post* to their efforts to

[17]"Total factor productivity (TFP) measures the economic and technical efficiency with which resources are converted into products...the growth of an economy, an industry or a firm is determined by the rate of expansion of its productive resources and the rate of TFP growth" (Nishimizu and Robinson, 1984: 179).

measure growth in output per capita that was not a result of increasing inputs per capita. The residual was quite large in their studies and significantly contributed to improved efficiency in the economic growth of the subject of their analysis - the economy of the United States of America. Both Solow and Abramovitz, however, were not in agreement as to what constituted the residual. Solow established that it comprised of technological changes in firm production. Abramovitz did not go so far as to dismiss this idea, however, he did argue that the residual is *a measure of our ignorance* which consists of every other element contributing to growth other than factor accumulation.

These two economists were among hundreds of economists who attempted to account for what constituted the residual. Jorgenson and Griliches (1967) argued that changes in the quality of inputs as a result of technological improvements was actually what accounted for the residual. This argument by Jorgenson and Griliches, and an earlier account of the argument by Griliches (1963) in the *Journal of Political Economy*, however, was not empirically sound, so Jorgenson and colleagues (1987) reformulated and made his changing quality of inputs argument more convincing through a series of case studies. Other economists, like Enos (1958), found and reinforced the perception, common at the time, that total factor productivity (TFP) explained residual growth in output that caused shifts in the production function which were not explained by increases in the volume of inputs. In fact, TFP was just one of three ways to measure the effect of technological change on productivity and productivity changes. The other two measures according to Mansfield (1966) were (as noted previously) growth in labour productivity and also the ratio of best-practice to average-practice productivity. To neo-classical economists, the residual was explained by technological innovation that resulted in technological transformation. Economists, like Usher (1955) continued writing in this tradition, expanding on and making important contributions to accounting for the residual. Rutton (1959), another famous economist at the time, went on to develop views in the economics literature on economic growth, by arguing "technological change.....designates changes in the coefficients of a function relating inputs to outputs resulting from the practical application of innovations in technology and in economic organisation" (Rutton, 1959: 606).

The residual was also of particular interest to Denison, who was not necessarily neo-classical in orientation, who argued that the residual could be explained by or consisted of significant advances in the differentiated commodity knowledge and economies of scale amongst firms in a given economy (Denison, 1962) and (1967). Denison found that this residual could be accounted for, for the most part, by significant advances in knowledge (as a differentiated commodity, knowledge specifically an expanded knowledge base through technical mastery and the X-efficiency had a significant effect on economic growth, because of its effect on labour productivity) and economies of scale. This idea of economies of scale in economic growth was built on Adam Smith's virtuous cycle of division of labour which was seen as increasing productivity hence, incomes therefore demand and consequently leading to increased market size, allowing for the cycle to repeat itself. Economic growth theorists who expanded on these concepts were Marshall (1975) and Kaldor (1980), stressing that the division of labour concept would in fact work better in a firm and industry environment where enterprises enjoy substantial size advantages and hence, have a greater incentive and need to specialise. Arrow (1962) then introduced the concept, of learning-by-doing in economic growth. Its merits were first recognised and championed by engineers in the wake of World War II who observed that continuous repetition of functions made for an increasingly productive environment in an enterprise. Although a simple concept, it was a central contribution to the literature on growth.

However, since for neo-classical economists the residual constituted technological innovation (made possible through investment in R&D), they could not understand why the residual was not subject to diminishing returns, as other types of investments were in their models, but instead had a consistent record of being a significant and increasing contributor to economic growth. As a result neo-classical economists faced a dilemma. On the one hand, they argued that investments were subject to diminishing returns, yet on the other, their models have also shown that the residual, a consistent contributor to growth as an investment is not subject to diminishing returns. So the dilemma for the neo-classical economists is the fact that technological innovations in theory must be subject (under their understanding and writings on growth theory) to diminishing returns, yet in reality this cannot be possible because technological innovations have contributed so much and in such a sustained manner to economic growth. The neo-classical economists have been unable to resolve this dilemma because they refuse to refute the diminishing returns principle (that assumes one input remains fixed while others increase) or the decreasing returns to scale, i.e. diseconomies of scale argument (which argues output increases less than in proportion to inputs) as doing so would undermine the axiomatic basis of their theoretical foundations. Therefore, they have historically explained away the dilemma by recognising that innovation is a critical component of economic growth, but at the same time, also arguing that it cannot be explained by economics.

As a result, neo-classical growth theory met with substantial criticism in the 1970s, not only because it argued that innovations could not be explained by economics, but also because of the diminishing returns argument. Principally, because neo-classical theorists had argued that because of the diminishing returns principle, growth rates in the high performing economies of the world would in fact experience a decline. Their predictions, however, were wrong; the high performing economies of East Asia proved this to be the case. The seventies and early eighties (despite the significant exogenous shocks caused by the oil crisis in the seventies and then global recession in the early eighties) was in fact a period in which growth rates in this region climaxed. This was in obvious contradiction to what neo-classical growth theorists had argued. The theory, as a result, was quickly discredited, as it could not explain or account for the growth rates of East Asia. In addition, as the endogenous growth literature points out, neo-classical growth theory failed to account for why countries have not converged in income, GDP, and other indicators of development. A point that neo-classical economists vehemently discount; arguing that it is obvious that differences in technological capacities and advancement between nations is a major cause of the gap or lack of convergence between the development of rich and poor nations.

As the previous analysis indicates, the neo-classical economists' model of technical change in economic growth has it faults. It is because of these faults in neo-classical growth theory that a number of economists initially in the 1960s and then more aggressively in the 1980s developed endogenous growth models. Economists in the sixties realised that although the technology literature dealt with the link between technology and economic growth, it failed to account for endogenous sources of technological transformation, as the theory argued investments should take place in increasing the stock of physical capital or capital-deepening therefore, increasing the capital-labour ratio and hence, growth rates.[18] Historically then, the theory has argued that such a strategy should be employed at the expense of similar investments in labour. *Prima facie* we can maintain that this argument is flawed because it has been recognised that technological transformation is not solely a function of investments in capital or physical infrastructure, it is a function also of investments in human capital. The rise of endogenous growth literature/models was in response to the seeming inability of neo-classical theorists to address these issues.

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[18]The argument being that increased investment in the stock of capital increases the productivity of labour and hence, a rise in economic growth. In the model itself, as argued by Solow (1956), the economy produces a single output let us call it X, this output X exhibits constant returns-to-scale in production, but X also exhibits diminishing marginal productivity in labour and capital. In order to increase productivity as well as per capita incomes the capital-labour ratio is increased (achieved via increasing investment over and above the rate of population growth) and as a result, the level of capital per worker is also increased. However, while each additional percent of GDP invested in physical capital may spurn GDP growth in general (as argued by neo-classical growth theory) if we consider GDP per capita, population growth the and investment to GDP ratio in isolation, the neo-classical growth theory argument becomes less convincing.

Endogenous growth theory is an updated version of Adam Smith's Virtuous Cycle. However, endogenous growth theory is widely thought to have actually been articulated in its modern form in the works of Arrow (1962) and Uzawa (1961), (1962) and (1965), who both endogenized technical progress in their growth models. Arrow argued that learning-by-doing factor productivity was an increasing function of investment. In addition, he also argued the famous learning-by-doing model where dynamic externalities of cumulated gross investment resulted in the generation of various learning capacities. Both R&D investment and human capital accumulation, Arrow (1962), Mansfield (1977), Sherer (1986), and Beck (1964) argued have significant positive externalities, reflected in the increased capacity of a nation to effectively utilise and research technologies. These early contributors to endogenous growth theory, as a result, established many of the foundations for the development of this theory in the 1980s. Uzawa (1961) and (1962) for instance built on Solow's model by developing a two-sector model. Similarly Ahmad (1966) in the mid-sixties began to analyse technology and technological progress as endogenous factors in his models, as opposed to viewing technology as exogenous by augmenting labour.

Endogenous growth theory, however, generally refers to the theoretical and empirical work on growth that emerged and gained prominence in the 1980s. Endogenous growth theorists agree and advance the notion that positive externalities or spin-offs result from investments, especially in human capital; as such investment serves to increase the nation's stock of knowledge and pool of technical experts. They argue that aggregate economies of scale and economy wide returns to scale will also significantly contribute to the advancement of a nation's technological capacities, as such investment will result in positive externalities. Central to this endogenous growth theory argument is the concept that innovations are a function of economic events. This is contrary to what the neo-classical theorists argue. The endogenous growth theorists state that the accumulation of knowledge and any other factor is not subject to diminishing returns, i.e. growth rates tend to be correlated over time. To these theorists, innovations *can be* explained by economics. So, unlike the Solow-type growth model the endogenous growth theory models are not subject to diminishing marginal productivity of capital. Hence, growth in these models occur because of non-decreasing returns, especially to knowledge and human capital.

These endogenous growth theorists are able to argue that innovations are indeed explainable by economics because they refute the diminishing returns argument. The diminishing returns argument does not apply to this theory as the theory argues that it is possible to increase all inputs or factors of production, e.g. land, labour and capital, in proportion. Hence, in their models a significant proportion of growth in a nation is a function of economies of scale or increasing returns to scale where factors of production all increase in the *same* proportion. As a theory, it argues that growth levels, and economies in general, have increased/advanced as much as they have in this century principally because of the impact of learning-by-doing, human capital accumulation and commitments to R&D investment into creating new technologies. As a result, growth has been facilitated by the qualitative and quantitative increases in productivity and the production process in general, that have enabled nations to produce standardised products and at internationally competitive export prices.

The more recent advances in the endogenous growth literature has come from the models developed by Romer (1986) and (1990), Lucas (1988), Aghion and Howitt (1992), Grossman and Helpman (1991), Segerstrom, Anant and Dinopoulous (1990), pioneers in their own right, with regards to recent developments in the literature. Romer, for example, in his 1986 article in the *Journal of Political Economy* develops a competitive equilibrium model with endogenous technological change. In this model of long-run growth knowledge, as an input in production, is subject to increasing marginal productivity. Therefore, Romer like these other authors, have developed models centred around a theory that has espoused the concept that inputs are influenced by or modelled as being subject to increasing returns which, as a result, is expected to lead to long run asymptotic per capita income growth in the long-run. The inputs in these models are subject to increasing returns (hence growth becomes a function of increasing returns) because the diminishing returns principle does not apply to their models, but also because the inputs are not all conventional factors of production. This non-convexity issue arises in the models because R&D and human capital accumulation are not conventional factors of production.

It is the much celebrated writings of Lucas (1988) and Romer (1986) that have spurned the renewed interest in growth theory through the 1980s and into the 1990s. Lucas, for example, has forced many economists to reconsider the role of human capital in technological transformation. In his 1988 article in the *Journal of Monetary*

Economics, he attributes much of Japan's and the East Asian region's economic success to policy-makers having implemented S&T policies centred around the investment in human capital. These authors in general though have expanded the analysis of endogenous growth theory that now formalises externalities from learning-by-doing and human capital accumulation, while endogenizing technological change. Therefore, the theory establishes an important causal link between growth and constant accumulation of knowledge capital.

However, important contributions have also been made to the new growth theory by the so called trade theorists who make up an important stream of endogenous growth theory. Trade theorists like Dornbusch (1977), Krugman (1987), and Grossman (1989) have had a significant role in the development of endogenous growth theory. Dornbusch (1977), for example, develops an elaborate model that expands on the Continuum Ricardian Model, a major finding of which is that cross-country spillovers of knowledge and learning-by-doing practices will - in the long-run - provide for continuous and sustained growth in given economies for which these authors have modelled. However, these authors, and in particular Krugman (1987), have also made the case that several shortcomings are evident in the work of neo-classical economists - specifically, the 'homeostatic' view of international trade held by neo-classical economists and based on the belief in a natural pattern of specialisation and trade, which it is argued, is a function of the nature of factor and resource endowments specific to every nation.[19]

[19] Krugman makes this point through reference to dynamic scale economies, i.e.comparative advantage theory, arguing that this is not necessarily a key to economic advancement as a result of specialization in trade. In fact, specialization provides

What primarily differentiates endogenous growth theory from traditional growth theories is that it does not subscribe to the diminishing returns argument, and thus, is able to explain innovations in the context of economics. The theory also focuses particular attention on the role of non-conventional factors in the production process. Hence, for the endogenous growth theorists, growth comes about as a result of the interaction of new technologies in an environment where diminishing returns are not a factor, but instead where human capital accumulation is heavily emphasised. Another distinguishing feature between the endogenous growth and neo-classical theory is that the former argues trade is not necessarily the engine of growth, as argued by the latter. Endogenous growth theorists reject the theory of comparative advantage articulated by David Ricardo in his *Principles of Political Economy* (1817). Endogenous growth theory is highly critical of the argument that mutual gains from trade can be facilitated between nations if they concentrate on developing their own specific comparative advantages. The theory argues comparative advantage is not a satisfactory nor sufficient way of accounting for economic growth (or the lack there of) especially in the South. The theory places more value on education and other informal training techniques, such as OJT and R&D

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difficulties for an economy, as was the case with the 'Dutch Disease', first apparent in the Netherlands natural gas industry. The discovery had the effect of crowding out all other tradeable sectors in the economy. According to comparative advantage theory, this is acceptable. However, contrary to what the neoclassical economists argue, it presents a problem because when natural gas is used up (as it is a finite resourse), Holland's historically strong manufacturing industries - since they would have been under-invested in during this intervening period of boom in the country's natural gas industry - would be unable to reassert itself or be internationally competitive once again. The 'Dutch Disease' is a generic term for this situation, which has also been a common occurrence in other mineral rich economies of the South, such as the oil industry in Nigeria and Indonesia.

activities, as engines of growth. It is not surprising then, that many endogenous growth theorists are highly critical of neo-classical economists who have championed globalization.

Theorists like Romer (1990) argue that globalization marginalizes many South countries and undermines their position in the international political economy (IPE). He proposes that rather than promoting the 'new orthodoxy' notions of economic policy, etc., as the engine of growth, countries in the South must focus more attention on the accumulation of knowledge as a catalyst for that growth. He argues that increased returns in marginal products can be achieved through investment in knowledge and human capital accumulation. Romer maintains that knowledge once attained can be reproduced at little cost and with many positive externalities, including an increased capacity for a nation's workforce to understand complex technologies and harness them to increase the productive capacity of that nation. His model suggests that knowledge externalities inherent in R&D, and therefore, the know-how on a technology amassed through R&D will make future efforts at R&D in a nation - into a related technology - that much easier, and faster because a basic knowledge and scientific expertise would exist amongst scientists and engineers in the research process. The result is that firms become better at conducting R&D, the spin-offs being an increased propensity for productivity and growth in industries, and therefore, increased returns to scale in production. Because technical change is endogenized in their models, investment in knowledge accumulation will result in increasing returns to scale, as a result of the positive externalities/spillovers derived out of and as a result of it. Externalities associated with greater stocks of knowledge would have the effect of reinforcing and adding to technological capacity stretching. As a result, a deepening and rising rate of firm and industry based technological transformation will occur. In fact, Romer maintains that "an economy with a larger total stock of human capital will experience faster growth" (Romer, 1990: S99).

However, the theory is not without its critics. There has been a significant backlash to the rising appeal of endogenous growth theory. Solow (1994), for instance, has argued that the new growth theory does not contribute to a clearer understanding of dynamic externalities in the innovation process, learning process or the absorption/diffusion process of new technologies. Solow maintains that the theory contributes precious little to growth theory as it is "too vulnerable to bias from omitted variables, reverse causation and above all to the recurrent suspicion that the experiences of various national economies are not to be explained as if they represent different points on a well defined surface:" (Solow, 1994: 48). Other economists, such as Srinivasan (1994) go further in their criticism of endogenous growth theory and question the applicability of the theory to policy. He argues that the theory's increasing returns argument and views on globalization are rather myopic and ill-conceived. Other economists are more wary of endogenous growth theory, especially in how it views what constitutes the residual. Krueger for example, argues that in light of the miraculous, dynamic and fast paced growth in East Asia the residual, in fact, constitutes and reflects economic policies. These policies include monetary and fiscal policies that promote high savings and investment and contribute to 'getting prices right', through free and unfettered market competition, under a free trade environment (Ito and Krueger, 1995).

However, these critics have failed to recognise that just by re-analysing the diminishing returns argument and factoring in unconventional inputs into the growth process and even re-emphasising the role of human capital accumulation (and a committed effort at the development of a S&T policy) in growth strategies, the theory has broken new ground and provided tremendous insights into the technological underpinnings of long-run growth (Pack, 1994), (Kortum, 1992) and (Mankiw et al, 1992). Despite the criticism that endogenous growth theories have received over the last few years, the same can be said of all other theories of growth when they first came on the scene. Despite this fact, critics still ask questions like - is endogenous growth theory really a 'new' theory? Many argue it is not. This may be true to an extent, because economists like Arrow and Uzawa did lay the foundations for the theory, but is this not the case for all theories? While Adam Smith may have also set the foundations for endogenous growth theory in his discussion of pin making technology, for instance, we cannot take away from the fact that endogenous growth theory, in its modern form, has its own merits and findings specific to more recent theorists. Every theory, however, no matter how articulate, has its critics; the endogenous growth theory is no exception. The theory is of great importance to the economic growth literature not only because of how it forces us to question many of the accepted and long-held arguments of neo-classical theory, but also because it draws attention to the importance of serious non-convexities that are so much a part of the diffusion and adaptation of new technologies into a firms environment.

The evolution of growth theories has had a rich tradition of exploring the impact of technological change on economic growth. We must recognise from the above account that these theories have given us important insights into how we can conceive and perceive of the role and importance of technology in growth. It enables a theoretical, empirical and modular basis for us to establish and argue the link between technological change and economic growth, without which such a link could not be substantiated or qualified in the first place. While such theories have developed so as to empirically account for the significance of technology in economic growth, another stream of literature has been developed to account for the role of epochal technologies in economic growth. This literature has its origins in the writings of Kondratiev (1935) and provides important insights into how nations can harness the catalytic power of technologies that characterise particular periods or 'waves' in the stages of global techno-economic transformation. We examine the dynamics of the innovation process and the concepts embodied in the Theory of Long Waves, in the following section, in order to review how the literature on technology has evolved in the late 1980s and into the 1990s.

2.2.4 The Innovation Process and the Theory of Long Waves

Recently the technology literature has focused more attention on the process of invention. This focus is linked to the rising popularity of the Theory of Long Waves and its focus on the recent advances in information technology (IT). The steady rise in the sophistication of technologies so as to harness the dynamic productive possibilities and capacities of sectors in an economy, the theory argues, is secured by an innovation process that characterises each cycle of technical and technological change. It is critical, then, that we examine what constitutes the innovation process and the theory developed to account for the role of epochal technologies in that process.

When we speak of invention it signifies the discovery of a new production technique. While innovation is the introduction of that invention into production methods. However, the pace and frequency with which innovations occur or take place is directly correlated to if and when it is profitable for the TNC to do so, i.e. if a protective IP and supportive regulatory investment framework is in place and if demand is large enough in the host country or overseas for a technology. Industrial innovation, as Rothwell and Zegveld (1981) argue, is a principle aim of governments of the North, as a means of stimulating economic growth. Their argument is similar to that of Schmookler (1962), who argues that government's of the North actively encourage the private sector to innovate so as to address issues of economic growth and respond to economic pressures. S&T policies, especially in a country of the North, are an aggregate representation of innovation policy. It is the extent of the public and private sector's capacity and ability, as well as commitment to technical innovation, that will in large part be a deciding factor in that nation's structural and socio-economic transformation and economic growth (OECD, 1979).

The process of innovation[20] is complex. However, an understanding of it is important if we are to conceptualise the process. Generally, the innovation process is

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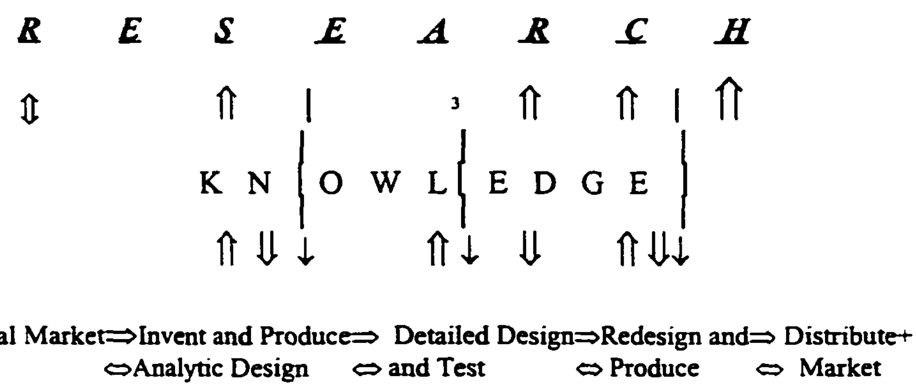
[20]Innovation results at a microeconomic level in altering demand and lowering cost functions because of the innovation's effect on the firm (in terms of innovations in processes) and the consumer (in terms of innovations in products). Because of scientific

understood as comprising activities that apply scientific knowledge to the R&D process of any nation (refer to Figure 1). After a gestation period, the technology enters the economy as a product or process technology. The innovation process itself comprises a series of steps, which innovation policy is greatly influenced by. These steps include: basic research, applied research, feasibility studies, prototype development, diffusion and maturity stages of technology.

Figure 1 - The Innovation Process



Source: adapted from Kline, S.J. and Rosenberg, N., "An Overview of Innovation", in Landan, R., Rosenberg, N. (eds.), The Sum Strategy (Washington, National Academy Press, 1986: 39).

However, Malecki devises a much simpler illustration of the innovation process, which although over-simplistic (and in some ways inaccurate, in that an innovation process can never really be linear), is nevertheless useful in the context of understanding the innovation process. In devising a 'linear model of innovation' that maintains

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research, innovation more often than not comes about in physical capital or the production process, hence the critical importance of innovation to any nation's economy because of the resultant change it brings to the way in which factors of production are utilized in production and hence how they influence economic growth (Trickovic, 1973).

industries throughout an economy have a common path they follow in research through to development, Malecki provides us with a helpful tool with which to conceptualise the innovation process (see Figure 2).

Figure 2 - A Linear Model of Innovation

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Basic and Applied Research ⇒ Product and Process Development ⇒ Production ⇒ Diffusion+ Marketing

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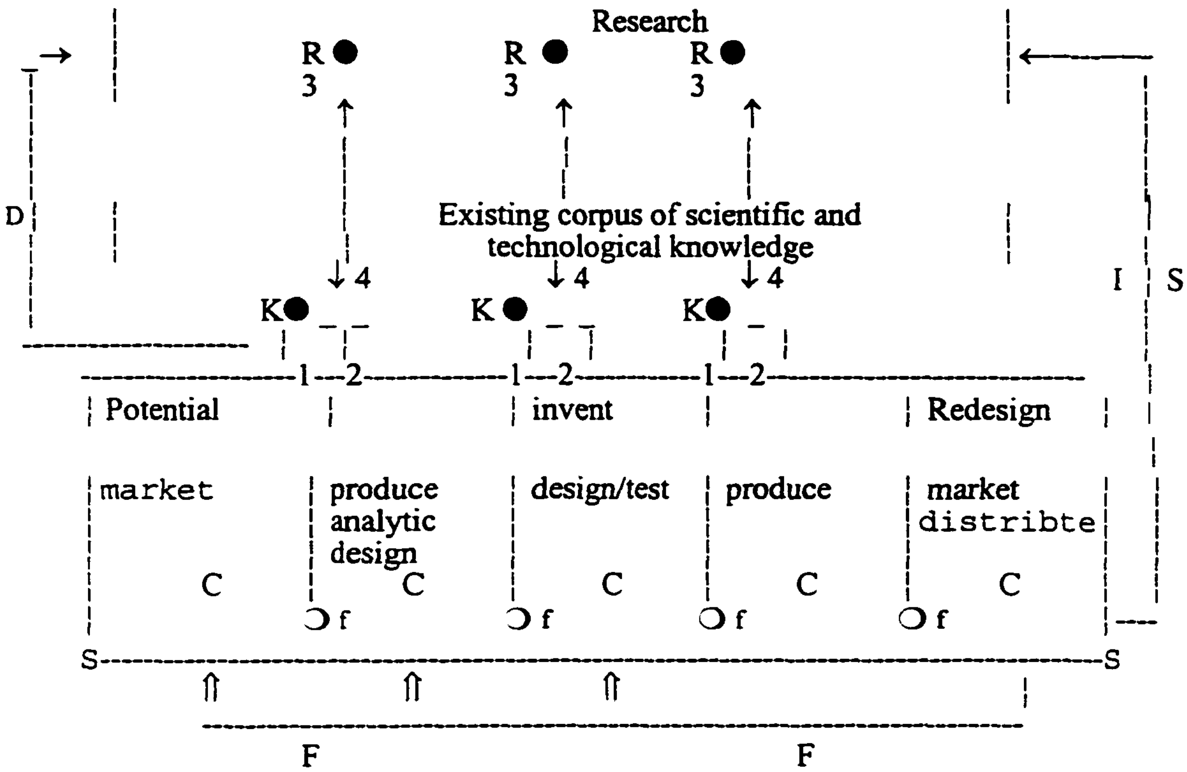
Source: adapted from Malecki, E.J., "Technological Innovation and Paths to Regional Economic Growth", in H.J. Schmandt, R.W. Wilson (eds.), Growth Policy in an Age of High Technology (Boston, Unwin Hyman Press, 1990: 98).

For many decades S&T were viewed in the context of a linear-to-marketing model, where both the production and marketing of new technologies were conducted in an unrealistically structured sequence. More recently, though, the innovation process has been viewed not as being linear but instead interactive (see Figure 3 below). We can see there are a wide array of feedback loops in the central chain of innovation. There are also important links between research and financial support for that research to effectively commercialise technology.

Figure 3 - An Interactive Model of the Innovation Process - The Chained Link Model



Individual firms and productive sectors at a more aggregate level

Symbols:
C- central-chain-of-innovation
F- feedback loops
F- particularly important feedback

Vertical Links:
K-R: links from knowledge to research
D: direct link to and from research from problems in design
I: manufacturing sectors contribution to scientific research
S: financial support of research by firms

Source: Kline, S.J. and Rosenberg, N., "An Overview of Innovation", in National Academy of Engineering, The Positive Sum Strategy: Harnessing Technology for Economic Growth (The National Academy Press, 1986: 76).

The innovation process in the figure is heavily reliant on design. The illustration fits nicely with the 'demand pull' and 'science push' theories of earlier decades because of it special focus on sustained continuous interaction and feedback. The figure illustrates the dynamics of innovation processes in a firm and the relationship of this firm to the S&T system in place in a country. The S&T system in place is reinforced by the innovation policies available to governments in the North. Rothwell and Zegveld list a number of policy tools governments of the North have at their discretion to use. All these policy tools represent different degrees of government involvement in technology policy. As Table 1 illustrates, the first three policy tools reflect a situation where government is deeply involved in the innovation process, while policy tools 5 and 6 reflect less government involvement in the innovation process. However, all these tools in and of themselves reflect government's goal to develop various ways to help create new technologies throughout industry and ensure a continuous demand and supply side of innovative technologies.[21] However, it would be a mistake to think that governments of the North simply adopt one specific policy tool to implement innovative or S&T policies (Nelson, 1993). It is often a combination of policy tools that will characterise the nature of a technology planning policy. Typically, what will almost always be the case is that one or two specific policy tools will be more comprehensively utilised than others, such policy tools usually involve the building of science and technical capacities/infrastructure and building national education capacities. However, the setting up of information networks in order to more effectively diffuse technology is also a policy tool of choice

[21]However, there is a controversy in the literature as to whether innovation comes through *push* or *pull* forces, i.e. by market pressures or technological progress.

amongst Western governments. Legal and regulatory protections as a policy tool for technologies almost invariably plays a central role in all Western nations' S&T policies.

Table 1 - A Classification of Government Policy Tools for Innovation

POLICY TOOL	EXAMPLES
1. Public enterprise	Innovation by publicly owned industries, setting up new industries, pioneering use of new techniques by public corporations, participation in private enterprise
2. Scientific&technical	Research laboratories, support for research associations, learned societies, professional organisations, research grants
3. Education	General education, universities, technical education, apprenticeship schemes, continuing and further education, retraining
4. Information	Information networks and centres, libraries, advisory and consultancy services, databases, liaison services
5. Financial	Grants, loans, subsidies, financial sharing arrangements, provision of equipment, buildings and services, loan guarantees, export credits, etc.
6. Taxation	Company, personal, indirect and payroll taxation, tax allowances
7. Legal and regulatory	Patents, environmental and health regulations, inspectorates, monopoly regulations
8. Political	Planning, regional policies, honours or awards for innovation, encouragement of mergers or joint consortia, public consultation
9. Procurement	Central or local government purchases and contracts, public corporations, R&D contracts, prototype purchases
10. Public services	Purchases, maintenance, supervision and innovation in health services, public building, construction, transport, telecommunications
11. Commercial	Trade agreements, tariffs, currency regulations
12. Overseas agent	Defence sales organisations

Source: adapted from Rothwell, R., Zegveld, W., Industrial Innovation and Public Policy: Preparing for the 1980s and 1990s (Greenwood Press, Westport Connecticut, 1981: 21).

Technological change that occurs as a result of innovation has some very important implications. First of all, technical change which comprises a change in the production function of a firm such that the techniques of production in a firm are altered causes a change in the pool or body of scientific and technical knowledge. Such change is termed technological change. Such technological change affects economic growth as a result of innovations. Such innovations then affect the firms production function hence, the cycle between technical change and technological change repeats itself. Such a cycle is associated with the theory of long waves and is critical to our discussion thus far on the role of technology in economic growth and the need for continuous and sustained innovations in order to fuel this growth process. Although most widely associated with and substantiated by the increasing role of information technology and micro-electronics in the growth of the world economy, the theory has its roots in the writings of Kondratiev (1935). The theory has been used to advance the view that not just technologies, but information technologies, are catalysts for economic growth. The accuracy of this argument, however, is still questioned because of the lack of definitive statistical evidence in this regard.

Kondratiev argued that long waves occurring at intervals of between 50 and 60 years comprise the span of the cycle under question.[22] The cycle itself constitutes four

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[22]According to Freeman and Perez (1988), five long waves have occurred. The first emerging in the 1770s, the second wave lasted from between 1830 to 1880 at the height of the industrial revolution when the steam engine and its role in textiles and shipbuilding as well as railway construction was most apparent. The third wave lasted from the 1880s to 1930 when electrical and heavy engineering emerged and were pursued in an aggressive manner. This period also saw the emergence of automobile industries, aircraft, etc., as well as intensive R&D efforts in those same industries, and especially in chemical and engineering firms. The fourth wave lasted from the 1940s to the 1980s, and was an era of mass production. This Fordist era was characterized by the rise of petrochemicals and synthetics and specialized R&D projects in these industries. The fifth wave is the most current wave and is dominated by electronics-based technologies, e.g. robotics, telecommunications, information technology, biotechnology and aerospace technologies. Production systems are now post-Fordist, i.e. more flexible, no longer based on Taylorist notions of mass production and firm based organizational structures. As a result, the relationship between worker and machine has changed. In addition R&D

stages - prosperity, recession, depression, and recovery. It is during the recessionary stage that inventions (changes in techniques of production - as a result of scientific discoveries and an enabling economic environment to facilitate R&D investment -) are likely to occur, the application of these technical changes occur in the expansionary upswing of the wave. This expansionary period is made possible through capital accumulation. While the change in technique is important for technological progress hence, economic growth, even more important, Kondratiev argues, is that investment be provided for R&D to take place in the first place, as it is that R&D investment that will facilitate for an upswing in the wave. This view directly contradicts Schumpeter (1935) and (1939) who argued just the opposite that it is the exogenous role of technological change through innovation (a totally new or radical technique with a new production function and 'clustered' technical change) that results in creating a new marginal product curve, new leading sectors of the economy and an upswing in the wave (Delbeke, 1984). Recession and depression stages of the cycle Delbeke argues occur because leading sectors demand the need for more export markets, however, because of the sheer size of these sectors and limited market capital is redirected to international money and capital markets. Market saturation, however, occurs in these domestic and international markets and demand falls, therefore, depression occurs. The cycle repeats itself when as Mench (1979) argues new demand occurs or as Schumpeter argues in response to new clusters of

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has increased yet again, but now is more collaborative as a result of strategic alliances. Because of the nature of technologies in this wave, they are more intangible in nature hence, the increased enforcement and protection of IPRs as a result of the recently negotiated UR.

innovations or as Kondratiev (1935) argues as investment increases. Plotted against time, a particular volume of production is attained by a given technological process which is subject to specific innovations/investments hence, improvements in the technology in use and the production system itself - and therefore the form the technological process - would take would be in the shape of an S.[23]

Hence, the impact of indigenous firm based R&D must not be underestimated. Innovations result in significant economic growth. In fact the original creation of know-how increases and widens the spread of technological transformation across a country. Such innovations may reinforce a cycle in which depression and recessions occur, but they cannot be avoided; in fact in theory and as well as reality, they have been an integral part of the world economy's growth process since the 1700s. They in fact contribute in the long-run to economic growth that steadily increases as the number and sophistication of technology increases. So if firm's in the South are to also enjoy the fruits of innovation, they must be a part of the innovation process, especially of new, original know-how that have the most to contribute to a nation's commercial and industrial development.

2.2.5 Transnational Corporations and the Technology Transfer Process

Technology is critical for the South if it is to enhance the way it develops and broaden its development options. However, because of low capital formation in many of

[23] Presentation by Dr. Sandor Boyson Guest Lecture to the IDS Department Seminar series, November, 22, 12:00-2:00 o'clock, 1997.

the countries in this region, and other endogenous and exogenous structural pressures, the South remains ill-equipped to locally research and produce modern technologies. Consequently, it is heavily dependent on imported technology. The most visible and active players in this sale of technology are TNCs, largely because they are active in R&D, as technologies have a synergetic effect on their productive and export capacities. The most common way these transnational actors transfer technology to the South is through Foreign Direct Investment (FDI). Historically, this transfer method has been the method of choice for the TNC, especially because of the appropriation of economic rents that come out of their competitive advantages in domestic markets. However, technology transfer, especially as of late, is increasingly steering toward joint venture arrangements involving contractual arrangements where equity capital is shared. Technology transfer may also be extremely highly packaged, taking the form of turnkey projects, that often comprise embodied and dis-embodied technological knowledge. This transfer method also has the distinction of the TNC not maintaining an on going relationship with the recipient. These arrangements often occur in metallurgy and chemical sectors, for instance. Arrangements, such as sub-contracting, involve no explicit payments by the recipient for received technologies. Management contracts though, typically occur when operational control is exercised by the TNC in an enterprise of a recipient nation. Licensing agreements, on the other hand, confer on the recipient legal rights to make use of IPRs in return for monetary compensation (IDB/UNCTAD, 1988) and (UNCTC, 1987).

Technology transfer is described by UNCTAD as, "the transfer of systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service....[hence it does not simply involve]....transactions involving the mere sale or lease of goods" (UNCTAD, 1983:2). The method of delivery of technology, be it FDI or other modes of transfer, is very much dependent on existing technological and financial capacities, and institutional factors, in the recipient nation. Nevertheless, foreign technology procurement, what ever form it takes, has become the basis by which much of the South has chosen to develop its domestic technology capacities. Technology transfer can be of two types: *direct* or *indirect*. The former type defines a situation where the HDC is involved in the actual procurement of the technology product, technical assistance, etc. The latter type, on the other hand, is illustrative of arrangements where the HDC receives technology via FDI, turnkey arrangements, etc. Here, the difference also lies in transfer methods, which can also be divided into equity and non-equity forms. The transfers can also be highly packaged, comprising either or both embodied and dis-embodied technological knowledge. In addition, the transfer may also be contractual or non-contractual (OECD, 1987). As mentioned before equity forms of technology transfer are primarily in FDI (because of externalised and internalised advantages to the TNC) where a package, either in the form of a capital good or IPR, is transferred. This arrangement is also characterised by a situation where the TNC has at least 10% control of equity capital. The package deals with integrating the technology into almost every aspect of the project the technology is imported for. Payments for such packages are either explicit or implicit, especially where IPR technology is paid for through royalties, hence the necessity of contractual and licensing agreements.

The *nature* and *type* of technology transfers then are influenced by the form of the package they arrive in. Assad Omer (IDB/UNCTAD, 1988) defines these forms of packaging as comprising *simple direct transactions,* where components are marketed. Similarly, technology transfer can also be carried out via *process packaging,* primarily of systems. The *project package* is the last form of technology transfer, and has the most restrictions on technology received in the licensing agreement, as the recipient could be a potential competitor in products manufactured from that technology. We can see from this analysis that the technology transfer process is complex; many argue it is also an unfair process - because by its very nature it exploits the recipients of technology. However it remains the only means by which South countries (who rarely engage in large scale R&D projects) can acquire the technologies necessary to pursue their technological capability building efforts.

2.3 CONCLUSION

This chapter has reviewed the conceptual aspects and definitional characteristics of technology. It has also provided insight into the theoretical contributions to the technology and economic growth link by conducting a modular analysis and review of the debates in the technology literature as they have evolved in the neo-classical, endogenous and Long Wave Theories. The chapter also reviewed the innovation process, examining the process by which and the policies that support the research and development of technologies in the North. Because South countries do not have the capacities to engage in large-scale local R&D we also reviewed the process by which they attained technologies that cater to their mass-production needs. Hence, specific attention was given to the technology transfer process and the role of TNCs in this process.

Chapter 3 - Science and Technology Policy Planning: A Theoretical Framework and Supportive Economic Policy Regimes

3.1 INTRODUCTION

The chapter will first seek to establish what a S&T policy is and what its component parts are. In order to further examine the latter point, we shall pay particular attention to an elaboration of what constitutes a science policy and a technology policy. The chapter will then seek to examine strategies that can be put in place in order to institute a S&T policy in the South. Focus will be on how these strategies can best reflect the technology transfer and trajectory goals of a nation. To provide a clearer understanding of how a technology transfer process actually takes place, a case of technology transfer between Dow Chemical and a petrochemical firm in South Korea will be used as a case. The chapter will then move onto a discussion of the methods of transfer available to a South country to acquire a technology. Consideration will also be given to the determinants of the transfer methods that are eventually employed by a TNC to transfer its technology to a South country recipient firm or firms. Attention will then be directed at establishing how the acquired technology is assimilated by the recipient firm and how the efficacy of the process can be improved. The chapter will then examine the issue of appropriateness and the tacit nature of technology and, in this regard, discuss the significance of a local or indigenous R&D effort to overcome the problems associated with tacitness and appropriateness of foreign technology to a South country firm environment.

Having discussed the dynamics of a S&T policy, the chapter will conclude by reviewing two critical economic policies that need to be in place in order to reinforce a S&T effort in a South country - namely a savings and investment policy and selective infant industry protection. In regards to the savings and investment policy regime, the chapter will discuss the importance of the profit-savings-investment nexus and how this concept contributed to the technological transformation of and has evolved in East Asia. Focus will then shift to a discussion of selective infant industry protection, where we will examine the debates revolving around import substitution industrialisation (ISI) and export oriented industrialisation (EOI) and the regulatory frameworks that have to be in place regarding foreign investment in order to promote local technology capacity building efforts, especially in the area of local R&D. Specific attention will be given to such regulatory regimes as they have developed in South Korea, however, analysis will also be directed at an examination of the lessons South countries can learn from India's 'closed' technology policy. The discussion of infant industry protection will end with a case study of industrial collaboration efforts between Japan and India that have taken the form of an investment partnership initiative that has resulted in the creation of the Maruti Udyog car company in India. In conducting such an analysis, the chapter maintains that while FDI certainly has a tendency to *replace* indigenous R&D and technology capability building initiatives, in general, as opposed to *supporting* such an effort this is not always the case. Hence, there are merits to such a form of investment which policy-makers overseeing a selective infant industry policy must be aware of and hence, must not be too hasty in adopting 'closed' technology policy regimes.

3.2 What is a S&T Policy?

"The proper application of science and technology in a developing country should speed growth and increase competitiveness by improving efficiency in the use of scarce resources. It should increase exports by making it possible to respond quickly and effectively to new opportunities created by changes in the world market and by the world-wide advances in technology" (Weiss, 1990: 17). Perhaps before we directly deal with the issue of S&T, we will examine some conceptual issues, namely what do we mean by science and technology? Science makes reference to *basic knowledge*, but also includes new knowledge and understanding that revolves around scientific principles. Science is a free good, available to all who read various scientific journals, books, etc.. Technology (as discussed before), on the other hand, refers to an *application* of that knowledge and understanding, typically to economic factors of production. In the technology literature, technology is understood to be a micro-economic phenomenon, as it is firm/industry specific information with regards to the *characteristics* and *performance* of product and production technology. However, the use of the term information alongside technology is often misleading, as the notion that technology is information implies technology is a free good, i.e. firms can implement production techniques by simply accessing a pool of technology. The fact is, technology is a commodity specific to a firm and not accessible by other firms because of patent restrictions.

Technology is a commodity even though it is intangible, and even though it is inherently differentiated knowledge that is applied to a firm's production techniques or embodied in its products (Kuznets, 1962). Technology is a stock of knowledge that facilitates for and is associated with technical know-how that enables improvements in products and process technologies. Technology though, has other connotations equally important to consider in our understanding of this complex concept. Mansfield (1975), Madeuf (1984), Hall and Johnson (1970), Robock (1980), Chudson (1970) and the National Science Foundation (1970) have all come up with an indispensable taxonomy of technology. Technology, to Mansfield, is classifiable via an embodied vs. disembodied dichotomy, while Madeuf views embodied technology as being further deconstructed into human capital and physical capital. Hall and Johnson view technology as even more specific and compartmentalised, arguing that embodied technology is product, process, system, person and firm specific. Robock and Chudson, on the other hand, view technology as specific to product schematics/design and production techniques. Ultimately though, as the NSF accurately points out, technology being the application of knowledge is composed principally of R&D, without which scientific principles would be unable to be utilised effectively in economic growth. Bhalla and Fluitman (1985) maintain that conceptual clarification and empirical precision dictates that we also make a distinction between science indicators and technology indicators. Science indicators typically include measures of scientific knowledge capacities like R&D, stocks of scientific journals, the number of scientists, engineers and other technologists and paraprofessionals like technicians, etc.[24] Technology indicators are typically viewed as

[24]However, this measure of scientific capacity by accounting for the number of technologists in a country is a controversial measure as it tells us nothing of the quality of these scientists and engineers or how effectively they conduct their research for example.

measures of technical change in a country as these indicators generally illustrate the degree of labour productivity in a sector of an economy at a given time, or they deal with capital-labour ratios that determine the degree of automation in firms, or the indicators can account for the volume of output of R&D, the number of innovations p.a., as well as patent statistics.

Science and technology are linked together when we seek to, account for or refer to certain capacities, as well as policies/strategies that are in place or attempts made to put them in place and generally over seen by a government department like a Ministry of Science and Technology or a Ministry of Industry and other related agencies and bodies in the public, as well as the private sector. In referring to these capacities or policies using S&T as representative of them, it is understood that for a nation to have a certain technology capacity demands a minimum threshold in terms of science based knowledge. This is because technological activity is in fact a synthesis of available levels of knowledge that are arrived at through R&D. To the extent that technological activity takes place in advance of available research, actual technological change is brought about in large part by continuous use of the technology and understanding/knowledge of the scientific principles behind it. The application of such technological knowledge is accomplished by production engineering, establishing new production capacities, capital goods manufacture, and R&D so as to build on existing technological knowledge capacities and to create new ones.

When we discuss S&T as a policy, we commonly view it as a planning tool. Sagasti argues that S&T planning can be "defined as the process of making anticipatory decisions about S&T development and placement of those decisions into the socio-economic development process. The criteria for making such decisions are derived from S&T policies, which in turn reflect, either explicitly or implicitly the will of the government and the groups in power" to engage in activities that further the capacities of the nation in R&D, use, production, absorption, regulation, importation and implementation of technologies (Sagasti, 1979). An S&T policy can be broken down into having two objectives. On the one hand, policy makers attempt to build the technological capacity of a nation through building capital infrastructure, such as technical institutes, science based universities, public and private sector funded research centres, and building the stock of technology and technical know-how in a given nation. Secondly, S&T policy is also utilised to develop a national education system that promotes education (throughout the primary, secondary and tertiary levels) that is *science based*. By investing in the education of a population, the country is investing in the expertise and skill levels of its future human capital by producing skilled craftsmen, technicians, artisans, engineers and scientists (Mudenda and Bardouille, 1988). By developing the scientific skills of its workforce, that nation will be able to comprehend imported technologies and applied technologies, and increasingly create capacities to conduct its own basic research hence, ensuring a highly sustainable technology base because of the high numeracy and literacy levels of its population. Girvan (1979) maintains that S&T policies or plans also consist of and must be focused on building the R&D establishment specifically, infrastructure and programs in the private as well as public sectors that are aimed at supporting engineering and consultancy firms, research labs, specialist workshops, information systems (i.e. research units, libraries and other various depositories of written knowledge) capacities.

While we can argue that it is possible to dichotomise an S&T policy, it is more accurate, however, to argue that we can establish that an S&T plan constitutes both a science policy and a technology policy. Sagasti provides some useful insight into this, on the basis of a comprehensive account of these two policy activities which we shall examine below in Table 2.

Table 2 - Differences Between Science and Technology Policies

ASPECT	SCIENCE POLICY	TECHNOLOGY POLICY
Objectives	a.) To generate scientific (basic and potentially useful) knowledge that may eventually have social and economic uses, and will allow understanding and keeping up with the evolution of science. b.) To operate a base of scientific activities and human resources linked to growth of knowledge throughout the world level.	a.) To acquire the technology and the technical capabilities for the production of goods and the provision of services. b.) To acquire a national capacity for autonomous decision-making in technology matters.
Main type of activities covered	Basic and applied research, which generates basic knowledge and potentially useful knowledge.	Development, adaptation, reverse engineering, technology transfer and engineering design, which generate ready to use knowledge.
Appropriation of the results of activities covered	Results (in the form of basic and potentially useful knowledge) are appropriated by wide dissemination. Publishing is the way to ensure ownership.	Results (in the form of ready-to-use knowledge remain largely in the hands of those who generated them. Patents, secret know-how, and human embodied knowledge ensure the appropriation of results.
Reference criteria for the performance activities	Primary internal to the scientific community. The evaluation of activities is based mainly on scientific merit, and in a few cases on possible applications.	Primarily external to the technical and engineering community. Evaluation of activities is based mainly on their contribution to social and economic objectives.

Scope of activities	Universal: activities and results have world-wide validity.	Localised to firm, branch, sector or national level: activities and results have validity in a specific context.
Amenability to planning	Only broad and areas and directives can be progammed.Results depend on the capacity of researchers (teams and individuals) to generate new ideas. Large uncertainties are connected to this.	Activities and sequences can be programmed more strictly. Little new knowledge is generally required, and existing knowledge is used systematically. Less uncertainty is associated with this.
Dominant time frame	Long- and medium-term.	Short- and medium-term.

Source: Sagasti, F.R. and Araoz, A. (eds.), Science and Technology for Development: Planning in the STPI Countries (IDRC, 1979: 16-17 - *quoted*).

We can infer from Table 2 that S&T planning is directed at devising a policy framework or guidelines as to what is going to be planned, and secondly, program/projects established so as to translate plans from paper into implementable activities. A S&T agency or government ministry or even entity within a ministry will oversee such activities. Typically the Ministry of Industry or perhaps the Planning Ministry will have to be selected for the task as it would oversee the general development plan, which the S&T plan would have to compliment and be a part of. A S&T policy is a deliberate planning strategy by policy-makers to develop the educational and technological base of a country so it may better apply technologies to its economic circumstance and productive systems. As a planning exercise, such a policy demands incredible foresight on the part of policy-makers, a vision that is facilitated by effectively utilising available, but scarce, resources to achieve specific goals (Waterson, 1962). S&T

policy is a concerted effort at diffusing technological advances through all levels of economy and society. Because of its comprehensive and complex nature, S&T policy is often a joint initiative on the part of the public and private sectors to technologically mature a nation.

Now that we have established the essential or fundamental features of a S&T policy, how must such a policy be implemented and to what end? Although a S&T policy is ultimately a reflection or result of a government trying to plan for the nation's technological transformation, it must be seen as a tool aimed at securing the nation's sustained economic growth as a whole. In this regard then, a S&T policy remains and must be implemented as an integral part of a nation's industrialisation strategy, and the extent to which such a policy becomes successful is a result primarily of how involved and committed a government is to the nation's industrialisation effort. For example, "in South Korea, the approach to S&T policy design and implementation has been strongly conditioned by the industrialisation policy which is aimed at developing selected industries considered essential for rapid industrialisation and for the expansion of exports" (Sagasti, 1978: 59). Sagasti further argues that in order to provide an enabling environment for foreign investment, the Korean government has provided a number of incentives for TNCs including tax holidays, etc. In addition, the state in East Asia have developed highly sophisticated financial policy plans, and supportive infrastructure such as industrial sites, harbours, as well as tariff reductions on certain inputs, namely capital goods or raw materials as part of an S&T effort. However, Sagasti does stress that "the promulgation of legal devices is one of the most important mechanisms for the promotion of S&T activities, and there is an array of formal laws or regulations that constitute an extensive legal system for the promotion of science and technology" especially in the East Asian region (Sagasti, 1978: 59). At the same time the state in East Asia has actively developed, supported and promoted indigenous technological capability building of local industry by having in place a number of economic policies that compliment the country's S&T effort. East Asia's S&T effort is based on a well developed policy understanding of the dynamics of a S&T policy. We turn now to a discussion of these dynamics at a theoretical level.

3.3 Planning for Technological Transformation in the South: The Role of S&T Policy Strategies

3.3.2 Technology Transfer and Technological Trajectory

If we assume that technology encompasses technical and organisational information needed for the manufacture of products, we can assume that the South countries have historically been importers and not suppliers of such technology.[25] Technical progress in the South has largely been facilitated by the *acquisition* and then *modification* of imported technology. A handful of South countries, now having attained NIC status, have created their own technologies but through generic changes of

[25] A distinction must be made here in that all South countries are endowed with technology that inherently has been a part of their culture and way of life for generations. This technology, however, is traditional or non-Western and in many cases unable to cater to the mass production needs of modern day enterprises. Because South countries have very few technologies that can cater to modern national and international economies, these countries must approach technology suppliers, typically TNCs, to acquire Western technology.

technologies that originally were acquired from abroad. Typically, such innovation efforts[26] were preceded and made possible by the modification of a technology to improve on or upgrade production processes or methods already in place, and as well, establish new lines of production (Dahlman, 1987). This was done by establishing a proficiency or basic mastery of technology through re-creating or imitating it, hence, establishing a rudimentary understanding of its operative mechanics. Then as the firm's technological capabilities were progressively built, the modification process was conducted with the expectation that it would adapt imported technology to the indigenous firm and industry environment so as to create an enabling environment for indigenous innovations.[27] Such efforts at adaptation are common approaches to firm and industry based technical change in South countries (despite the fact that the costs of such imitation are high and that

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[26]Such innovation efforts constitute innovation capabilities which in turn "consists of creating and carrying new technical possibilities through to economic practice" (Dahlman, 1987: 766).

[27]Dahlman argues that radically new technologies are the result of breakthroughs in basic research. Such new technologies are not the product of innovation efforts in the majority of South countries. By innovation efforts in South countries then we refer to indiginous changes above and beyond modifications or improvements that, however, incremental nevertheless constitute an innovation through applied R&D. These "minor innovations are important because their cumulative impact can lead to productivity increases greater than those initally possible from major innovations" that typically characterize R&D activities in North country firms (Dahlman, 1987: 766). Because minor innnovations have a cyclical effect where production capacities are increased which triggers an increased influx of resources to be directed at investment, part of which is used to increase qualitative and quantitative aspects of production yet again by generating new techniques and so on and so forth the process repeats itself. The nascent capabillities and features in an innovation harness the tremendous and dynamic effect of productive and invstment capacities that once acting together in a desired manner result in an innovation.

imitation is not always successful[28]) rarely if ever will technical activities in these countries be directed at basic research (Teitel, 1984). However, there have been exceptions to this strategy. Nations of the South, such as Brazil, India and China that have historically had a strong base of human capital capacities, i.e. a pool of scientifically educated workforce, have chosen to develop their technology in phases going 'upstream' as opposed to the more common 'downstream' approach most commonly associated with the NICs of East Asia[29] (see Figure 4 below).

Figure 4 - Technology Development Phases

Basic science research ⇒ Innovation ⇒ Product design ⇒ Process ⇒ Production ⇒ Marketing
⇐ ⇐ development ⇐ engineering ⇐

--⇒ ⇐--

Upstream (Brazil, China, India) **Downstream** (East Asian NICs)

Source: adapted from - Reddy, P., "Emerging Patterns of Internationalisation of Corporate R&D: Opportunities for Developing Countries?" in C. Bonadenius and B. Goransson (eds.), New Technologies and Global Restructuring - The Third World at a Crossroads (London, Taylor Graham, 1993: 96).

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[28]The risk of such imitation can be reduced if the firm has relatively superior stock of human capital to understand and apply the technology and physical capital, like production facilities and process in general, good production management (that include strategies to effectively adopt, adapt and make generic improvements to techniques), are in place; however, this is rarely the case in much of the South.

[29] It should be noted, however, that this is a linear model and hence the reader must not (in analyzing it) do so with the objective of establishing what it implies, but rather view it as representing the two oppossing paths to technology development that nations can adopt. If we examine what the model implies we should see that Brazil, China and India should have a plethora of break-through products due to investment in basic R&D which is simply not the case. Technology commercialisation and venture capital structures in Brazil, China and India have historically been deficient at best.

What is the first consideration then in a strategy to build S&T capabilities in a South country? The first thing is that policy-makers in a South country will typically have to identify whether they want to adopt an upstream or downstream approach to their country's technological development. In establishing this, the policy-maker will have to identify, on the one hand, the country's strengths and weaknesses and also the technological trajectory and aspirations of the country's industry. Technological trajectory is the path a country's industries take to achieve technological transformation. The orientation of this path is reflective of the nation's factor endowments, comparative advantages, but also skill levels of its scientists, engineers and other paraprofessionals. Regardless of the type of technological trajectory the country adopts, its industries will (at least initially) be dependent on the TNC for help on operating the technology. Once industries have attained an intermediate technology capacity and increases its production capacities, it will depend less and less on the technology supplier. Firms in these industries will achieve technological self-sufficiency to the extent that they have the capacity to re-engineer production processes and engage in adaptive and product design activities - once these capacities are built then the firms can investigate and pursue its innovation aspirations (Pavitt, 1987). A South country firm must ask itself a number of questions before this can occur and before it makes a commitment to prospect for and acquire a technology. These questions include:

- Is the technology appropriate for the firm environment?[30]

[30]This is a critical question because the wrong technology could prove totally useless in a firm's production process, but also because a technology is sensitive to relative prices particularly if the elasticity of substitution between labour and capital is

- How advanced of a technology does it seek to attain?

- What criteria does the firm use to establish what its technology needs are, and once the technology is found, what type of transfer method does it agree to?;

- Why is the firm seeking a particular type of technology and bearing in mind a TNC will rarely provide the entire technology, what element of the technology (either 'information', 'means' and 'understanding' especially in the area of production and design) should it acquire first? And if the firm does select a certain element of technology, does it have the appropriate skilled human capital and productive/organisational capacities to put that element of the technology to work effectively?;

- What criteria and search methods is the firm going to utilise in order to select a given technology?

- What are the firm's production plans and what is the size of the market[31] it is attempting to cater to, as well as the number of other firms it will have to compete with?;

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high. Hence, it is critical for the firm to have a plan in place as to how the technology will be transferred, introduced, managed, assimilated and adapted. The firm can accomplish this by the active involvement of firm engineers and managers in the following departments: i.) product design (to specify the type and nature of technology the firm needs); ii.) process engineering (to address such concerns as how the product should be produced, by whom, and the use of a given technology in a production process in order for the firm to meet set production goals/targets); and, iii.) industrial engineering - (to describe the methods employed to plan and control the production process). As a result, the departments will be involved in overseeing the deisgn of schematics or blueprints of the product, production routines, components and techniques needed to accomplish production goals.

[31]Dahlman et al (1987) argue that market size is important because if it is small it may be in the best interests of the firm to promote a turnkey transfer package, whereas if the market is relatively large, the firm may have to promote an FDI transfer as the firm

- Since the assimilation process is costly, where and how will the firm assimilate the acquired technologies?

The questions that could be asked are endless because "when firms choose technology they choose more than a method or technique for making something at expected costs, benefits, and engineering norms. They also choose the capabilities they can acquire from experience with the technology - capabilities that would enable them to move on to new activities or that could be used elsewhere in the economy" (Dahlman et al, 1987: 763). Dahlman et al note that the degree to which firms will be able to upgrade current productive capacities as well as diversify into other production methods will be a function first and foremost of the firm's strength in procurement and project execution, as well as how well managed the firm is and how flexible the imported technology is. Even more important though is the nature of the firm's knowledge capacities[32], production engineering[33] and R&D capacities and, the strength of its trouble-shooting capabilities, i.e. production process maintenance skills, which if strong, will facilitate for capacity stretching and bottleneck-breaking. However, if this effort at firm based capacity

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would be struggling to compete with other firms in the domestic and international market, and thus, would need the marketing and distribution expertise of a foriegn TNC.

[32]The strength of such knowledge capacities is dependent on experience with production systems through learning-by-doing, repetition, but also experience based on theoretical or technical understanding which the workers must possess and have acquired through on-the-job training (OJT) and formal education.

[33]Production engineering comprises the provision of information to facilitate for the operationalization of technology. Dahlman et al (1987) maintain this involves decision-making over design alternatives as well as the supply of core and/or peripheral technology.

building is at all to be successful institutions necessary for technological change, i.e. an IP system, must be set up to encourage inventive activity. In addition, R&D based organisations must be built, along with institutes, centres and other nodes of inventive research oriented activity like universities. A very close network or relationship must then be fostered between these entities (Nelson, 1993).

However, once the firm has raised these questions and identified the technology supplier it will turn to, it must then (in consultation with the TNC) identify what technology transfer method it will use. Typically, this decision is not made by the South country firm, but rather by the TNC. The TNC will assess how much it will gain from a particular transfer method, and although the two parties (i.e. the TNC and South country firm) will engage in intense negotiations on the contents of the technology package and method of transfer, for various complex reasons, the TNCs choice of transfer method will be selected.[34]

We shall examine a model of technology transfer so as to acquire an understanding of the dynamics of this rather complex process. Although it is not specific

[34]The reasons for this as indicated are complex, however, of major importance is the fact that the bargaining power of the South country firm is undermined because - all TNCs (due to the fact that the nature of the market for technology is oligopolistic) over charge for the technology, and because typically, South country officials, both from government and the private sector, involved in the transfer process are often not skilled negotiaters and as a result fall victum to the experienced IP lawyers and business excutives from the TNC negotiating the transfer contract that will provide maximum gains to the TNC; without the South country firm acquiring too detailed a knowledge of the TNC technology. Also because the market for technology is rarely competitive, South country officials cannot threaten to go to another TNC for the same technology as they will often meet with equally unfair terms of transfer there as well.

to each and every type of transfer relationship, it offers a general framework through which we can conceptualise the process. Perhaps the most taxing stage of the technology transfer process (aside perhaps from the actual negotiation) is the decision over whether to proceed with the technology transfer in the first place. Once this decision is made, a number of sequential activities will occur, these activities are stages that comprise the transfer process. The first stage of the transfer process begins with feasibility studies conducted by both the prospective technology recipient, as well as supplier[35]. This process alone (especially by the prospective technology recipient firm, which generally hires a management consulting firm to conduct the study) could take years to complete. When it is complete, however, solicitations of bids are made for elements of the technology or technologies, as well as engineering and plant construction. Again the contract negotiating process could be extremely lengthy, as both parties are attempting to acquire the most benefits from the licensing agreement. Immediately after the conclusion of these negotiations, an agreement regarding the terms and conditions of the transfer are established, a relationship consummated, and the transfer process is started, typically by the transfer of process or product design, along with data, comprising of research results and scientific information regarding the technology. This occurs through intense consultation between technical staff, i.e. scientists and engineers representing the TNC and the technology recipient firm. Then, as Teece (1976) argues, manufacturing facilities

[35]The TNC, for instance, would analyze the potentials and capacities of the raw materials, labour, markets and know-how in the country where the recipient firm is based, so as to establish whether there is a future for its operation in that country.

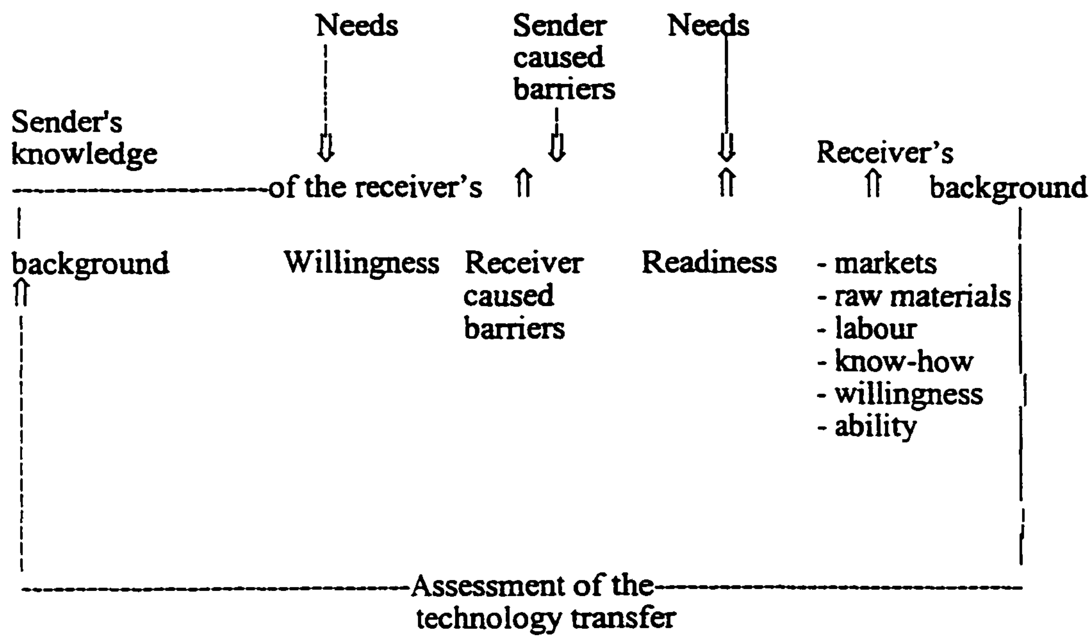
or manufacturing 'start-up' are installed via civil engineering and construction expertise provided by the TNC. There is a significant infusion of new equipment into the production facilities in the importing firm environment, however, depending on skill levels present amongst firm workers at the time, skill training is imparted to workers through OJT overseen and conducted by instructional teams from the TNC. Once the plant is up and running, the TNCs trouble shooting team will be promptly extracted from the scene, signifying an end to the manufacturing start-up stage of the transfer package. It is in this start-up phase (and also a pre-start-up phase when personnel need to be selected and trained, and as well where debugging takes place) that the losses to the recipient firm in the commercialisation of the technology from the technology transfer process significantly accumulate. This is the case principally because of the effects technology transfer costs, which "are the costs of transmitting and absorbing the relevant firm, system, and industry-specific knowledge[36] to the extent that this is necessary for the effective transfer of the technology" (Teece, 1976: 36). However, costs are also incurred because of sub-optimal production (even temporary shutdowns), engineering costs associated with the transfer and process, product, innovation and design engineering and as well payment to personnel training of firm staff, etc.. After this phase, production should start to increase and the firm should see noticeable increases in the performance of

[36]Firm specific knowledge would comprise of organizational and technical knowledge, while system-specific knowledge would be information acquired during manufacturing and other project related endeavours. Industry-specific knowledge would be basic computer programming and mechanical information common to the given industry involved in transferring the technology.

physical as well as human capital. However, costs will still intermittently plague the recipient firm. For instance, in the area of R&D geared at adapting and modifying the technology, the firm will incur significant costs.

The sender of the technology and the receiver of the technology enter the transfer relationship because they perceive there to be a mutual advantage to both the parties engaging in the transfer process. There must exist, on the part of both parties, the need and willingness to engage in the transfer process. The figure (below) illustrates this, but it also illustrates how the TNC and the technology recipient country will erect barriers, in the case of the former, regarding under what conditions, specifically restrictions, the technology will be transferred and used, and in the case of the latter, regarding regulations as to how the TNC can operate in the recipients country and concessions it would have to make in order to ensure that the TNC aids in, and not totally undermines the country's efforts to develop its technology capacities. Figure 5 also illustrates that recipient firm's must engage in a technology assessment after the actual transfer so as to ensure the efficacy of the technology in its productive environment.

Figure 5 - Basic Model of Technology Transfer



Source: A.C. Somli, "Technology Transfer: The general Model", in A.C. Somli (ed.), Technology Transfer (Quorum Books, 1985: 31).

We can infer from the figure above that the technology transfer process is complex. There is interaction between the actors in the process at virtually every level. We will take an example of a technology transfer process so as to better conceptualise the dynamics of the process. We take the example of the case of the transfer of petrochemical technology by Dow Chemical to a South Korean firm.

3.3.3 Technology Transfer: A Case from South Korea

We shall take a case of the transfer of technology from Dow Chemical Company and its absorption and diffusion by a Korean firm so as to examine a specific example of a transfer of technology from North to South. Enos (1982) maintains that in attempting to acquire technology from Dow Chemical, the Korean government was attempting to build the capacities of its petrochemical industry, especially in the intervening period between 1972-76, four critical years that was the period in which the country's Third Five Year Plan came into effect. The government surveyed the North countries to establish what process designs would be most appropriate for the country's petrochemical industry. The government was also interested in attaining two petrochemicals - polyethylene and vinylchloride (VCM), for these processes as well. The Korean government initially engaged in negotiations with a number of TNCs for the provision of such petrochemicals, however, their terms were not acceptable to almost all the petrochemical TNCs approached. Dow Chemical was the only remaining TNC left that agreed to the Korean governments terms. An agreement was drafted between the two parties, after a long period of negotiations, in which it was agreed that Dow Chemical would enter into a joint venture with the Korean government, where it would supply the manufacturing processes (the most modern and identical ones utilised in Dow Chemical companies throughout the world) for polyethylene and VCM.

The terms of the transfer package were that Dow Chemical would supply half the equity capital, while the Korean government would supply the other half. And as each party's share of the equity capital was only 15% each, amounting to a total of 30% respectively, 70% still had to be secured - which it was agreed would be Dow Chemical's responsibility as it would take charge of the floating of foreign loans from banks in the West to supply the remaining 70% of the capital. The president of the Korean firm producing polyethylene and VCM, it was agreed, would be Korean. In addition, Dow Chemical would make available to its Korean partner any process improvement in the production of these petrochemicals that its plants around the world discovered. Also as part of the transfer package Korean workers in the firm (not industry) would also be trained by personnel from Dow Chemical, such that Korean engineers would attain the knowledge of design of the technology and skills to utilise as well as improve equipment used in production; while firm managers would attain appropriate administrative capacities necessary for the effective and efficient functioning of a petrochemical firm. Production capacities transferred and installed would be such that they would reflect and cater to the Korean government's "total domestic demand forecast for the first year after the plant came into operation" (Enos, 1982: 73). In exchange Dow Chemical secured the rights of being:

1.) the only supplier of raw materials (for seven years), excluding ethylene used in the manufacture of VCM;

2.) a royalty of 4% of the value of output and half the firm's profits;

3.) initial selection and placement of supervisors in the petrochemical producing firm;

4.) the limited spread of technical knowledge regarding the production of these chemicals to the one specific firm involved in its production (Enos, 1982).

3.3.4 Methods of Technology Transfer, Determinants of Transfer Method and the Assimilation of Technology

Having examined the technology transfer process, we must focus attention now on the methods of technology transfer that the policy-maker has available to negotiate the transfer of technology from a TNC. The policy maker must understand that transferred technologies typically fall into four categories: 'basic technological knowledge,' consisting of basic design engineering as well as product and process knowledge; 'technical services', which include product and process engineering necessary for initiating, maintaining and sustaining production systems/techniques; 'management services', including project and production management; and, 'embodiment activity', which is the assembly and/or construction of physical structures within which production takes place (Dahlman and Sercovich, 1984). There are, however, a number of transfer methods that are typically employed in a transfer process. The determinants of which mode of technology transfer will be employed is a function of the nature of the technology involved (its complexity), the strategy of the seller (its size and corporate strategic interests and experience in the transfer process), capabilities of the buyer (availability of skills and information in factor markets), as well as the host governments policies, i.e. do they provide adequate incentives for the TNC to engage in business in the country (Lall/UNCTAD, 1995). All these transfer methods have their relative merits and disadvantages for the South country firm. What follows is an overview of these transfer methods. The discussion is not meant to be exhaustive, but rather illustrative of the major transfer methods typically employed in the transfer of technology from North to South countries:

Foreign Direct Investment :-

Advantages - This has historically been one of the few ways that the most up-to-date technology, i.e. frontier technologies, and production capabilities are attained by South country firms. The FDI could be joint venture with majority local participation (i.e. majority local ownership of equity) hence, facilitating for increased South country firm control over its technological transformation. Therefore, because of this the FDI would facilitate for the rapid transfer of technological information and understanding, resulting in a wide range of externalities.

Disadvantages - FDI does not serve to promote the building of indigenous technological capabilities as it serves to substitute and not reinforce these capabilities. For instance the transfer package will often provide capabilities to operate and maintain a production system, however investment capability, i.e. providing capabilities to expand new production systems is rarely if ever provided in the transfer package. In addition, the FDI package will often be structured such that the subsidiary only has minority local participation. Rarely, if ever, is the FDI contract majority local participation hence, the South country firm has a limited control over its technological transformation and a limited understanding of the technology by local workers remains the norm, because the technology transferred or patents supplied are often incomplete or deliberately vague.

Assessment - Generally, FDI creates more obstacles to attaining technological mastery at the firm/industry level than it does opportunities for the building of indigenous or independent firm based technological capacities. For instance, FDI does not offer a way to create new skills and knowledge amongst a firm's workforce. As well, South country firms in this transfer relationship effectively renounce their independence in critical decision-making regarding the nature and amount of R&D, improvements and incremental changes to the technology. FDI then provides a more restrictive environment as to how the technology can be used; and it creates a dependent relationship between the

South country firm and the TNC with obvious ramifications for the control the firm has over its daily activities.

Licensing :-

Advantages - It generally facilitates for a relatively fast and unfettered attainment of product and process know-how. There is also generally a great deal of local control over the use and especially adaptations of the technology by South country firms. This is because in arms-length licensing agreements, the contract is less restrictive (relatively speaking) in that South country firms are given the option of approaching a TNC other than the TNC it has signed a transfer contract with to be the supplier of other technology needs.

Disadvantages - The record of the efficacy of the assimilation or absorption of technology by the South country firms under such transfer arrangements have not been great. In addition, South country firms have a difficult time attaining information from the TNC about advancements made in the technology. This is typically because the TNCs are slow to provide access to or provision of such advancements to these firms.

Assessment - This transfer method provides some degree of control by a South country firm regarding how it makes use of the technology, however, the success to which they can utilise the technology is undermined by the unwillingness of the TNC to provide prompt and comprehensive reports of advancements made to that technology.

Turnkey Projects :-

Advantages - Entire factories and production processes can be transferred using this method therefore the infrastructure will be in place for the South country firm to begin production immediately as the turnkey plant would almost always operate very effectively. This is because a rudimentary understanding of the technological processes of production would be transferred to the firm's workforce through technical assistance relatively quickly.

Disadvantages - For obvious reasons, since the nature of the turn key package is such that the coordination and implementation of the technical and infrastructural aspects of the plant are done on behalf of the South country firm by the TNC. This does not facilitate for a first hand understanding by the South country firm of production processes, affiliated technologies and the very structure of the plant and its component parts, firm officials remain very dependent on TNC officials for maintenance functions and to gain knowledge about how a technology is to be utilised in the production process.

Assessment - Because this mode of transfer creates and reinforces a continuous dependence by the South country firm on the TNC, it does not promote any indigenous R&D or even a familiarity with the technology such that incremental changes can be made to make it more appropriate to the firm environment. This transfer method actually undermines any firm based efforts at technological transformation.

Trade in or Purchases of Capital :-

Advantages - This means of production is acquired by the South country firm without the proprietary baggage and hence, royalty payment obligations of goods/technologies subject to IPRs protection. Therefore, valuable equipment for entire production processes can be attained at less cost by the South country firm.

Disadvantages - Because the instructions on how to operate the equipment that accompany the imported equipment are general and not as detailed as the blueprints or patents that typically accompany contractually based technology, any comprehensive understanding of the equipment is limited. In addition, the usefulness of these instructions are again called into question as they are specific to and reflective of the firm environment in the country they were designed and built for. So issues related to the appropriateness of the equipment exist in such a transfer method.

Assessment - Unless the workforce of the South country firm is very familiar with the equipment and skilled enough to use the machinery as prototypes for reverse engineering exercises and unless the firm has capacity already in place to adapt the machinery to the firm environment, it is doubtful this method of transfer will contribute to any great extent to firm/industry based technological transformation.

Technical Agreements or Purchases of Technical Assistance :-

Advantages - Facilitates technological understanding because foreign specialists hired to disseminate or teach South country firm workers about the technology provide very detailed instruction on the science and practical nature of the technology. In this way, local specialists become well verst in the theoretical and applied understanding of the technology such that their knowledge and skill levels increase. In fact, local specialists who amass a certain level of expertise concerning the technology may in turn be used to teach more local human capital about a given technology.

Disadvantages - This method of technology acquisition has one real problem in that it becomes an easy way out for firm executives who would rather use foreign expertise to give technical instruction to their firm's personnel. Hence, whenever there is a perceived gap in knowledge or understanding, the firm's executives will be quick to turn to or solicit foreign expertise to impart knowledge on a technology or production process. So to a large extent, a dependence on foreign parties is still promoted by the use of this transfer method.

Assessment - However, this method of transfer only facilitates for technological understanding amongst the personnel of the South country firm to the extent that a basic or perhaps fundamental technological/science based knowledge level is already in place amongst the personnel. The fact is, this mode of transfer is a supplementary or complimentary way to build on an understanding by firm personnel of the science behind the technology, but often this method of transfer is not undertaken in this spirit but rather utilised to provide a basic scientific understanding that should already be in place amongst the personnel, but is not. Hence, a great deal of technical instruction may often be necessary, time consuming and expensive, placing a drain on the firm's technological transformation resources and efforts.

The policy-maker may very well be inclined upon assessing the merits and costs of each transfer method to utilise or favour a number of methods, as opposed to relying just on one. Ultimately, though, the policy-maker must insist on the use of the transfer method best suited to the particular circumstance a firm or industry finds itself in vis its current technology capacities. However, the policy-maker must take into account that the extent to which any one of these transfer processes augments firm (industry) based technical capacities is a function of whether the transferred technology functions as a parental germplasm. In other words, the extent to which it can be used for and subjected to generic changes. The extent to which this is at all possible, the greater the likelihood will be that technological capabilities will actually mature in the firm. So the nature of the transfer process has a ripple effect on all cumulative or successive firm based activities to advance up the technology mastery ladder. The first and most critical stage being simply using and becoming familiar with the technology, and imitating the technology by engaging in reverse engineering and to make the technology more appropriate to the firm environment by engaging in adaptive engineering (through implementing minor changes). The second stage refers to indigenous innovative activity put into place by the firm via small and large scale R&D projects.

However, as important as the nature of the transfer process is, to the policy-maker, the issue of appropriateness of technology is equally important. If the firm is to enjoy maximum returns from the technology, it must be appropriate. The firm then must choose technologies (that are either labour intensive or capital intensive) that are reflective of and supporting to its infrastructural, productive, and human capital capacities. A labour-intensive technology has a lower capital-labour ratio K/L, i.e. the technology will increase employment not decrease it, because it limits mechanisation or automation in the production process. A modern technology would typically have a high capital-labour ratio K/L, and as a result, less human capital would be needed in the production process, therefore, the technology is best suited for countries with a low labour supply - which is not often the case in the South - which has an abundant supply of labour. However, the benefits of a high capital-labour ratio K/L technology are tremendous - consider that it has a high output-capital ratio Y/K and a high output-labour ratio Y/L, i.e. the technology facilitates for higher output per machine, per worker and per unit of time and also is able to produce more output with less investment. Although a labour-intensive technology does not necessarily have these features, it is best suited to the production environment in South countries with vast consumer goods industries. The capital-intensive technologies, however, are best suited for the capital goods industries of the North, for example petrochemicals, iron and steel production, etc. However, the selection of the choice of technology by the policy-maker for a particular industry must only be done after careful consideration and study of the technical capacities and aspirations of the firm/industry.

This said, firm and government officials must be quick to recognise that if the firm is to enjoy and employ effective means of technological advancement, the onus for the effective acquisition and utilisation of the technology rests solely in the hands of the firm itself. This is because the TNC only provides the South country firm with incomplete information as to how to make best use of the technology - for obvious reasons, i.e. to sustain a dependence by the South country firm on the TNC , such that the firm constantly returns to the TNC when ever it is in need of another technique or piece (so to speak) to solve the puzzle. It follows then that the South country firm must work hard to establish the expertise and capacities to engage in its own research so when ever it is in need of additional techniques, it is not obliged to always return to the TNC - hence, solving the puzzle independently. We can measure or quantify the success of such an exercise by assessing the availability and types of techniques available at present, as opposed to 5 years ago, in the firm or even comparatively studying growth in productivity levels between these two periods. We can also assess such improvements by analysing output per hour of labour, output per worker, and output per unit of inputs measured by a numbered index. If the quality and quantity of productivity increases it will signify progress that is a function of sustained technological change. However, such change could also be reflected in changes in the firm's capital-labour ratio, i.e. a production process that has a higher propensity to be more automated.

If the firm is to successfully utilise the acquired technology into environment, it must engage in a number of adaptation efforts to achieve maximum productivity potentials of the technology. By engaging in such an exercise the firm's workers not only attempt to master the technology but also to further capacity stretching, bottle-neck breaking, modifications of product design and product mix. In fact, once firms have engaged in research, however small into the technology and other types of 'petty' invention to which firm managers can apply a utility model, a significant mastery of the technology would have already taken place. Enos (1962) defines these petty inventions as comprising a *beta* stage, where technical changes that are minor are directed at adaptation. An *alpha*, stage on the other hand, comprises effort leading to the introduction of radically new technology. Although the *alpha* stage constitutes major technological changes, Enos found that in his study of the petrochemical industry in the United States of America, that significant reductions in production cost per unit actually came from the *beta* stage. The study then served to illustrate the importance of small technical change directed at adaptation or modification - which actually improves production techniques. The *beta* stage is so important because it is in this stage that technological mastery occurs, reflected in greater productivity and the creation of adapted techniques. Hence, it is critical that a South country firm's workforce assimilating a technology amass a significant amount of effort and experience using the technology so as to promote such mastery (Dahlman and Westphal, 1981). Again, the extent to which such activity will at all be possible will depend on the type of transfer method. For example, as we saw earlier in the case of FDI (the method of choice for TNCs for the transfer of technology) mastery of technology does not always occur, and if it does - it does so in a limited fashion.

Historically, South countries have attempted to avoid or at least control contractual transfers of technology, i.e. FDI, so as to avoid the long list of terms/restrictions that are attached to how the technology importer can use the technology. Westphal et al (1984) for instance gives the case of Korea, they describe it as a country being amongst a handful of such countries that were able to technologically transform through the acquisition of limited formal technology via FDI. Korea was able to secure and rely on informal transfer methods, only using FDI to acquire seed technology. The bulk of its technology acquisition efforts were done through arms-length purchases of technology, through purchasing capital equipment, then unpackaging it through learning-by-doing and using other learning methods, and also through apprenticeships (either sending students abroad or bringing experts in to the country to train students), reverse brain drain and, imitation through reverse engineering. Korea severely curtailed the entry of FDI into its economy through tightening controls on that type of investment. The government encouraged the entry of joint venture type investment in the country where Koreans were ensured an equal share of the equity. Therefore, wholly owned subsidiaries which did not promote Korean ownership of some amount of equity and increased competitive forces on Korean firms was not encouraged. This was strictly enforced by foreign investment regulations (at the peak of its industrialisation) which limited foreign participation ratios to 50%, which were, however, steadily relaxed in the 1980s (Kim, 1991). However, the overall contribution of FDI to Korea's "economic development has not been significant", relative that is to other East Asian and especially South East Asian NICs (Kim, 1991: 226). Korea did not rely on FDI and licensing agreements, instead it relied on turnkey plants and the importation of machinery (machine tools) and other capital equipment[37], especially for its chemical, steel and cement industries. Also, informal transfer methods were widely promoted by the Korean government, such as reverse engineering and various apprenticeship activities for Korean engineers abroad. Over the past fifteen years, though, Korea has relaxed policy regimes regarding FDI so as to acquire more advanced technologies.

Policy-makers should be aware, though, that the Korean case (specifically its success in acquiring technologies and investment through means other than FDI) is an exception more so than it is the norm for South countries. It is common for FDI to be the only way of getting technologies into the South because the TNC is more inclined to

[37]In fact, "capital goods imports were worth 34 times the value of FDI, 72 times the value of foriegn licencing, and almost 300 times the value of technical consultancies" (Kim, 1991: 229).

adopt this transfer method as it provides higher returns. However, the TNC does not just commit to FDI in a South country; there are strict criteria it follows. For instance, unless there is relative economic and political stability in a South country, the TNC will not invest. This has been the case in the mineral rich countries of West Africa, like Sierra Lione and Liberia where TNCs have a huge stake in these countrys' mineral wealth but have noticeably been absent from these economies over the last five to seven years since the outbreak of civil war. However, the decision by the TNC to commit to FDI is a complex one and indeed very controversial. Econometric studies of the determinants of FDI flows to a South country have been conducted by Dunning and Buckley (1977). Typically, such studies of FDI determinants can be broken down into time series analysis, FDI cross-section studies and inward FDI cross-section studies. An elaborate set of theories have been articulated to account for what determines the flow of FDI from a given TNC to a South country. These theories have established two factors as being major determinants of FDI flow; the first being *demand-side pull factors*, and the second being *supply-side push factors*. Demand side pull factors include macro determinants associated with the actual size and potential growth prospects of the market (as this will determine the degree of specialisation of production and use of high technologies as well as benefits from economies of scale) the TNC is looking to invest in (Petrochilos, 1989). But also, over and above these considerations are such criteria as factor prices (i.e.wage rates and capital costs), interests rates, the trade deficit in the balance of payments (if it is high, the host country would tend to impose higher tariff and quotas, but if low, trade barriers will also be low) and the nature and variety of investment concessions that host countries have in place as an incentive for TNCs to invest. Supply side push factors, associated with industrial organisation theory, also have a significant role to play in FDI flow in that micro determinants such as product differentiation, firm size and the nature of the product cycle influence the TNCs decision to pursue an FDI initiative in a country. The bottom line, though, is that the TNC's consideration to invest and its investment behaviour in general are determined by profit considerations, and not just based on the criteria in either the demand-side pull factors and supply-side push factors, that are collectively, but not exclusively used in the TNCs consideration to invest. So often what will occur is that, if and when the TNC has lost exclusive protection over the product it is producing, it will make the decision to shift production to South countries that have the capacity to produce standardised goods and at low costs because of low wages hence, giving the TNC a cost advantage and hence, continued profit even after it has lost its exclusive right to produce the product.

The policy-maker, however, must recognise that the acquisition of technology does not in itself mean the firm is automatically going to be building technology capacities. The technology has to be mastered. As noted earlier, this is influenced by the method of technology transfer, however, other factors also come into play; specifically, technology mastery involves a keen understanding of production management and engineering factors. The former refers to critical organisational and control capacities as they relate to the production process. While the latter relates to control and organisational capacities vis-à-vis raw materials, production scheduling and other trouble-shooting activities. Technological capabilities are amassed in stages. First, the firm must master operational know-how of what are called 'easy' technologies. Such a mastery involves the firm's workforce becoming extremely familiar with the use of equipment in which a technology is embodied. The workers then may have to engage in repetitive use of the machinery, memorisation of its functions and use. In Japan and Korean firms, it was not un-common for workers to shout out aloud how and what they were doing with the equipment as they did it. The supervisor on the production line, therefore, would be on the ready to correct any mistakes in worker's description of how they were using the equipment. The next stage of mastery of a technology then would be directed at 'difficult' technologies so as to promote deepening of the firm's technical capacities. Such mastery would typically demand that the worker possess more technical skill. Such skill would enable the worker to effectively amass more skills by the use of the technology, but also go beyond the operation of equipment to the modification of that equipment, by engaging in product design and improvement, as well as contribute to incremental changes in production processes and improvement in the use of technology in that process. This stage is very critical to a firm's technological maturation as by engaging in such mastery, the workers are exhibiting 'know-why' skills, i.e. by designing products and processes as well as improving on them, they exhibit a technical or scientific understanding of the reason why machinery/equipment, as well as the technology embodied in them, work the way they do. Such level of mastery is also very important as it affords the assimilation of complex technologies that will provide high value added and increased competitivity as well as sophistication of the firm's products in overseas markets. However, such level of mastery inevitably enables the firm to increasingly engage in indigenous R&D, as a result, technology tacitness issues can be tackled (discussed below) and effectively addressed. In addition, innovations - the products of R&D - enable the firm to develop frontier technologies hence, placing the firm and entire industry at the centre of rapid technological growth and their products in high demand.

Hence, technological capabilities are "the *skills* and *information* - technical, managerial and institutional - that allow enterprises to utilise equipment, manuals, designs, patents and blueprints efficiently. They comprise the effort that every enterprise must itself undertake in order to master the knowledge that has to be used in production. They are not the technology that is 'embodied' in physical equipment or in instructions purchased by the enterprise, though these are the tools with which capabilities are put to work. Nor are they the educational qualifications possessed by employees, though the receptive base for capabilities needs a trained workforce. They are partly the skills and learning undergone by individuals in the enterprise as they learn to manage the technology and cope with problems, and partly the way in which the firm combines all the above to function as an organisation" (Lall/UNCTAD, 1995: 18). Technology capability building, as a result, occurs when the firm applies those technologies that it is actually engaged in technology capacity building, because it is under these circumstances that the firm can effectively utilise the methods and techniques endogenized in technology to facilitate for technical advance in its production process.

This advance is facilitated by the fact that technology is a method for doing something (typically engaging in efficient and effective production) hence, using this method "requires three elements: information about the method, the means of carrying it out, and some understanding of it" (Dahlman and Westphal, 1983: 6). However, the firm must be careful when selecting technologies they must be appropriate to the factor endowments and environment of the firm. For instance (as mentioned earlier), acquired technologies must reflect or be appropriate to the level of automation/mechanisation at the enterprise or industry level. If the production process is labour intensive capital intensive technologies imported for firm based production would obviously not be appropriate, as that type of technology would work well in a large scale capital oriented production process.

In addition, the selection of the technology must be contingent on price factors. The affordibility of the technology then has to be a factor in the consideration of technology acquisition. However, this is not the sole determinant of whether the firm will acquire a technology. This is principally because "the process of acquiring technological capabilities is a complex and variegated one. Technologies cannot be transferred to developing countries in the same way as a physical product. There are many 'implicit' elements that have to be learned by local enterprises. This process involves time, effort, cost and risk, and complex interactions between firms and between firms and institutions. It is highly sensitive to the incentive environment (macroeconomic policies, trade and industrial regimes) and to the availability of such factors as skills and information. There is thus no predictable learning curve down which all firms travel. The costs and risks of learning differ by technology, with complex technologies involving much higher costs than simple ones. The process is a cumulative and evolutionary one, building upon past choices and experience" (Lall/UNCTAD, 1995: 4).

As a result, before the firm makes a decision to commit the resources to diffuse the technology and hence, engage in technological capability building, there are three factors a firm must examine. These factors have been articulated in various diffusion models. The classic diffusion model developed for agriculture was that of Griliches' (1957), and the classic model developed for industry was Mansfield's (1961). Both these models hint that the three factors that firms must have under consideration before they make the decision to commit to the diffusion of technology is: a.) the number of competitor firms in a given industry that might have already committed or actively engaged in the diffusion of that technology; b.) the assumed and calculated benefits of engaging in such a diffusion effort, and; c.) the costs of adapting the technology. The firms must carefully identify which one of the factors applies to them and then structure its technological development objectives accordingly. Dahlman and Westphal (1983) divide firm based technological development into three areas: production capability that is necessary to operate the technology; investment capability used to upgrade or develop new productive capacities, and; innovation capability necessary for the creation of new methods/techniques. Hence, when we speak to building technology capabilities, we make reference to altering the conditions surrounding the above mentioned three types of considerations such that significant expertise can be built in operating technologies to then master them and build on them - perhaps even alter them. This facilitates even further expertise and eventually a firm based capacity to engage in indigenous R&D and production processes. However, it is only with training and education of human capital though that any of this can be possible as the workforce needs to understand the production processes used from the outstart in production. Therefore, the workforce of a firm can only unbundle the black box that is the imported technology to the extent that they are able to understand how the technology works in the first place.

However, this said, the building of technology capacities is an on-going process/project; it will change over time as the needs of both the firm and consumer evolve, but also as the firm/industry and the entire sector mature. Hence, the necessity of efforts to build technology capacities and accommodate these changes. Typically, the process must initially begin with the recognition that skills are lacking in the workforce and the entire infrastructure necessary for production is lacking. Then an appropriate course of action would be, for example, to enter into contractual relations with a TNC, such as a licensing agreement and once acquiring the technology the firm should ideally engage in reverse engineering, as well as R&D initiatives so as to better unravel the acquired technology and develop greater knowledge of production processes and the product itself. Or the firm may decide to purchase a turnkey project, where a variety of infrastructural and technical support is provided by the TNC to the South country firm. Because the entire production process and know-how to operate the process is transferred to the South country firm, it allows that firm to build progressively and systematically, but most importantly consistently, on its investment and innovation capability. The strategy for technology capability building will of course differ depending on the sectoral strengths and availability of relevant factor endowments between different nations at the time of a needs assessment and action for the acquisition or transfer of technology.

3.3.5 The Tacit Nature of Technology and the Importance of Indigenous Technological Capability

The transfer of technology, although essential for South countries to begin to establish capacities necessary for technology capability building, creates a problem that in the long-run, could significantly affect the South firm's capacity to technologically transform. This problem has to do with the fact that much of the knowledge about techniques of engaging in a production process utilising a specific technology is *tacit*. These techniques are not embodied or codified in any instructions as to how to go about utilising a transferred technology. The situation is not helped by the fact that the recipient firm of a foreign technology will often attempt to utilise the technology in a generic manner. Because the tacit characteristics of the technology are not understood by the recipient firm, the technology is often used at a sub-optimal level, i.e. it is not being used with absolute efficiency. Even when the firm attempts to make generic changes to the technology, it faces significant problems, as mastery of the technology is undermined because the firm's workforce is not able to effectively unpackage and understand the technology because they lack an understanding of the tacit characteristics of that technology. This problem of tacitness can be some-what addressed by learning-by-doing approaches to technological mastery on the 'shop floor', as it enables different ways in which to apply the technology for productive purposes until one has exhausted all avenues under which the technology can be employed. For example, Firm B (a technology receiver in a developing country) must move beyond a simple assimilation of Firm A (technology supplier in a developed country) technology, even though that technology may be considered a best-practice technology. Through assimilating an acquired technology, Firm B is simply duplicating techniques for its own particular circumstance. In doing this, Firm B is employing Firm A's understanding of technology and how the technology must be used. However, that understanding was initially developed to employ a technology that would be appropriate to and work in an environment and under constraints specific to Firm A, not Firm B. Therefore, an understanding of the technology specific to Firm B's environment must be developed for the technology to be optimally or most effectively used in Firm B's setting; because even if the technology may be best-practice to Firm A it certainly is not for Firm B. In order to create such an understanding, the workforce of Firm B must be highly trained so as to engage in technological mastery of the technology such that they can create technologies indigenous to Firm B through R&D methods specific to Firm B. The innovation then would be specific to Firm B, and produced with the notion that it will work most effectively in Firm B's production environment. As a result, the technology could be used in an optimal fashion in Firm B because the firm's workers have a tacit understanding of the technology. The implications of this would be that Firm B's technological capabilities would grow because of the use of know-how specific to the firm's effort at R&D. Therefore, the firm can move from being technologically dependent, i.e. reliant on the purchasing of foreign technology, to technologically self sufficient, perhaps even one day a pioneer (Ergas, 1987).

However, the fact still remains the South countries are in need of technologies. The fact is, they are dependent for the majority of their technology needs on foreign suppliers, as a result of their limited capacity to engage in indigenous R&D. While there is agreement that at least in their initial stage of industrialisation, South country firms inevitably need foreign technology to secure their technological transformation, there is little agreement as to how such firms should use the imported technology. As illustrated by Korea and all other East Asian NICs, they were able to develop a "research and manufacturing base that is able to copy, adapt and build upon imported technologies [...giving...] it a base of capabilities to cope with emerging technologies that is probably unmatched, especially in advanced manufacturing activities" (Lall/UNCTAD, 1995: 30). However, this turn of events in Korea is the exception rather than the norm in the South. Furthermore, over-coming problems of tacitness is not the only consideration for South country firm's in deciding to engage in innovation activities of their own. There is mounting evidence that suggests that the majority of South countries are not making use of or developing their own technology in any significant fashion. This is commonly argued (as we have reviewed above) because the necessary firm/industry based capacities are not in place to do so. This is not the only contributing factor though. Equally important to note is the fact that the North countries make up a majority of those parties actually registering patents in the South, and what is worse still, is that those patents are not being exploited or made use of. The very fact that patents are lying idle takes away from the productive/commercial use they *could* very well have in industry growth in a South country. While the majority of patents registered in the South remain in the hands of Northern TNCs (and are unexploited), the fact that only a handful of patents are claimed by South countries out of which about half those patents are also under or not utilised, in the long-term, will prove to be a serious impediment to South country technological and economic growth (Massel, 1973). As a result, the need for innovative activity and patent registry by indigenous South country inventors is critical if patents are to be indigenously owned, but also if the patents are to be effectively utilised instead of just lying idle and not engaged in productive activity. In addition, as Vaitsos (1972) points out, if foreign TNCs are allowed to take out more and more patents in South countries, they will be able to secure a competitive edge in the export of their products to South country economies, as South country business or industry would be unable to imitate or offer similar goods for export to the same markets. As a result, competition from South country firms would be eliminated and international cartels of TNCs would be reinforced as a result of patent pools. These outstanding issues can only be satisfactorily addressed to the extent that the policy-makers of South country governments actively put in place and build significant indigenous R&D capacity in industry, the public sector and the scientific community. The extent to which this will become a reality will be a function of how, in what way and how fast South countries are *willing*, *committed*, and *able* to plan for their technological transformation.

3.4 Economic Policies that Compliment the S&T Policy

This said, there are a number of economic policy measures that must be in place in order for an S&T policy to be at all effective. Two policies in this regard are of special importance, the first is commonly referred to as savings and investment policies, and the second is selective infant industry protection. We will review both and also analyse their implications for S&T capability building efforts in the South.

3.4.2 Savings and Investment Policies

The profit-savings-investment nexus is perhaps one of the most central tenets of macro-economic growth policies that best explains, in large part - aside from S&T policy planning, the growth dynamic of all East Asia. Japan by far has understood this concept and translated it into practice. Such application of this fundamental theme in economics in the East Asian context has brought the region unsurpassed prosperity in social and economic growth efforts. We must, prior to an analysis of the profit-savings-investment nexus, briefly examine the theory of savings.

Saving is a function of choice between present and future consumption. Saving enables growth, just as growth enables saving. High-saving countries grow faster than low-saving countries, because higher saving actually increases the growth rate of output by significantly increasing capital accumulation (Mankiw, et al., 1992). It is the attainment of significant capacities in capital stock that contribute to increases in growth rates[38]. Therefore, it is imperative that nations increase savings rates in order to promote

[38]Increase in stocks of capital have been cited as a major contributing force of increasing growth rates. Kwon (1986) empirically and quantitatively proves this by decomposing the measured growth in TFP. He proceeds to develop a translog cost function in order to derive cost/output and cost/capital-utilization elasticity functions. In doing this, the author attempts to include capital utilization, a component in his over all analysis, into an analysis of the sources of growth in the South countries of East Asia in the manufacturing sector. In linking TFP to selected parameters of a cost function, Kwon illustrates that technical change, change in capital utilization and returns to scale (all component parts of a productivity index) grew rapidly over a 19 year period 1961-1980.

capital formation and as a result economic growth. Hence, a savings and investment policy is critical to any nation's development.

There is, however, no one type of savings characteristic of a particular economy. Instead there is a wide range of savings methods and sources because of the abundant and varied actors in a nation's economy. There is, of course, domestic savings (S_d) that comprises public sector (S_g - raised from budgetary saving (S_{gb})) and private sector (S_p - raised from corporate saving (S_{pc}) and household saving (S_{ph})) saving, and there is foreign savings (S_f - which comprises official foreign saving (S_{fo}) and private foreign saving (S_{fp} - which comprises debt financing (S_{fpd}) and direct investment or equity financing (S_{fpe})) (Gillis, et al., 1992).

Total savings in a given country then amounts to:

$$S = S_d + S_f = (S_g + S_p) + (S_{fo} + S_{fp})$$

If disaggregated, savings policies can be understood as:

$$S = [(S_{gb} + S_{ge}) + (S_{pc} + S_{ph})] + (S_{fo} + S_{fpd} + S_{fpe})$$

Japan's and East Asia's success with the profit-savings-investment nexus lies in policies that significantly increased the propensity of three very important actors to save.

In fact TFP grew at 3.0% p.a. of which scale economies contributed 38.1%, technical change 44.6% and the change in capital utilization rate ammounted to 17.3% contributions to TFP, respectively. His article argues that it was in fact a rapid growth of capital in this region which enabled labour to process larger amounts of materials and increases in the rate of growth of TFP, that accounted for the transformation and rapid growth, especially of the Korean manuacturing sector. Hence, in terms of relevance to policy lessons, it is paramount that South countries learn from this experience and significantly increase capital levels - achievable through increased saving and decreased consumption.

The first of which was the households, then the private sector and also the government. We find that countless hypothesis have been developed to explain the determinants of household savings, from Keyne's relative-income hypothesis, to the Duesenberry hypothesis, and the permanent-income hypothesis formulated by Milton Friedman. Household and corporate savings are two very important variables in the savings dynamic of a nation. Governments in East Asia harnessed their savings capacities and potentials (i.e. especially of households and corporations), and used it to significantly contribute to the regions dramatic growth in the past four decades. In terms of a policy context, the question is how were these governments able to do this, when in the South as a whole, the propensity to save has always been so alarmingly low? East Asian governments, beginning with Japan, historically encouraged high corporate profits, savings and investment. The effects of these large rates of savings and investment have been reflected in remarkable growth rates in real GDP, which for East Asia in 1994 in percentage figures, amounted to 8.5% for Thailand, 8.7% for Malaysia, 6.8% for Indonesia, 8.4% for Korea, 6.5% for Taiwan (province of China), 5.5% for Hong Kong and an amazing 10.1% for Singapore (JISEA, 1996).

The neo-classical economists attribute East Asia's high rates of savings and investments to *'sound fundamentals'*, i.e. the efficacy of macro-economic management in the region (Singh, 1996).[39] For example, they cite inflation levels and exchange rate fluctuations that have historically been very low. In addition to this, these economists

[39] The following analysis builds on the arguments made by A. Singh in UNCTAD (1996) Study No. 9 on East Asian Development.

also attribute high savings and investment rates in households to complimentary policies by East Asian governments that have encouraged the implementation of land reform, and relatively equitable income and wealth distribution. These factors combined with low financial repression and positive real interest rates, they argue, made for a conducive environment to promote savings. However, these economists only tell half the story. They fail to speak to the region's systemic features such as its highly educated population.

There are varied accounts though as to what one factor was responsible for East Asia's dynamic growth. Nsimba[40] argues it is a combination of TFP led growth in East Asia complimented by domestic savings that were able to finance investment and factor input accumulation that grew the East Asian economies so fast and dynamically. However, most economists choose to side with either one view or the other. So there are conflicting views about which approach to growth played more of a role in East Asia's industrialisation. One view suggests that it was TFP growth, while others argue it was the role of domestic savings or factor accumulation that facilitated for such dynamic growth.

The neo-classical economists, for instance, point to the importance of technical progress as a factor in the region's growth.[41] TFP in the region has historically been high, and it is argued that this has led, in large part, to the dynamic growth in the region.

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[40] Interview with Edouard Nsimba, Economic Affairs Officer, Department of Social and Economic Policy Analysis, United Nations, New York, July 8, 1997, 10:00-11:15.

[41] Technical progress is measured in terms of total factor productivity (TFP), which is a measure of technical progress as a proportion of output growth in aggregate.

Bosworth et al (1994), for example, argues TFP has accounted for 12% of the regions sustained growth. This view, however, is contradicted by Lou and Kim (1994), as well as Young (1994), who argue that TFP has historically been very low in the region. Instead, they attribute the region's growth to the rapid expansion of factor inputs, i.e. capital inputs as a result of the sizeable rates of capital accumulation. If we assume then that most countries in the region have had little technical progress (which is very hard to imagine), then we must assume, as Krugman (1994) argues, that rates of growth in East Asia are not sustainable. This can be argued for the simple reason that if these countries are investing in access of, or in some cases up to 40% of GDP, it is not likely that they will be able to raise investment rates any higher. Because their population is already highly educated, governments would have to concentrate on building other factor endowments. However, if technical progress were not occurring at a significant rate, it is entirely likely that decreasing returns to investment will be the offshoot of this and hence, constrain the growth capabilities of these countries. UNCTAD economists refute this view (UNCTAD, 1994). They maintain that the extraordinary growth rates in East Asian economies are attributable in the main to significant rates of capital accumulation. Therefore, decreasing returns should not occur, providing we understand that large rates of investment (inherent in which are capital goods) should result in a greater pace and degree of technical progress, principally because technology can be diffused at a faster rate as result of a highly skilled labour force. Under these conditions, economic growth would accelerate not decelerate. Clearly UNCTAD economists put more stock in the efforts of the accumulation process than the 'sound fundamentals' approach of the orthodox economists. Hence, to a large extent it is the dynamics of capital accumulation in the region that acted as a catalyst for transformation of the economy.

Interactions between profits and savings in East Asia acted in such a way that a cyclical effect was created, where large corporate profits would spurn investment and would at the same time be the outcome of investment. Therefore, exceptionally large rates of investment and the concurrent effect of domestic savings serving to buttress this investment contributed significantly to growth in the region. The government supported and galvanised this by creating policies aimed at boosting the process of capital accumulation principally by developing rents and creating an environment where profit levels increased to such levels that under conventional laissez faire Capitalism, would not be conceivable let alone possible (Akyuz and Gore, 1994). The marginal propensity to save, as well as to invest, has historically been high in the region. Corporate profits served to stimulate savings and capital accumulation; this accumulation process was, in turn, buttressed and increased by government efforts at rent creation, and other similar policies. At the same time, because of high levels of investment in the region, as a result of large profits, the propensity of households to save was dramatically increased. Other voluntary savings initiatives were developed by East Asian governments like creating attractive long-term savings plans (Singh, 1995). However, household savings were also encouraged through more coercive means, such as increasing levels of contributions to social security benefits, restrictions on imported luxury items, and in some cases, credit rationing, for consumption and mortgage purposes. What is remarkable is that these nations managed to achieve current account equilibrium along with significantly high growth rates (Palma, 1996).

Thus far the analysis of the profit-savings-investment nexus has illustrated that high savings and investment, in addition to be a distinguishing feature of the East Asian economies, have led to the significant, sustained and rapid technological transformation and economic growth of the region. Boltho (1975) investigates gross savings rates comparatively amongst major North countries, and Japan ranks number one. This is evidenced in the fact that gross savings ratios as a percent of GNP (at current prices) for Japan during the period 1953 to 1972 were 36.9%. Disaggregated, they amounted to 15.8% for households, 13.5% for corporations and 7.8% for government. Compare this with the USA which for the same period had savings ratios which totalled only 18%, once disaggregated it amounted to 8% for households, 7.7% for corporations and 2.4% for government. Why is there such a dramatic difference in gross savings ratios between Japan and most other North countries? The difference is so dramatic because Japan has been so successful in increasing savings amongst household and corporate actors. How has Japan done this? Japan, like much of the other East Asian countries, has been successful in promoting saving so as to promote economic growth, by implementing a series of policies. These policies target or are centred on promoting good relationships between government and the private sector, on the one hand, and equally good relationships between corporations and the financial system. The state in the region has historically promoted technical transformation and investment by its control over or curtailment of domestic competition. In addition, governments in the region have extensively engaged in credit rationing, this has generally reflected the extent to which these governments will go to establish a certain relationship between corporations and financial systems. Hence, financial repression has always been a characteristic feature of economies in the region, as governments have attempted to artificially control the interest rate structure to set up an economic environment that it perceives is conducive to the effective performance of the private sector. Typically, the relationship between 'parent' banks and corporations have been structured in such a fashion that credit has been readily available to companies on demand, creating an environment that has facilitated for the accelerated propensity to save and invest on the part of the private sector.

What we have attempted to illustrate through a review of the profit-savings-investment nexus in East Asia is that the high propensity (especially of corporations) to save in the region was a direct function of high profits and high inducements to save, i.e. a cycle between growth and savings exists where increases in growth raise savings rates which come full circle to increase growth. Similarly, in the context of households, a high propensity to save a large portion of income is attributed to the fact that most incomes are high in the first place (IMF, 1995). In addition, the propensity of households to save and invest has also been relatively high because of the "low income elasticity of demand for foreign goods, the low level of development of financing and credit facilities for consumers, (...as well as...) formal and informal controls on imports of consumer durables" (Singh, 1996: 45). The profit-savings-investment nexus was created as a result of conscious efforts of governments in the region to create a savings level so high, that East Asia is recognised as having the highest savings rate in the world. These savings levels have translated into the availability of more resources for government to pursue its industrialisation objectives and specifically sponsor many of its S&T activities/programs.

3.4.3 Selective Infant Industry protection

To encourage indigenous S&T capability building though it has also been quite apparent that government's of the South must also carefully or prudently regulate the import of disembodied (e.g. patents, technical assistance) and embodied (e.g. machinery and equipment) technology and further still regulate foreign investment through the imposition of certain investment controls on the nature of foreign capital entering the country. "The regulation of technology imports may protect infant industries and stimulate their development, lead to a better balance-of-payments, generate increases in employment and promote the development of local S&T capabilities. In effect, new industries may be given the opportunity to become more efficient before facing competition from imported products; industrial balance of payments problems may be ameliorated by import controls and the regulation of foreign investment; limitations on machinery imports may encourage more intensive use of domestic resources, particularly labour" (Sagasti, 1978: 67). Such import controls are an integral part of an economic policy aimed at spurning industrialisation[42] through infant industry protection.

Infant industry protection occurs because an industry as yet has not amassed comparative advantage capabilities hence, dynamic competitive capacities. "Infant

[42]"Industrialization refers to the simultaneous occurence of high growth of industrial output with the industrial sector accounting for a progressively larger share of the GNP, largely at the expense of agriculture - and a transformation of the structure of industrial production itself" (TEP, 1992: 260).

industries are industrial activities that are being undertaken for the first time in an economy" (Bell et al, 1984: 101). These industries must face a situation where " the economy's existing endowment of skills and human capital does not provide for it to attain immediate technological mastery" (Westphal, 1982). Infant industries will remain so unless and only if significant capabilities are amassed to enable technological change hence, a move toward maturation - i.e., rising productivity with corresponding falls in unit costs. Maturity of such an industry is indicative of a group of firms having attained a high level of technological capability such that they become internationally competitive. But under what conditions is such a maturity dependent? Most economists argue that such a strategy will involve the application of import substitution industrialisation (ISI) policies in the country. Such policies aim at protecting such firms through government involvement in price distortion which will normally infer that government intervenes in trade and economic activity, i.e. process of resource allocation. Such strategies have been the subject of countless analysis and study by economists, some of whom have argued it does not promote the maturation of industry and some who argue it has. Typically economists arguing the new orthodoxy will purport that countries following an export oriented industrialisation (EOI) strategy will have greater real GDP growth rates, manufactured export growth rates and overall economic efficiency as reflected by lower incremental capital-output ratios (ICORs). Other economists, however, argue that without infant industry protection, foreign competition from large TNCs would undermine the competitivity and livelihood of these emerging industries. From a policy point of view which strategy is the correct one? What does the evidence show us?

Dodaro (1991), employing a cross section regression analysis, attempts to illustrate the relationship between the level of a country's development (i.e. per capita GNP increases) and the composition of its exports and how this contributes to economic growth. The analysis serves to reinforce in a conclusive and quantitative manner that exported growth strategies are not absolutely superior in acting as catalysts for economic growth. In the data set of countries, the author compares those that utilise or practice ISI and EOI policies/trade orientation (Dodaro, 1991). Countries with the EOI policies are not necessarily better off than ISI countries because the exports of EOI South countries are very limited because they cannot take advantage of value- added because, any attempts to process/manufacture exportable goods to any significant degree is met with great opposition (in the form of greater trade and non-trade barriers) from North countries.

Despite this evidence, the infant-industry argument is still not accepted by many economists as a helpful mechanism for a nation to develop its firm/industrial based technological capacities. This is the case despite the fact that many North countries in the nineteenth century actively utililized policies to protect infant industries from foreign competition because they realised their firms as infant industries did not enjoy economies of scale. Such sentiment was quite common amongst German economists at the time who were wary about German industry competing without some form of protection against advanced and well established British industries. Even John Stuart Mill argued for infant industry protection saying "the only case in which, on mere principles of political economy, protecting duties can be defensible, is when they are imposed temporarily (especially in a young and rising nation) in hopes of naturalising a foreign industry in itself perfectly suitable to the circumstances of the country" (Mill, 1848: 101).

Some economists, like Krueger (1982), have argued ISI actually serves to stem or retard technological capabilities. As a result, they have argued the infant-industry argument is untenable. However, this would appear to contradict the experience of East Asia that the 'revisionist or governed market view'has argued had quite a successful history utilising selective ISI strategies, but interchangeably with EOI strategies. East Asian government's actively intervened in the economy, especially when it came to protecting infant-industries (Amsden, 1989). Amsden, for one, argues the Korean government has extensively utilised protective policies regarding its infant-industries. For example, it actively promoted export subsidies, import quotas, licenses, selective credit subsidies, tax exemptions, Korean ownership of firms, and other mechanisms of trade protection. However, the Korean government made sure that such an incentive regime did not become subject to rent-seeking, i.e. the policy regimes that were implemented were very disciplined so as to maintain and not compromise its efficacy (Wade, 1990). This was achieved because of the incredibly close consultation between the public and private sectors in the region that established common goals and worked toward them. More recently attempts to establish whether infant industry protection or EOI are superior policy regimes for faster productivity growth has added little to the infant industry or the EOI method of or approach to the industrialisation debate (World Bank, 1993).

In fact some economists like Castley (1997) have altogether dismissed the statists' claim that government intervention or the 'visible hand of the state' and the neo-classical development school's claim that an unfettered free market were catalysts for the rapid growth that has taken place in East Asia. In reference to the growth experience of Korea, Castley argues that dynamic trade expansion cannot be accounted for by conventional explanations, that account mainly for the role of 'internal factors'. While supply side variables have historically been argued to have contributed to Korea's dynamic industrialisation, trade expansion in the country was a function of complex set of factors. Granted, on the 'supply side', lower labour costs and subsidies significantly contributed to growth in Korea, but on the 'demand side', specialisation brought on by economies of scale also played a critical role in this growth. Even more important to this growth (and the region's growth as a whole), Castley argues, was the role of external regional forces - specifically the triangular trade pattern masterminded by Japan. "Accordingly Korea's (economic) expansion was not a matter of market forces or free trade policy, as the neo-classical school would have us believe or government intervention, although export incentives undoubtedly contributed to this growth, but rather Japan's investment and trade policies which in turn were determined by Japan's industrial restructuring" (Castley, 1997: 206).

Nevertheless both government and industry in East Asia have in large part remained oblivious to, and especially, dismissed the statistically and empirically supported studies of the new orthodoxy espoused by Balassa (1978) and (1985), Krueger (1978), and others who have advanced the notion that better industrial performance could be provided by the non-intervention of government in the economy. By historical experience we can see that despite Castley's arguments governments in the region have realised that *selective protection*[43], i.e. not-indiscriminate protection, of infant-industries has resulted in the dynamic transformation of their country's industrial base. In protecting infant-industry governments in the region have succeeded not only in protecting and limiting competition to emerging firms, but also resulted in ensuring that these firms have an enabling environment for the mastery technology and hence building their own technological and productive capacities.[44] This has been recognised as going a long-way in addressing South country firm's technological dependence on North country TNCs. Such propensity to rely on these technology suppliers for what have often been inappropriate technologies negotiated under terms that do little to build indigenous technological capacities has significantly undermined the S&T effort of many South countries. Hence, the critical importance of having a well established infant industry policy to promote indigenous technological capacity building through greater local R&D and under market conditions that are favourable for the sustained operation of infant firms without the concern of them being eliminated as a result of overly aggressive competition from more mature and technologically advanced foreign TNCs.

[43]By doing this, more resources can be concentrated into a few industries, therefore, the firms will be able to attain a critical mass in those factors that will result in their technological transformation.

[44] Interview with Mr. K. Rahman, Senior Economist, UNCTAD Liason Office, July 8, 1997, 10:00-11:15, New York.

Import controls that are part of an industrialisation policy must not be confused with foreign investment regulation, which is an important part of an S&T policy as it aims at developing indigenous or local S&T capabilities in industry. Korea, for instance, regulates the activities of foreign investors in order to facilitate technological transformation within its industrial sector. The government does this by limiting the industries and markets in which foreigners can invest in. It actively works to prevent TNCs in its economy from pursuing restrictive business practices (RBPs) and it ensures that know-how and skills are passed onto Koreans working in the subsidiaries of foreign TNCs. However, Korea is unique in this respect as it has been able to effectively legislate, regulate and control the nature of investment entering its economy. Not many other South countries can claim to have such control over TNCs and types of investment entering and operating in their economy. This is the case because Korea has not fallen victim to the massive foreign exchange and debt crisis that Africa and Latin America have.[45] Because these countries desperately need foreign exchange, their regulation and

[45]Only recently has Korea (as has most of the entire East and South East Asian region) fallen victim to the enormous currency crisis that took root in the region in the latter half of 1997. In fact Korea has had to recieve a multi-billion dollar bail-out package sponsored by the US and the IMF. The crisis has largely been precipitated by the irratic behaviour of portfolio investments going in and out of the East Asian economies and wide spread speculation by foreign investors in Korean and international currency and stock exchange markets. In fact much of East and South East Asia is currently struggling to recover and resecure investor confidence in their economies. Such investor confidence may not be quite so forth-coming, however, for quite some time because several banks throughout the region have collapsed because loans owned to them by businesses that used the money/credit to engage in massive construction activities have as yet to be paid back. As it stands, the continued decline in the value of most major Asian currencies like the Thai Bat, the Korean Won, the Indonesian Rhupia, and to an extent, the Japanese Yen; are continuing at unprecedented rates. In fact, most of these

criteria for TNC entry into their markets are not as strict as Korea's hence, TNCs take advantage of this and engage in limited efforts to aid these countries in indigenous technology capacity building efforts. In fact Korea has made use of a comprehensive regulation mechanism for imports through the use of a system of licensing agreements. These are contracts where the TNC sells firms in Korea the right to use their products. By having a registry of patents, governments can monitor and rectify TNC abuse of licensing contracts which occur because TNCs often overprice or supply inappropriate capital and intermediate goods to South country firms. Korea's infant industries, that were particularly effected by the government's infant industry protection policy since the 1970s, fall into two categories - the heavy and chemical industries. These industries matured as rapidly as they did in part due to the policies of the government, but also because the relatively unfettered industrialisation of Korea provided for rapid structural transformation of industry. However, efforts to protect the domestic market while spurning liberalised exports was a major initiative by the Korean government that enabled the transformation of industry. To stay internationally competitive, Korean firms have had to produce standardised products for export hence, the quality and technology employed in the production of these products changed significantly in order to maintain the competitivity of Korean exports. So while Korean firms were protected in domestic markets, they avoided complacency as they had to maintain international competitiveness - this has not been the experience of much of the South though.

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countries have experienced in access of a 30% drop in the value of their currencies with no reprieve in sight.

While there are important lessons to learn from Korea's effort to build its technology policy by heavily regulating the investment environment, there are also important shortcomings to such policy initiatives. Specifically, the technology planning experience of India has illustrated what such regulatory policies should not do - namely, focus too much on promoting a 'closed' technology policy. The Indian government has had a long history of attempting to achieve technological self reliance (i.e. promotion of indigenous technological innovations as opposed to a reliance on the import of foreign technologies) in its industrial sector. To accomplish this, the government has promoted a 'closed' technology policy (Fikkert, 1994). In order to promote the development of such a policy the Indian government has promoted a weak patent regime in the country, it has also significantly limited the entry of FDI in to the economy, and has also stringently regulated technology purchases by Indian industry of foreign technology. While these initiatives have been perceived by Indian policy-makers as critical policies that are absolutely essential to promoting technological self reliance - we ask the question has this actually occurred?

Authors like Desai (1980) and Lall (1987) have argued that efforts by South country governments to limit the entry of foreign technology is a misguided policy, because far from promoting technology capability building at the firm level, it retards it. They argue the reverse is true, and that is if foreign technology is allowed to enter the South country firm environment local R&D will in fact be stimulated. However, Fikkert (1994) maintains that such an argument is flawed because the purchased disembodied technology that supplies South firms with basic designs and know-how for assimilating the technology is enough to support existing production systems and, therefore, R&D into those technologies is in fact not mandatory. So far from spurning indigenous R&D efforts in the South country firm, foreign technologies just promote a further dependence of these firms on technology from foreign TNCs. Fikkert (1994) makes use of panel data from 571 Indian firms in the period of the middle to late 1970s, and develops a model where R&D and technology purchase are choice variables. The parameters of the model are established by the use of a set of exclusionary and cross-equation parameter restrictions. He treats R&D and technology purchase as endogenous variables so as to examine the implications of the Indian governments regulation on technology purchase licences, and comes to the conclusion that technology purchases of foreign technologies by Indian firms does in fact substitute for expenditures on indigenous R&D.

Hence, we can establish that there is significant merit to certain aspects of a 'closed' technology policy. It enables for infant industry protection, but also encourages local R&D effort that is undermined with the indiscriminate importation of foreign technologies. In the Indian case, Fikkert found that stimulus to local R&D in Indian firms was small as a result of the 'closed' technology policy environment. However, such results are specific to the Indian firms examined in his model, and should not be viewed as indicative of what will happen in other South countries that adapt similar policy regimes. It is argued here that *some* features of a 'closed' technology policy are in fact beneficial to a South country. Experience has shown that significant restrictions, especially on the entry of FDI, can in fact spurn or support or be complimentary to a R&D effort in a country as opposed to entirely replacing such local effort in this regard.

Similarly the nature of the patent system effects the occurrence of reverse engineering and R&D effort in industry. Generally, a weak patent system will facilitate for rapid and sustained duplication of technologies by local South country firms as well as an increased R&D effort (Diwan and Rodrick, 1989). India has had relative success in promoting local equity participation and technology transfer activities so as to build its technology capacities. The Maruti Udyog Car Company, for example, with Suzuki of Japan signed a collaborative agreement in 1982 to produce passenger cars, micro-buses, pick-up vans and jeeps in India (Joseph, 1990). Although the process of indeginization of automobile technology has been much slower than expected and the quality of cars produced only satisfactory, a significant transformation has occurred in the Indian automobile industry. Specifically, it has been modernised, its manufacturing infrastructure has been revamped, and product technologies diversified and upgraded.

3.5 CONCLUSION

In this chapter, we examined the dynamics of a S&T policy. We dichotomised a S&T policy and examined the components of a science policy and a technology policy and then examined how a S&T policy could serve as a planning tool. We then developed guidelines for instituting such a policy framework in a South country. In this context we reviewed how the policy-maker may want to approach a technology development path and what questions he/she will have to consider before the decision is made to import the technology and during the assimilation of that technology. We also considered what steps need to be taken to effectively assimilate the technology so as to better understand how it can be diffused and modified in the South country firm environment. To help complete this account we reviewed a model of technology transfer and a case of technology transfer between a petrochemical firm in South Korea and Dow Chemical.

The chapter also reviewed the methods of technology transfer available to a South country firm. Specifically, we undertook an assessment of FDI, licensing, turnkey projects, trade in capital, and technical agreements - examining both their merits and disadvantages. Attention was also given to the various theories accounting for what the determinants are for a TNC to make the decision to invest in a South country. The chapter then turned to an analysis of how the South country policy-maker can insure the firm or industry is getting appropriate technology. We focused specific attention, in this regard, to labour and capital intensive technologies and considered under what circumstances either one of them could serve as parental germplasm so as to contribute to the existing technology capacities and expected technology goals of a firm. The chapter also maintained that this approach to technology mastery in the firm could greatly be aided by small-scale R&D efforts in the firm aimed at minor or incremental modifications to imported technologies, bolstered by a well established reverse-engineering program.

We also alluded to the fact that while foreign technology helps immensely in local firm based technology building efforts, it should not replace a R&D effort in that firm. This is important as a foreign technology has certain tacit features unique to the firm environment it is coming from and not the firm environment it is transferred to. Hence, the productive capacity of South country firms will always be undermined unless and until they can introduce into their environment technologies suited to the production processes and management systems of that firm.

The chapter then examined two critical economic policies that must be instituted in tandem with or in support of, the S&T framework we developed. These two economic policies are the investment and savings policy and the selective infant industry policy. The analysis of these policy regimes accounted for why they are important to the S&T effort of a nation by giving specific attention to their role in the technological transformation of East Asia. Specifically, we examined their role in Korea and India. The experience of Korea and India in technology capability building provides important lessons for the South, highlighting both the does and don'ts of an indigenous technology effort buttressed by a selective infant industry protection policy regime. The operative word here is 'selective'. There clearly cannot be indiscriminate use of ISI policies, there must be a delicate balance struck between ISI and EOI policy regimes. Similarly elements of both a 'closed' and 'open' technology policy must be pursued, policy-makers must recognise the shortcomings and advantages of both policies and extract best-practices from them.

The chapter established that the creation of technological independence is the long-term policy objective of an S&T effort. Strategic or more short-term goals include providing for or building the capacities onto which these long-term goals can become a reality. While a S&T policy remains focused on efforts to acquire physical and human capital technology needed by economic sectors to facilitate for industrial and technical transformation, as we have seen, complimentary policy initiatives need to be pursued.

Such policies as savings and investment and selective infant industry protection will serve to reinforce and increase the efficacy of a S&T policy. Until, and unless these supporting policies are operationalized in tandem to a S&T policy, these policy efforts will be incomplete and generally unsuccessful. This is primarily because a S&T policy cannot operate effectively in isolation or in a vacuum.

Chapter 4 - S&T Planning Strategies: Best Practice Techniques from East Asia for the South

4.1 INTRODUCTION

The chapter examines East Asia's S&T policies, specifically the S&T framework - including, the infrastructure, policy regime, and best practice strategies employed by Japan and Korea to direct their efforts at technological transformation. In analysing S&T policy planning in Japan we will engage in a critical discussion of national agencies involved in planning the country's S&T effort. The chapter will then engage in an epistemological review of the growth of technological capacity in and examine how the 'growth miracle' of Japan actually came about. We will then engage in a retrospective and prospective examination of Japan's S&T planning initiative, and look to lessons from the past and planning efforts in the future that seek to address some of the shortcomings of Japan's S&T effort.

The chapter will also focus on examining the evolution of S&T policy planning in the Republic Korea, so as to draw from the experiences of what not long ago was a developing nation. So as to broaden the analysis to a consideration of lessons for S&T planning in the rest of the South, a comparative analysis of S&T policy regimes in Korea and Malaysia will be examined, with special reference to the education component of a science policy. The discussion will then shift to a consideration of the South's experience, outside of East Asia, with S&T planning, mention will be given of such efforts on the African continent. The analysis will then seek to establish how developed the S&T effort is in the rest of the South by focusing particular attention on S&T efforts in Vietnam. While the chapter seeks to explicitly and implicitly identify how and in what ways the South nations as a whole can learn from the S&T experiences that guided East Asia's industrialisation path, it is argued that such a path cannot be replicated, but instead only certain policy lessons can be learnt from it. The chapter concludes by briefly reviewing the recent financial upheaval in East Asia and in this context attempts to highlight some of the weaknesses of the region's growth dynamic and the effects this crisis may have on S&T in the region.

4.2 S&T Policy Planning in Japan

4.2.2 A Critical Discussion of National Agencies Involved in Building Japan's Technology Capacities

Japan is the world's second largest industrial economy, second only to the United States. In 1989, Japan had the highest per capita income in the world. A decade ago in 1988 its GDP amounted to US$2 500 billion, 2.8% of which it spent on R&D (the majority of which comes from the private sector) and nearly a decade later in 1996 Japan's total GDP in millions of Yen amounted to 480, 493. This is very strong growth, in fact the percentage growth in GDP from 1977 till 1996 amounted to 640.5% (Euromonitor, 1998). In 1991 Japan's total expenditure on research and experimental development by type of expenditure amounted to Yen 13, 771, 524, 000; while in 1992 there were 813, 360 scientists, engineers and technicians engaged in experimental R&D - in itself an important indicator of the priority given to technology capacity building (UNESCO, 1998: 156-164).

A cabinet decision in Japan in 1986 created the General Guidelines for Science and Technology. These guidelines laid the foundation for the country's S&T policy over the next couple of decades. The document stressed the importance of basic sciences and fundamental technologies in the future growth of the nation and improving the quality of life of Japanese. To further this, the government has played an extensive role in funding large scale projects. It is as a result of such efforts that Japan has become a world leader in advanced manufacturing technologies, micro-electronics, automobiles, energy technologies, etc.

The direction and goals of Japan's effort to technologically transform itself are grounded in the government's promotion of gyosei shido (administrative guidance).[46] The institutional framework of government involvement in S&T policy planning in the country is structured such that only a handful of government agencies play a role in the nation's technology policy.[47] The Science and Technology Agency (STA)[48] is responsible for coordinating the country's S&T policy agenda, in that it is principally involved in deciding the nature of research conducted throughout the country. It has secured such an important mandate as it is directly affiliated with the Prime Minister's Office - and hence, assumes responsibility for the entire S&T effort in Japan, like planning, coordinating and

[46].McGaffigan, and Langer (1975) conduct an extremely comprehensive analysis of these guidance practices, while dated the work is extremely insightful.

[47] Interview with Mr. Hiroaki Sato, Director, Research and Planning, JETRO (Ministry of International Trade and Industry), July 5, 1997, 2:30-5:30, New York.

[48]Part of the Prime Minister's Office, its programs are predominantly concerned with promoting basic science research.

implementing S&T policies and budgets for such efforts. While the STA overseas the direction of research in Japan, it is the Ministry of Finance that is the principle coordinator of where and how much of the government budget is allocated to S&T research at the university, private and public sector levels, and to national research institutes, for example, the Japan Atomic Energy Research Institute (JAERI). High level Japanese policy makers and leaders are actively kept abreast and involved in S&T planning in the country, as a result of the activities of the Council of Science and Technology (CST)[49] and the Science Council of Japan (SCJ) - institutions affiliated with the Prime Ministers Office. Perhaps one of the most important and recognised players in Japan's S&T planning is the Ministry International Trade and Industry (MITI) and the Economic Planning Agency (EPA) (Johnson, 1982).

MITI oversees industrial and trade policy. The ministry has a very crucial role in the development of industrial technologies. First of all, MITI influences both the terms of transfer agreements and composition of the transferred technology package. It was in fact under the Japanese foreign investment law of 1950 that MITI tightened and controlled the criteria for awarding technology licenses and FDI. "The law was used to make patent licensing agreements the main formal channel of technology transfer and to screen technology imports through agreements. In this screening process the government sought to influence which new product and production processes were to be introduced into the domestic economy at what time and so as to secure better contractual terms,

[49]A supra-ministerial organization in the Japanese Prime Minister's Office.

including a lower price for the Japanese firm negotiating a licensing agreement with the foreign firm and to select the firms importing the technology on the basis of their capabilities to effectively make use of the technology productively" (UNCTAD, 1994: 60). Secondly, MITI has had a critical role in industrial science policy, basically as a result of the work of its own agency, the Agency of Industrial Science and Technology (AIST), which is concerned with developing programs to further applied science research. The agency makes this possible as a result of the 16 laboratories it controls with a staff of over 4 000 and a budget of $600 million. The AIST has an important role to play in coordinating projects such as the 'Basic Technologies for Future Industry' and 'large scale' project efforts. The AIST is most recognised for its contribution to the *sunshine* (new energy sources) and *moonlight* (energy conservation) technology programs. Technologies that are developed by the AIST are made available to the private sector in Japan, but also overseas by the Japan Industrial Technology Association (JITA). Other notable government ministries that have a significant role in S&T policy are the Ministry of Education, Science & Culture, which is primarily responsible for funding research conducted in universities. The Ministry of Health and the Ministry of Transport and Telecommunications are also recipients of large amounts of funding, as without a healthy population and good communications infrastructure, the proliferation of technologies throughout Japan are adversely affected.

The Research and Development Corporation of Japan (JRDC) also plays an important role in the country's S&T effort as it establishes networks between researchers as well as inventors and the private sector hence, helping to ensure that completed research is made available to entrepreneurs. To aid in this effort, the Japan Key Technology Centre (KEYTEC) established in 1985 provides incentives to spurn pre-commercial R&D in the private sector, through loan services, capital investments and mediation in arranging joint research (OECD, 1991). KEYTEC also makes venture capital funds available to private sector companies involved in developing technologies in strategic fields. Similarly, the New Energy and Development Organisation (NEDO) also provides funds for private sector R&D, especially in non-energy technologies. However, a key institution in the business of diffusing and ensuring the proliferation or provision of technological know-how in Japan is the Japan Information Centre for Science and Technology (JICST). Its activities compliment similar efforts by MITI through the Patent Office to disseminate technical know-how throughout the economy (Ozawa, 1975). Above and beyond this infrastructure a series of programs are also provided to support the country's S&T effort, like the Exploratory Research for Advanced Technology Programme, funded by JRDC, so as to promote R&D into frontier technologies.

4.2.3 An Epistemological Discussion of the Growth of Technology Capacities in Japan

It is a well known fact that ever since the nineteenth century in the period of the Meiji Restoration and even today, Japan has always been a net technology importer (Kunio, 1986). Both in this century and the latter part of the last century Japan has essentially been involved in a game of technological 'catch-up' with the North. Because the country did not have the physical capital infrastructure (although it had the human capital know-how) for so long, it had to import foreign technologies. However, it was apparent in the latter part of the 1960s that Japan did have the capacities to engage in

R&D into basic research, the country has, however, *not* concentrated on doing this, an issue that we will touch on later in the paper.

National leaders during the Meiji period increasingly came to realise that if Japan was to develop at the pace much of the North had, it would have to engage in an initiative of technological and economic reconstruction. Japan imported technologies first to develop its textile industry, however, the country was quick to diversify its economy by importing technologies for the steel industry. Japan, in the late nineteenth century, imported technologies to build steel mills in the country, after which the country was actively engaged in the production of pig iron, steel and eventually, the country began an active shipbuilding industry. The early years of this century were critical in Japan's bid to technologically transform in that the nature of Japan's technology imports dramatically changed to accommodate, and in large part reflect, the country's bid to build its infrastructure and increase its industrial production/capacities.

This early period of industrialisation in Japan involved sizeable government involvement to the extent that for several decades in this century, the Japanese government, through MITI, was involved in industrial production (Trezise, 1976). Increasingly, in later years in this century, additional technology imports benefited the Japanese economy immensely, as they were in the areas of medicine, chemistry and physics, all of which contributed to the further diversification of the Japanese economy and the birth of pharmaceutical and engineering industries. By the 1950s and 60s, Japanese electronics, automobiles, synthetics, etc., were effectively competing with similar exports from the North. In the 1970s, Japan rapidly branched out into semiconductors, petrochemicals and advanced synthetics. At this point many economists had come to accept that the industrial, infrastructural, economic, and technological transformation of Japan was not only dynamic but sustainable. The country continued on its path of rapid industrialisation, and by the 1980s and early 1990s with the production and competitive exports of biotechnologies, information technologies and other high-technology products, Japan has become undisputedly recognised as an *economic giant*. How did Japan as a late industrializer, as compared with the rest of the North, technologically transform itself so rapidly and dynamically?

4.2.4 The Making of a 'Miracle': How Japan Industrialised

First of all, it is a fallacy to argue and account for the growth dynamic of Japan to be to any extent a result of a miracle or due to chance. Japan's technological transformation cannot be viewed as having come about as a result of an unorganised juxtaposition of policies - it was calculated, premeditated, and planned. Japan's growth effort, through the creation of a technically competent workforce, attempted to spurn the development of high-growth industries that exhibited the potential to create and sustain dynamic comparative advantages for Japan (Blumenthal, 1980). Although this growth process has been described as nothing short of a miracle, it cannot be explained or justified as *being* a miracle - we take exception to this point of view.

There have been countless studies done in the 1960s, 1970s, 1980s and 1990s by authors like Rosovsky (1961), Lockwood (1968), Ohkawa and Rosovsky (1973), Shinohara (1982) and Lee and Yamaza (1990) that account for how and why the Japanese economy transformed as dynamically and rapidly as it did. So as not to repeat what many of these works have argued, the following discussion will attempt to address two specific questions. Namely, why did such dynamic growth occur in the Japanese economy? What specific S&T planning methodologies and policies did the government promote and implement to sustain the country's transformation?

Many economists have attributed the growth in Japan, in part, to a favourable international economy in the crucial years of its growth. Many of these economists speak of the importance of the General Agreement on Trade and Tariffs (GATT), that after World War II, actively promoted international free trade. Although technologies were not subject to the same economic rules that governed trade in products, technology in this environment was readily available to Japanese firms under relatively good negotiated terms. What lies at the heart of Japan's growth dynamic, however, are not exogenous, but rather endogenous variables. It was the Japanese government's obsession with acquiring new and varied technologies that served to transform the economy. This transformation was brought about in two ways: the multitude of technologies entering the economy served to diversify its manufactured products, both for export and domestic consumption; secondly, those technologies served to make industries in the economy more productive as continuous changes, as a result of new technologies in product and process, gave rise to the creation of high-value-added industries. More specifically, the Japanese government's S&T policies in the Meiji era and successive years promoted an education policy and technology policy that concentrated on two critically important objectives: a.) contributing to the general social welfare of the population by the creation and active promotion of an universal, scientific and technically grounded education system. By creating such an education system, the government aimed at educating its future human capital to university and college levels in order to make them better understand technologies once they entered the workforce (Kitamura and Cummings, 1972).[50] In fact, it is widely accepted that Japan's post war growth was in large part attributable to the development and supply of substantial technical manpower capacities, such as scientists, engineers and other professionals and paraprofessionals. From Table 3 below we can see how from the 1950s and well into the 1980s, attendance/enrolments at Japanese university and colleges have tripled. Many of these enrolments have increased as they have in higher education, over the decades, because many Japanese students have considered the benefits of a high level education as far out waying the costs, especially in the long-term. Such steadily increasing enrollment levels have contributed to a significant increase in human capital accumulation in the region over the past four decades.

[50].Kitamura and Cummings also engage in an extremely insightful discussion of some structural problems inherent in the Japanese education system, and how the government is attempting to address these shortfalls.

Table 3 - Attendance in Higher Education and the Number of Students Enrolled

	Attendance in Universities and Junior Colleges (%)			Number of Students Enrolled	
Year	Total	Male	Female	Universities	Junior Colleges
1955	10.1	15.0	5.0	132, 296	37, 544
1956	9.8	14.7	4.9	135, 740	36, 285
1957	11.2	16.8	5.4	137, 451	34, 133
1958	10.7	16.0	5.2	142, 584	34, 888
1959	10.1	15.0	5.1	151, 879	37, 889
1960	10.3	14.9	5.5	162, 922	42, 318
1961	11.8	16.9	6.5	175, 832	47, 278
1962	12.8	18.1	7.4	197, 211	55, 613
1963	15.4	21.7	9.0	211, 681	61, 417
1964	19.9	27.9	11.6	217, 763	61, 070
1965	17.0	22.4	11.3	249, 917	80, 563
1966	16.1	20.2	11.8	292, 958	108, 052
1967	17.9	22.2	13.4	312, 747	121, 263
1968	19.2	23.8	14.4	325, 632	127, 365
1969	21.4	26.6	16.1	329, 374	128, 124
1970	23.6	29.2	17.7	333, 037	126, 659
1971	26.8	32.5	20.8	357, 821	136, 392
1972	29.8	35.7	23.7	376, 147	141, 631
1973	32.2	37.5	26.6	389, 560	154, 771
1974	34.7	39.9	29.3	407, 528	164, 077
1975	37.8	43.0	32.4	423, 942	174, 930
1976	38.6	43.3	33.6	420, 616	174, 683
1977	37.7	41.9	33.3	428, 412	183, 224
1978	38.4	43.1	33.5	425, 718	181, 181
1979	37.4	41.5	33.1	407, 635	176, 979
1980	37.4	41.3	33.3	412, 437	178, 215
1981	36.9	40.5	33.0	413, 236	179, 071
1982	36.3	39.8	32.7	414, 536	179, 601
1983	35.1	37.9	32.2	420, 458	183, 871
1984	35.6	38.3	32.8	416, 002	181, 223

Source: adapted from Arai, K., "Japanese Education and Economic Development", in Lee, C.H., Yamazawa, I., The Economic Development of Japan and Korea - A Parallel With Lessons (Praeger Press, 1990: 51).

Another effort to upgrade the technical know-how of Japan's human capital was undertaken by the private sector in Japan. In fact, the private sector in Japan has a long standing tradition of developing and implementing elaborate training and education programs for employees, designed so as to continuously upgrade their skills and enhance their expertise. Consider the account and observations of a group of economists during their visit to one Japanese company - "the company treated its newly hired engineers as trainees for the first three years and rotated them through a variety of assignments, including both production and research. The trainees ...[were]...also given occasional two-week courses at the company's educational centre. In the third year each trainees...[was]...assigned a thesis...to be written on a technical topic. At the end of the third year the trainee...[were]...given permanent assignments, to either R&D or production. Training...[did not stop]...after the third year. Each engineering section had monthly seminars...these were supplemented by one and two-week full time courses at the educational centre...[or semester courses at the graduate level and sometimes employees were sent for short-term training abroad]" (Okimoto and Saxonhouse, 1988: 578-579).

Japan's human resources do not only benefit from intrafirm on-the-job training (OJT), but also another practice unique to Japanese firms - i.e., employees are constantly moved around in the firm, therefore, experiencing different jobs, responsibilities and duties, but also different technologies. Education, it is quite apparent, has a critical role throughout Japanese society at the formal, informal and intrafirm levels in that Japanese human capital are constantly educated throughout their life. It is this constant learning, and application of that knowledge to the economic beast in Japan that has been at the centre of the Japanese growth dynamic.[51] Japan has learnt well from the works of economists such as Becker (1964) and Schultz (1963), who long ago argued the merits of the education of a nation's human capital (especially at the tertiary levels) as the key to economic growth - as it supplies technically competent and qualitatively more efficient and effective workers.

Building Japan's human capital capacities through formal education and intrafirm training has enabled another objective of the government to succeed. This is represented in the second critical aim of the government's S&T policy, namely; b.) while the government recognised the importation of technologies in its economic and technological transformation, it also recognised that in order for that transformation to be sustainable, the imported technologies had to be introduced into industry in highly unpackaged forms. This policy influenced both the nature and types of technologies that entered Japan. But also by ensuring that the technology was unpackaged, the government ensured that the country's workforce would understand and become more competent and familiar with imported technologies, because they would be involved in learning-by-doing associated with the imported technologies (Saxonhouse, 1988).

Learning-by-doing of any technology by a given workforce, endogenous growth theory argues, will often enable incremental changes to be made in these technologies by

[51]Indeed it could be argued that the East Asian growth dynamic as a whole has been based on a concentration by the state on education. The Republic of Korea for example spends over 20% of its budgetary expenditure on public education (Choo, 1990).

a technologically competent workforce. This has ramifications for the development of basic research capacities within a given nation that traditionally imported technologies. The critical importance of learning-by-doing also lies in the fact that technology is essentially an integrated system with different elements; once a workforce learns to manipulate those elements, they will often succeed in altering the technology - making it more efficient/effective and appropriate. Therefore, the Japanese government actively promoted a policy among its private sector that encouraged a mastering of technology by a given firm's workforce, which in effect resulted in that workforce *adapting*[52] the technology in order to incrementally make it more efficient by increasing its productivity potentials. This mastery of technology became one of the principle driving forces behind Japan's technological transformation. The second end result of this adaptation resulted in capacity stretching, bottleneck breaking, improved by-product utilisation, modifications in product design and expansion of product mix in Japanese firms (Evenson and Westphal, 1995).

The government in the initial years of its industrialisation also depended less upon the importation of proprietary technologies (e.g. foreign direct investment (FDI), turnkey investments, etc.), that were generally more expensive because of their attendant royalty payments and also because such investment methods enabled TNCs to 'operate at will',

[52]By incrementally adapting imported technologies, the Japanese workforce also succeeded in altering them just enough so as to make them distinct enough from their original imported forms, so as to make them amenable to utility model protection. Hence, in a sense by making imported technologies better, through incremental changes, the technologies could no longer be considered as falling under the proprietary protection of a foreign multinational.

and thus control the technology transfer process as well as the recipient nation's technological transformation goals. However, as the economy developed and increasing exports generated increased revenue and increased education developed a more skilled workforce, more technically sophisticated and, hence proprietary oriented technologies were licensed. However, to maintain a degree of control in the technology importation process and to sustain learning-by-doing in Japanese industry, MITI encouraged, on the one hand, joint venture investments (with majority local ownership), subcontracting and contractual arrangements, and on the other hand, the continued importation of unpackaged technologies (Terutomo, 1985).

4.2.5 Japans S&T Policies in the 1990s and into the Next Millennia

Japan's S&T policy over the last two decades has been directed at addressing a principle concern of observers of Japan's technological transformation, both outside of Japan and inside Japan and that concern is over the continued dependence of Japan on imported technologies, and as yet, an unsatisfactory effort on the part of the government to build domestic capacities to conduct basic as opposed to mainly applied R&D (Tshikawa, 1979). Consider that basic research accounted for just 14% of Japan's R&D expenditures in 1987, while applied research accounted for 24.3% and experimental development 61.7%. In addition, Japan's S&T policy suffers from the lack of specific improvements that need to be made in the area of government underwriting of industrial R&D that traditionally has been low in Japan.[53] Japan's S&T policies, however, have

[53] Interview with Mr. Hiroaki Sato, Director, Research and Planning, (JETRO) Ministry of International Trade and Industry, July 5, 1997, 2:30-5:30, New York.

been directed at pinpointing areas of industry that exhibit a potential for future growth, and subsequently these industries are further supported by government (Johnson, 1982). Such methods of support include increased investment, the increased provision of scientific and technical support to stimulate the creation of new generic technologies, government support of mergers, joint consortia, etc., but also to a large extent by the provisions of grants, loans, technology related tax credits and consultancy services.

There are several attendant successes in the government's efforts to increase the country's basic R&D capacities, this is reflected in the rates of return from R&D investments. The amount of patents per scientist and engineer is the gage for which to measure the rate of return from R&D investments - and that rate of return for Japan, relative to the rest of the North, has been steadily increasing (Okimoto and Saxonhouse, 1987). Okimoto and Saxonhouse listed the level of such patents to have quadrupled in the last two decades. We will attempt, with minimal recourse, to account for this rapid rise in the rate of returns from Japanese R&D by answering the question - what were the institutional and policy characteristics of Japans S&T policy that made this increase possible? First of all, Japanese R&D expenditure has dramatically increased from levels two decades ago in an effort to offset its dependence on foreign technology imports and increase patent activity/productivity. A deliberate effort is also evident in the country's S&T policy to reduce its technological balance-of-trade deficit (which has historically been large for good reason, i.e. the country's tremendous dependence on technology/technical know-how imports from the West). Secondly, Japan has become significantly advanced in its technological capabilities, especially in the areas of iron and steel production, state-of-the-art technologies, based on concepts of solid-state physics, the development of new materials, agricultural chemicals, nuclear energy processing, semiconductors - especially metal oxide semiconductors and gallium arsenide mass memory chips, robotics, pharmaceuticals, biotechnologies, and industrial lasers (Okimoto, Sugano and Weinstein, 1984). These technological advances would not have been possible without the intervention and guidance on the part of MITI, as to which technologies to import and which indigenous industries to protect, invest in and provide the most government sponsored R&D for. It is precisely because of this concentration on the utilisation of more sophisticated technologies in Japanese industry that resulted in the exploitation of value-added-industries, which in large part accounts for Japan's rapid industrialisation (Shinohara, 1982). Those industries that have dominated Japan's export market have actively utilised advanced technologies to continuously develop new products for export, what many economists have come to call the production of varied goods in a 'flying geese' pattern.[54] Okimoto and Saxonhouse also argue a third S&T strategy that resulted in increasing the rates of returns in Japanese R&D and this is an effort to increase the role of small firms in technological R&D. This particular planning strategy is distinct to Japan. It is an effort masterminded by MITI to get small venture firms more actively involved in the creation of new high-tech industries. To accomplish this task, MITI established the Office of Venture Business Promotion and Small and

[54]The use of 'flying geese' pattern in this context is not to be confused here with what economists often term as a 'flying geese' pattern when they explain the order in which many of the East Asian economies industrialized after Japan did.

Medium Enterprise Agency in order to provide venture capital financing to innovative small business.

We will now discuss areas within Japan's S&T policy initiatives where there is significant room for improvement. As was noted before, the legacy of technology in Japan is that traditionally it has been imported. As it stands now, the Japanese industry is still acquiring many of the technical capacities necessary to break away from it dependence on technology imports, as it is still in the initial stages of developing its indigenous basic technology capacities. For quite some time yet, Japanese firms will continue to be largely dependent on imports of technologies, and then incrementally changing those technologies through creative combinations. At the same time, it is widely recognised that Japan's reliance on foreign technologies is *steadily* being cut, as a result of increased efforts to promote closer co-operation between public sector-university-private sector R&D efforts to generate technology-relevant basic research knowledge, as the basis for future, new scientific knowledge (Knezo, 1991). This effort to create new knowledge has a greater economic relevance recently as product cycles are getting shorter in high-technologies, hence the perceived urgent need on the part of globally competitive firms to be the first innovator, so as to fully exploit the patented product.

Increasingly there is also a recognition that the Japanese education system needs change, especially in high-level education. Specifically, many scholars speak to the lack of PhDs in Japan, as graduates from BSc programs are abruptly taken into a firm and trained while working. While such a policy is invaluable in a situation where a country is attempting to catch-up with more technologically advanced nations, such an education system is not appropriate for a nation that wants to limit its reliance on adapting/applying foreign technologies to its economic system and promote basic research instead. We can see how Japan differs from the United States in the level of its basic research by comparing the number of Nobel Prizes for science based research, each country has received since 1945 to the late eighties (Cross, 1989).[55] Specifically, Japan has only received five such prizes, while the United States has received over 140 for its basic science research (Narin and Frame, 1989).

It is commonly believed, even by Japanese scientists, that Japanese R&D is geared at applied research/sciences, and as a result does not contribute to the long-term capacity building of basic research in the country (Johnston, 1989). Consequently, the CST is strongly urging that efforts must be made to alter the basic framework of Japan's S&T policy and strategy, as Japan risks being further left behind by other countries of the North in original basic research. The CST, as a result, has actively been involved in revising the basic framework of Japan's S&T strategy to ensure Japan's continued competitive advantage in information technologies (ITs), biotechnologies, new materials, etc. Specific policy changes that have come about as a result of this increased effort to

[55]It is perhaps an irony in that, because the Japanese education curriculum is so intense in terms of a concentration on physics, science and mathematics, many scholars argue the need to rote learn to do well in these subjects which necessarily restricts creativity, in itself a prerequisite for original science based R&D. Another indicator of Japan's underdeveloped basic science capacity, Cross (1989) argues, is reflected in the fact that Japan publishes only one fifth of the literature in science based journals in comparison with the United States.

build basic science capacities is that Japan's R&D spending increased by more than 10% in the late eighties, while research budgets have been increasing steadily at 4% p.a. since the late eighties. At the same time, R&D funding for the Ministry of Education, Science and Culture (one of the principle Ministries where funding for basic research goes) has increased significantly to the extent that it is now responsible for around 50% of the government's R&D expenditure. Much of the increase in funding to this Ministry is primarily because of the important role it plays in basic research. This increase in funding for the Ministry has resulted in less funding for the MITI and EPA that principally are involved in applied research (Knezo, 1991).

In addition, because the Japanese private sector has traditionally shouldered much of the burden of R&D funding in Japan, the government has increased in absolute terms initiatives, such as loan guarantees, tax credits, preferential and sometimes protectionist policies for Japanese industry (AIST, 1989) and (NSF, 1989).[56] According to the National Science Foundation (NSF), more than 10% of basic research was funded by Japanese industry in the late eighties, and the industries carried out 32% of all basic research. In comparison United States industry funded closer to 15% of basic research and carried out 20% of all basic research in the same period (STA, 1990). As part of the national

[56]In Japan 80%, of R&D funding comes from the private sector, as compared to the United States private and public sector that share an equal amount of R&D spending. While basic research in Japan is a little less than 13%, in the United States over 14% of the country's R&D budget goes into basic research. The Agency for Industrial Science and Technology and the National Science Foundation estimate that around 33% of basic research is conducted by industry and 55% by university researchers in Japan, in the United States though, 20% of basic research is conducted by industry and 50% by university researchers.

initiative of Japanese S&T policy to increase levels of basic research, MITI - under the authority of it's many sub-divisions, but most notably the AIST - in the last decade has spearheaded an initiative called the Basic Technology for Future Industries Program.[57] This program has been implemented at the industry and firm level to encourage basic scientific research, by financially supporting theoretical and experimental research into new industrial technologies that those firms would traditionally not engage in because of high risk or cost factors. However Sato[58] argues that Japan still lags behind the United States in the number of scientists engaged in R&D. This is yet another area Japanese S&T policy needs to be improved. For instance, while Japan has in access of 500, 000 researchers and scientists involved in science based R&D, the United States has over 1,000, 000, of such technology specialists.[59] One distinguishing factor between researchers in Japan and the United States is that the former's research manpower are predominantly engineers, while the latter's research manpower are largely scientists. Whether this has an impact on the quality or nature of research in either country is not

[57] An example of the serious underdevelopment of Japan's basic research capacities is evidenced in the fact that Japan has only been able to technologically advance in those technologies with a predictable technological trajectory. Because the aerospace industry demands a significant basic science capacity (which is as yet not fully developed in Japan), Japan has been unsuccessful in entering this industry.

[58] Mr. Hiroaki Sato is Director of Research and Planning of JETRO - a branch of the Ministry of International Trade and Industry who was interviewed on July 5, 1997, 2:30-5:30, New York.

[59] However, this comparison should not be too heavily read into as the US is significantly engaged in military related R&D, while such non-economic R&D is negligible in Japan, so naturally the United States would have larger numbers of researchers.

clear, but there are bound to be economic implications as a result of this. However (as mentioned earlier), what definitely has an impact on the nature and quantity of basic research in Japan is the fact that Japan has a significantly lower level of technology specialists trained to the PhD level relative to other country's of the North - most especially the United States. As has been argued by the US Department of Education (1987) and Anderson (1975) what is now needed of Japanese S&T policy is an effort to encourage greater basic research. This cannot come about from researchers who are not trained to the PhD level, as the quality and theoretical/technical components of their research will be far inferior to countries like the United States. Hence, the Japanese government will have to encourage bachelors level graduates to go on to further graduate studies.[60] One principal way of doing this is through increased funding by the Ministry of Education, Science and Culture for graduate students in the form of scholarships to programs and departments as well as affiliated research centres (Keichi, 1988).

In the 1990s, MITI and the EPA continue to recognise the critical importance of technology in economic growth, more so they recognise the importance of knowledge-intensive industry in that growth, and hence the need for a technically superior and competent workforce (Peck and Tamura, 1976). Japan's S&T policy, therefore, is

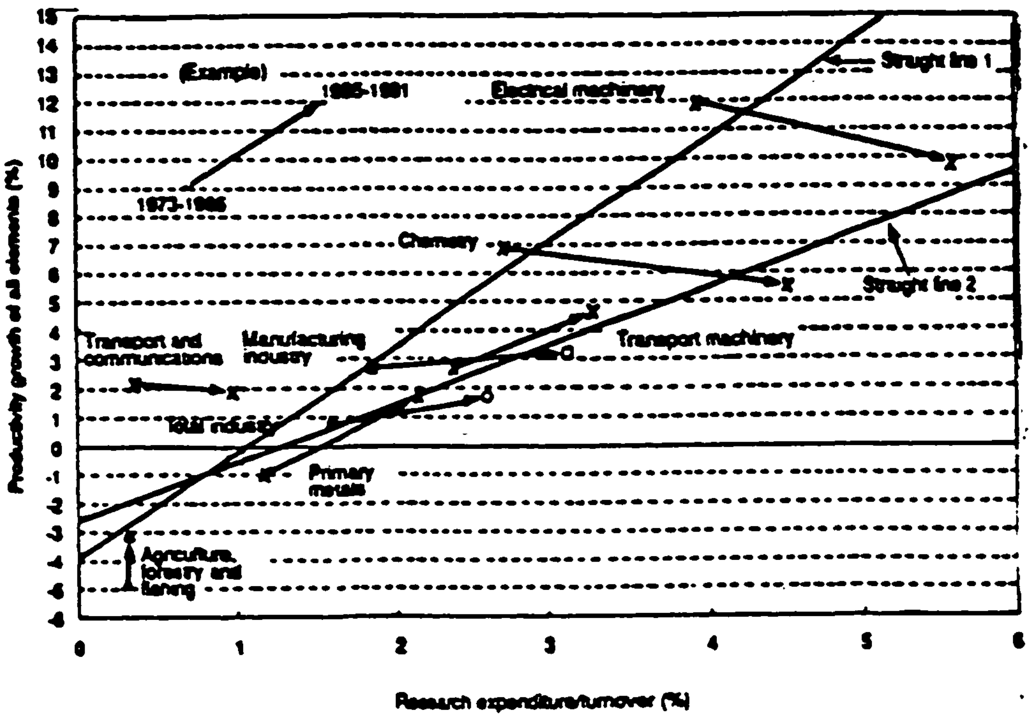
[60]The magnitude of the gulf between PhD qualified research personnel in Japan and the United States is perhaps best illustrated by a survey conducted in 1982 by the National Academy of Sciences, that found that more than 1200 PhD level researchers were involved in the United States biogenetic engineering industry, while levels of PhDs involved in Japan's biogenetic engineering industry was not even half this level (U.S. Congress/OTA, 1984). (Although the study is dated, it serves to highlight the immense improvements, at least in high level education, Japan's S&T policies need to make).

committed more than ever before at raising levels of technical, managerial and scientific expertise amongst the nation's future and present workforce. In fact, the Japanese government's 1993 White Paper on the Japanese economy argues that sustained economic growth via increases in productivity and social infrastructure cannot be realised without investing in creating and maintaining a highly skilled workforce (Business Intercommunications, 1993). Rahman[61] argues a heightened concentration on human capital and moves toward more value-added, knowledge-intensive industry would appear to characterise the nature of Japan's S&T policy in the mid-nineties. Such policy direction is expected to continue into the next century, as there is a realisation that if Japanese industries are to remain globally competitive, they will have to be technologically advanced in terms of their basic science and research base. This will have to be the case, as the gestation period between new technologies that come out of the basic research process and their application to industry and economy is getting shorter. This means that those industries that hope to remain at the forefront of international commerce will have to increasingly, especially in the next century, be the first to come up with new inventions so as to commercially exploit them in advance of other competitors. Such policies will promote larger efforts at encouraging basic research in both the private and public sectors. Such a strategy, it is expected, will positively impact the rate of technological innovation to gross domestic product (GDP) growth in the country, where it is expected to exceed its 40% levels before the end of the millennia.

[61] Mr. K. Rahman is a Senior Economist at the UNCTAD Liason Office, who was interviewed July 8, 1997, 10:00-11:15, New York.

In fact in the closing years of this century, the levels of technological innovation sectorally are high and are promising for similar, if not better, innovations in sectors in the next decade. The MITI and the EPA argue current levels of technological innovation are expected to remain high, as these innovations are continuously resulting in positive returns in productive growth in all industries/sectors in the economy (Allen, 1981). The data presented in Figure 6 would appear to quantitatively substantiate this argument.

__Figure 6 - The Relationship Between Research Expenditure and Productivity Growth in All Japanese Industries__



Source: adapted from Business Intercommunications Inc., __White Paper on the Japanese Economy, 1993__ (Tokyo: BII, 1993: 63).

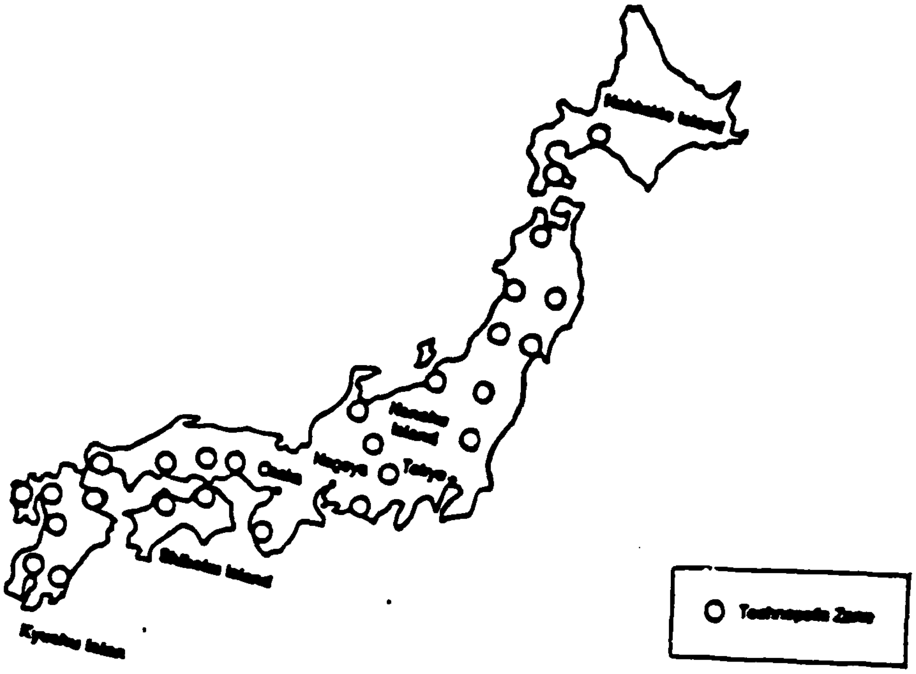
4.2.6 Japan's Technological Transformation in Retrospect and Prospect

It can be inferred from the previous analysis that the economic and technological transformation of a nation in large part depends on how actively its government is involved in creating and strengthening the technical and scientific education of its population. And secondly, how well that government ensures the introduction of technologies to be applied to its economic system at a given time, under certain terms and guided by elaborate technology capacity building plans. Generally, what we speak to here is how effectively the government coordinates and implements a given S&T policy in an effort to transform its economy.

It is a well recognised fact that Japan has one of the most coherent and best established S&T policies among any nation in the North. This policy, as we have seen, is targeted at establishing a competitive supremacy in high-technologies, a function of exogenous factors (i.e. global competition in this area) and endogenous factors (i.e. the lack of natural resources in Japan, hence the inappropriateness of investing in resource dependent industries). Japanese S&T policy is directed at developing and sustaining a 'creative, knowledge intensive industrial structure' (Uekusa, 1988). Japan's S&T policy has performed as well as it has because of the vision and foresight of policy-makers and the commitment to technologically transform industry by top executives. Such vision, and bold ambition, is reflected in technology policies in the sixties that were geared at producing high performance computers and in the seventies information processing. Perhaps the two of the more ambitious technology projects were the Sunshine Plan (to develop alternate sources of energy) and the Moonlight Plan (aimed at developing energy efficient technologies). Japanese S&T policy in the nineties has placed the country on a path to further upgrade its computer technologies by the creation of fifth generation computers, and basic industrial technology in order to develop next generation technologies, such as polymers, alloys, biotechnologies, perfect crystals and other advanced materials.

By far the most ambitious technology project, and perhaps most important S&T policy planning initiative yet, is the government's active effort to continue its Technopolis Plan (Tatsuno, 1986). It is largely an effort to further develop the country's high-technology capacities by building a number of high-tech cities, from Hokkaido Island in the north of the Japanese archipelago, to Kyushu Island in the south (see Figure 7). This initiative became a legislated law in 1983. What the plan involves, and to a large extent has already done, is to promote manufactured-oriented R&D and frontier/knowledge-oriented R&D in the country (STA, 1972). This initiative is geared at stemming a pattern where Tokyo has traditionally been the centre for technology activity in Japan. Policy-makers hope to diffuse technology capacities country-wide because of this initiative. MITI is attempting to establish 26 technopolis zones, each of which will be centred around a highly populated urban centre, with advanced infrastructure - both communication and technology based. This planning initiative is aimed at developing centres of technology activity throughout Japan, and just not in Tokyo. Initial successes are already apparent in this effort to disseminate and ensure the proliferation of technologies throughout Japanese society. These initial successes are reflected in the success of the prototype Tsukuba Science City, where two universities and over 50 national research institutes are based.

Figure 7 - The Japanese Technopolis Plan



Source: Japanese MITI, Japan's Technopolis Sites (MITI: Industry Industrial Location Policy Division Report, 1990).

4.3 S&T Policy Planning in the Republic of Korea

4.3.2 Korea's S&T Framework

South Korea is a country of approximately 42 million people. GDP growth amounted to 11.3% in 1988 and GDP in 1989 amounted to $204 billion, with a trade surplus of US$11.4 billion in 1986. Nearly a decade later in 1996 Korea's total GDP in millions of Won amounted to 412, 115. Growth of this economic indicator has been consistently high, consider that the percentage growth in GDP from 1977-96 was 1, 271.9% (Euromonitor, 1998). R&D expenditure in Korea amounted to US$5.3 billion (2.6% of GDP) in 1989. Such high R&D expenditure rates have continued into the

1990s, where in 1994 we see that total expenditure for research and experimental development by type of expenditure amounted to Won 7, 894, 746, 000. This is considerably high R&D expenditure, for a South country, but not surprising as it has 13 scientists and engineers per 10 000 Koreans and in 1994 there were 131, 587 scientists, engineers and technicians engaged in experimental R&D (UNESCO, 1996: 156-164).

Korea's principle industrial sectors range from automobile to steel production, as well as industrial chemicals and electronics. Korea has been the success story of the developing world. It has emerged from being a technology imitator to innovator, in the high-technology area, in a matter of three decades. This largely occurred because of the importance given to S&T by the leaders of Korea. Consider that the administrative/organisational structure for science and technology in Korea is such that the Ministry of Science and Technology (MOST) comes only second to the Ministry of Government Administration, in the hierarchy of departments close to the office of the Prime minister and President. Similarly the Ministry of Commerce and Industry as well as the Ministry of Education have a high priority in the government department hierarchy, as do the National Academy of Science, the Central Educational Research Institute and various other institutes. The Korean government has stated that its S&T goals include:
"i.) training and maintaining high-level technical manpower;
ii.) promoting the productivity of R&D;
iii.) developing and introducing comparatively advantageous and advanced technologies" (UNESCO, 1985: 282).

To accomplish these goals, Korea has had a dynamic S&T institutional support structure in order to secure a successful S&T planning regime. This infrastructure comprises of the Ministry of Science and Technology (MOST), Korea Advanced Institute of Science and Technology (KAIST), the Korea Science and Engineering Foundation (KOSEF), the Advanced Energy Research Institute, the Nuclear Fuel Development Institute, the Institute of Machinery and Metals, the Heavy Equipment Testing Institute, Ocean Research and Development Institutes, the Institute of Energy and Resources, the Standards Research Institute, the Institute of Chemical Technology, and the Institute of Electronics Technology. MOST was established in 1967, and its primary function is to administer, coordinate and formulate the development of South Korea's S&T policy. It does this by establishing the mechanisms and programs/projects necessary to make such policies a reality. The most important of these programs has been the effort to establish the KAIST and KOSEF. The KAIST is sponsored by the government to engage in cooperative research projects with both research centres and laboratories in the private as well as academic sectors. The KOSEF has the important task or role of training scientific personnel and assisting them with any scientific research activities they may currently be engaging in. It also plays an important role in obtaining scientific and technological information from abroad and amassing such information in databases for later dispersal to nodes or centres of research throughout Korea. The other institutes (mentioned above) are also a central component of Korea's S&T policy as they engage in specialised activities concerned with the learning and assimilation of, as well as research into specific technologies. These institutes also undertake specific projects aimed at aiding industry in their R&D efforts with particular technologies.[62]

The dynamism of Korea's S&T planning infrastructure would not be at all possible were it not for the commitment of senior policy-makers and leaders in the Korean government. In fact, Sagasti (1979) has argued that "government intervention to develop local S&T capabilities will be effective only when committed action is taken simultaneously to build up an infrastructure for the performance of S&T activities, to regulate technology imports, to define the pattern of demand for S&T knowledge, to promote the performance of S&T activities in enterprises, and to provide support for S&T activities" (Sagasti, 1979: 81). Korean leaders have actively developed a network of institutions that cooperate in making the country's S&T effort possible and as successful as it has been. Such initiatives have received the legal direction and support they have because of the Technology Promotion Law passed in Korea some years ago which sets the legal parameters for the operation of S&T activities in the country and obliges the government to commit the resources it does in its national budget to this effort. Korean leaders have also given S&T a significant priority in the country through closely interfacing economic development plans with S&T plans. For example, the Korean government, like the Japanese government has in place a technology screening policy which, although part of the S&T capacity building initiatives, was also an important component part of the country's industrialisation policy. This screening policy was very

[62] Interview with Mr. Abraham Joseph, SeniorUNNADAF/UNSIA Affairs Officer, Office for the Special Coordinator for Africa and the Least Developing Countries, June 25, 1997, 3:30-5:00, New York.

visible at the height of its industrialisation in the 1970s which had a significant impact on the efficacy with which Korean firms introduced and assimilated technologies into the firm environment (Enos, 1988).

4.3.3 Korea and Malaysia - A Comparative Analysis of S&T Policy Regimes

As a central component of East Asia's attempt to adopt the Japanese style growth dynamic, policies to build human capital capabilities became the focus of its growth path. Human resource development also became a central focus of the region's industrialisation policy regime, as governments had become disillusioned with development or growth centred on economic factors alone and wanted, instead, to develop their country's social sectors. Secondly, it was widely recognised that investment in human capital consistently led to rapid economic growth, as was evidenced in Japan. A third, and perhaps most critical point is, "the provision of increasing productive employment for the labour force, as well as increasing productivity, especially in the so called 'informal sectors' of the economy would provide the best route to solving the apparent dichotomy between growth and development, and in ensuring that the gains of economic development were equitably distributed amongst the population and different regions of the country. If investment in human capital, the second of the three factors mentioned, was seen as the traditional 'supply side' of human resource development, the emphasis on the employment goal brought into play the crucial role of 'demand' in ensuring the optimal utilisation of human resources" (Amjad, 1987). While this has occurred in East Asia with a great deal of success, it has not occurred in much of the South. Joseph[63] argues that India, for instance, churned out many scientists and technicians, but many of them remain unemployed (or under-employed) despite their advanced expertise. This has occurred because the Indian government has failed to promote satisfactory human resource 'demand' policies as part of its S&T initiatives to compliment the 'supply-side' of its human resource policies. East Asia has been successful in both training and finding employment for its scientists and engineers because it has developed policy regimes that successfully harmonise both the 'demand and supply-side' of its human resource policies.

What follows is a discussion of the human resource planning component of the S&T policies in an East Asian first tier NIC and a South East Asian pre-NIC. In the case of the former we examine Korea, and in the case of the latter, we examine Malaysia. It will be argued that to a large extent, Malaysia's manpower planning policies are reflective or indicative of similar planning policies elsewhere in South East Asia and the South in general. We will argue that unless Malaysia's and the South countrys' approach to S&T policy planning is reassessed and given a new direction, growth in the region will be unsustainable and the region will be relegated to the status of LDC and middle-income country and not NIC.

Manpower planning in Korea has largely been the key to its industrialisation effort.[64] Building of skill levels amongst the country's workforce has been of special

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[63] Mr. A. Joseph is a Senior UNNADAF/UNSIA Affairs Officer in the Office of the Special Coordinator for Africa and the Least Developed Countries, interviewed on June 25, 1997, 3:30-5:00, New York.

[64] Interview with Mr. Fahri Boumechal former TNC Affairs Officer, United Nations Center for Transnational Corporations, on July 1, 1997, 10:00-11:15, NewYork.

importance to government policy-makers who sought to radically transform their nation's industrial structure so that it could build a superior heavy and chemical industry (HCI). The overriding obsession of the government to develop HCIs was a function of the security concerns of the military led government in power in the latter part of the 1970s and early 1980s. However, the end result of this effort was the establishment of a superior HCI in the country. Exactly how the government did this was a function of how well it educated its human capital to understand and effectively diffuse the complex technology entering this critical sector of the Korean economy.

This initiative to educate the country's workforce was achieved by large credit supports used to overhaul the education and training systems in place at the time of initial industrialisation (the 1960s), so as to generate sufficient indigenous technical expertise to work the complex technologies of an HCI. The curriculums of training centres, technical high schools and post-secondary engineering institutions were overhauled during the seventies and oriented to suite the country's specific human capital skills needed to put an HCI in place. Part of this nation wide training initiative was an active effort to oblige companies to provide comprehensive OJT, and government made it mandatory for Korean workers to possess at least one skill and be licensed in that skill. "In addition, for each field of engineering the government actively recruited outstanding Korean scientists abroad and established modern laboratories where research on the improvement of production technologies was conducted in collaboration with industry researchers and university professors" (Joon-Kyung Kim, 1995: 25).

Hence, the government was largely successful (as a result of its drive to establish an HCI) in providing, at extremely low cost to its population, a vocational and technically sound education. In large part, the government has attempted to provide to its workforce and potential workforce the necessary and sufficient scientific education they will need in as short a time possible before they enter the workforce. Intensive training has taken place throughout the country and the delivery of such training and research objectives have been made possible by the more than 30 institutes of professional research and the 283 training centres operated by public and private agencies. An integral part of the countries accumulation of skill levels amongst its workforce, though, has been the emphasis by policy-makers on OJT, so as to have a human capital base familiar with new technologies that constantly enter the industry/market, and at the same time, enable them to be comfortable with working around those technologies. The importance of OJT in Korea's industrialisation effort cannot be under-emphasized, as OJT was at the very heart of the country's industrialisation effort where technologies needed for the industry were sophisticated enough to demand a highly skilled workforce. In addition, in the government's bid to rally all available human capital endowments so as to industrialise rapidly, a significant effort was made to repatriate Korean scientists and technologists working and living outside of Korea, by offering attractive terms of employment in order to facilitate for a decrease in 'brain drain' (Amjad, 1987).

The Korean government has largely been successful with its effort to continuously upgrade the skills of human capital so as to match the constant changes in technologies that require new, diverse and more sophisticated skill levels. Over the decades, Korea's expenditure on education, as a percentage of GNP, has consistently risen. Although the Malaysian manpower planning initiative under the New Economic Policy (NEP) has been accorded top priority in the governments economic restructuring efforts, it is a relatively new initiative. This is the case for a number of reasons, which collectively have compromised Malaysia's S&T initiatives. Malaysia has historically been preoccupied with macro-economic planning at the expense of planning for human capital accumulation, resulting in an extremely fragmented S&T panning policy. Perhaps the most harmful obstacle to effective manpower planning in the country is its extraordinarily large reliance on foreign investment. A characteristic very foreign to the East Asian NICS (for very good reason - principally to retain autonomy over S&T policies), but very common in South East Asia (mainly the second-tier NICs). TNCs have come into the country, and, since technology transfer is largely unregulated in the private sector, have, on the one hand, brought with them inappropriate technologies and have had no obligation to contribute to OJT; as a result, the Malay labour force has been deprived of accumulating skills necessary for indigenous technology diffusion.

In addition, Malaysian policy-makers underestimated the structural and technological shifts in Malay industry and hence, could not compensate for this because the workforce generally remains unskilled or semi-skilled in the 1990s (with a few exceptions). It is only very recently that the government has limited the amount of capital intensive production techniques entering its country so that it may better acquire appropriate technologies, at reasonable cost, that suites the skill level of its workforce/industry. However, much has to be done to regulate the technology transfer process itself. Encouraging developments have occurred, though, and this is in the area of government support for OJT through its Human Resource Development Fund (HRDF). However, in as far as skill formation and development at the formal level goes, while investment in primary education is extremely high, such investment is not occurring in tertiary education. Hence, intermediate level skill formation is not being adequately catered for, and as a result, hampering the efficacy with which the government is attempting to spurn human capital accumulation. This state of affairs would appear to characterise the S&T planning efforts of the South in general, the following section will account for why this has been the case.

We have already briefly discussed the role of technology and education in East Asia's transformation. However, the nature of our analysis demands a more comprehensive discussion of the region's growth policy initiatives so that implicit policy recommendations can be made more evident as a result of the analysis. Specifically, what will be discussed here is the technology model that was employed by the NICs in East Asia. Their technology policies comprise of strategies that proactively manage and promote the development of private sector forces. Ting (1987) argues that at least initially the East Asian NICs encouraged FDI and steered away from establishing any large S&T beaurocracies. A self sustaining indigenous market for technology inputs were facilitated by the acquisition of appropriate technologies and hence their effective assimilation into firm based production systems. This enabled the development of large export capabilities utilising labour intensive technologies, then the development of indigenous technological capabilities in the area of innovation, such that many of these countries branched out into the production of capital goods and even their own technologies for export, e.g. as happened in Japan, Korea and Taiwan.

Consider a typical technology input and output development framework used by the East Asian countries to achieve NIC status. At the macro level, public science and technology policies and programs were in place that actively supported firm based technology and product development programs that occurred through product imitation, modification, improvement and finally, innovation methods once the appropriate firm capacities were established (consult Figure 8).

Figure 8 - Input-Output Development Framework

MACRO LEVEL OUTPUT	*MICRO LEVEL*	*DELIVERY SYSTEM*	*TECHNOLOGY*
Public science and technology policies ⇒ and programs	Firms' technology ⇐ and product devlpt ⇒ programs	Factor and final goods market	⇒Product imitation, ⇐modification, improvt, and innovation ⇑

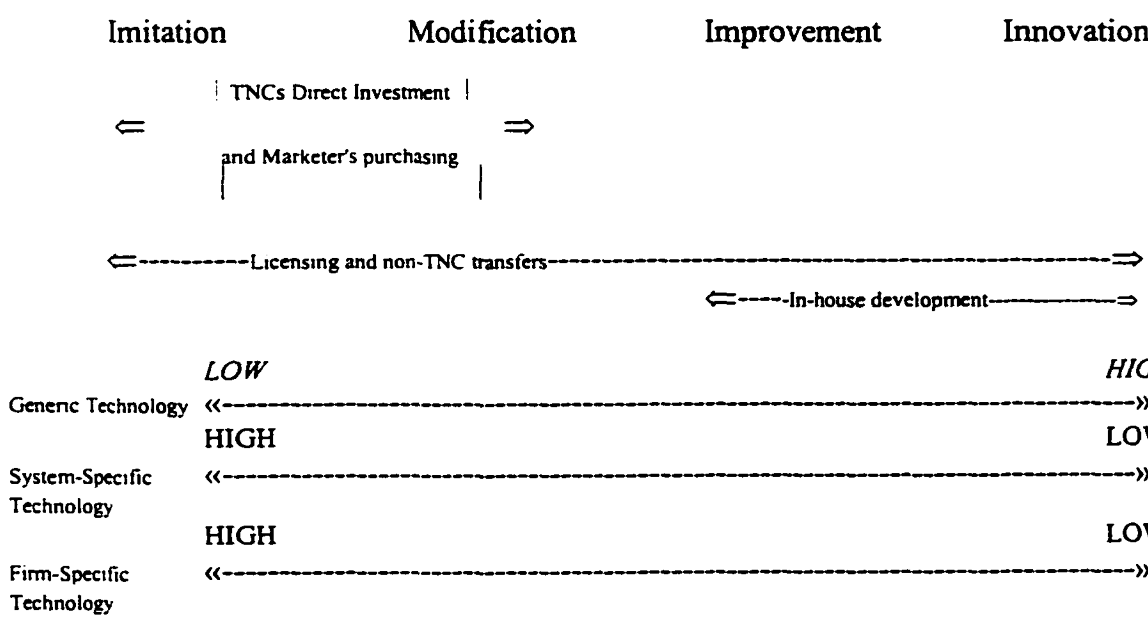
Source: adapted from W. Ting, "East Asia: Pathways to Success", in A. Segal, Learning by Doing (Westview Press, 1987: 132).

Ting argues that it is "this strategy of deliberate indigenous technology development [...that...] basically...separates the East Asian countries that have taken-off industrially and those that have not" (Ting, 1987: 134). For instance, the author gives the example of Malaysia and Singapore. Both are passive recipients of foreign technology in the form of labour-intensive electronics assembly operations from US based TNCs. Although Malaysia has in recent times been one of the largest exporters of semi-conductors in the world - the assembly operation is wholly owned by US TNCs.

Malaysian firms provide the cheap highly labour-intensive assembly of subcomponents in their capacity as production arms of foreign TNCs. However, since all the design and fabrication aspects of the chips are done in the US, the transfer of technology or technological skills to countries like Malaysia and Singapore involved in such operations is limited, if not negligible. Therefore, Malaysia has as yet to enjoy technological transformation and indigenous technological capacity building efforts common to other East Asian NICs, and as a result, has as yet to claim NIC status. This to a large degree is reflective of industrial and technology policies that cannot possibly promote indigenous technological capability building effort as the appropriate S&T framework may not as yet be in place. However, this statement must be qualified, as Malaysian S&T policy-makers have been quick to identify this flaw in their S&T planning strategies, so much so that "in 1990, Malaysia created the Advanced Manufacturing Technology Centre (AMTC) to assist local small scale enterprises in the application of advanced manufacturing technologies, such as computer-aided design and manufacture CAD/CAM, to enhance their international competitiveness. The Standards and Industrial Research Institute of Malaysia (SIRIM) has played an active role in the industrial development of Malaysia by coordinating and promoting technology transfer, standardisation, industrial research and consultancy, technical support services and other related activities" (UNCTAD, 1996: 10).

Malaysian policy-makers have learnt from the experiences of South Korean firms like Hyundai, for instance, which have a well established market for motor vehicles both in the Korea, as well as abroad in countries of Europe and North America. Similarly, Taiwanese firms have staked a claim in the competitive international electronics market. Even hi-tech Hong Kong based firms, Ting (1987) argues, have developed comparative advantages in the electronics market and has amassed a significant knowledge of the market and the production of these products such that "IBM-compatible computers based on circuit-boards and disk drives that are designed in-house" are produced in this tiny city-state for dozens of markets around the world (Ting, 1987: 136). To provide a more detailed analysis of the dynamics of the stages of development of East Asian country technology capacities, Ting gives particular attention to a product technology innovation continuum (PTIC) (see the Figure 9 below).

Figure 9 - Product Technology Innovation Continuum



Adapted from: W. Ting, "East Asia: Pathways to Success", in A. Segal, Learning by Doing (Westview Press, 1987:137).

In the imitation and modification stage, technology was purchased from the TNC, then duplicated through reverse engineering techniques. The skills used in this process were typically labour intensive, but system-specific such that gradually skills were accumulated through learning-by-doing methods. During the improvement stage, learning-by-doing was aggressively stressed and practised on the 'shop floor', such that adequate skill levels were achieved by the firm's workforce to facilitate the emergence or construction of a generic technology system. Independent product development skills created in the particular East Asian country, as a result, typically utilised production know-how to make incremental or generic changes to products. At the innovation stage, technology, engineering and design skills would have been acquired by the firm's workforce, facilitating for limited innovations (at least initially), but innovations nonetheless. All these stages of capability building in a typical firm would have received active government assistance, especially during the industrialisation of the East Asian region where governments are particularly active in their proactive management of market forces. The Korean government, for instance, intervened "both functionally and selectively, in all product and factor markets. It offered high, variable and prolonged periods of protection to selected activities, while forcing those that approached competitiveness to export significant parts of their output. It directed domestic investible resources to infant industries, and deliberately fostered the emergence of giant private sector conglomerates (the *chaebol*) that could internalise various imperfect markets. It invested heavily in education, especially technical education, and induced private firms to launch employee training schemes. It also invested in R&D and technology infrastructure institutions, while inducing (through subsidies and other incentives) and cajoling local firms to develop their independent research capabilities. All these factor market interventions had highly selective aspects, being integrated into the overall direction of industrial development as driven by trade and industrial policies" (Lall/UNCTAD, 1995: 30). As a direct result of such government action in the country's technology capability building efforts, the Republic of Korea has the most advanced technological capabilities and the highest ratio of R&D to GDP relative to the rest of the South.

4.3.4 The Experiences of South Countries in S&T Planning

As it currently stands, the South at large, is desperately attempting to remain a distant participant in the global race for technological supremacy.[65] As with all the development battles of the South today, it would appear, without being too overly pessimistic, the South is in a loosing battle with its S&T effort. Much of the South, save for the newly industrialising economies (NICs) and a few middle income countries (Brazil, India, Argentina, etc.), are in a downward spiral technologically. Increasingly authors are acknowledging that "what separates these countries [...South countries...] from OECD countries is a huge gap in their capacity to use technological change as a motor for growth, structural transformation and modernisation. They have a cruel lack of the institutional structures and human capital which would allow them to absorb, reproduce, adapt and improve imported technologies alien to their traditional know-how. They often lack the relatively simple qualifications required for operation, assembly and repair" (TEP, 1992: 20). Many countries in Africa, Latin America/Caribbean and Asia,

[65] Interview with Dr. habil D. Pilari, Division of Sustainable Development, Department of Policy Coordination and Sustainable Development, United Nations, July 8, 1997, 4:00-5:30, New York.

are desperately trying to stay in the technology race, but what we are increasingly finding is that the rules of that race are changing everyday, in terms of IP, the WTO, etc., that are making it increasingly harder for the South to technologically (and for that matter, economically) catch-up with the North. Although many scholars will be quick to dismiss the South's ability to actually catch-up with the North, the NICs have given the South hope, and challenged this view. Many economists are now viewing the Southeast Asian countries as the next players in the technological race to transform. Is this view warranted? Can countries like Vietnam, for instance, be the next *Asian Giant*?

The thesis has maintained that technological transformation is rarely, if ever, actively planned for by developing nations in their development process.[66] Granted, countries of the South have policies put in place to build education systems or import technologies from TNCs, however, these policies are rarely at the centre of the South's development strategy. Any casual observer of the South will doubtless know of the fact that in much of the South, education is not universal and significantly less government expenditure goes toward education than does spending on the military. We find further still these countries will import foreign technologies, but there is no consensus among policy-makers as to what specific, best-practice technologies should be imported. In addition, there is no effort to build national technology capacities. University research, for instance, is virtually unheard of, private sector and public sector research is extremely low. In addition, research scientists and researchers in the South are rarely funded and

[66] Interview with Mr. Agerico Lacanlale, Deputy Director, United Nations Industrial Development Organization, July 7, 1997, 3:00-4:30, New York.

their numbers extremely low. Can we then say the South has a coherent S&T policy? We can interpret an answer to such a question from Karumuna's (1995) account of the state of the S&T effort in the LDCs in special reference to Africa. He argues that "for the least developed countries in Africa, technological capacity building poses many and varied challenges. At the top of the list is the lack of political commitment, beyond the declarations of intent in conference resolutions, declarations and plans of action. Such commitment should be spelled out in action-oriented national, subregional or regional policies and strategies, which should be supported by the allocation of the necessary resources to achieve the stated goals in technology capacity-building. The necessary institutional framework for policy-making in science and technology matters is virtually non-existent, or else ineffectual and unable to provide leadership in terms of policy formulation and implementation or to galvanise the scientific and technological community in public institutions, universities and scientific establishments to contribute to creating a strong technological base" in the sub- Saharan African countries (Karumuna, 1995: 94)

The experience of sub-Saharan Africa in S&T has been especially characterised by failure. Haphazard or scattered S&T efforts on the continent have resulted in the absence of dynamic industrial growth precisely because of the lack of a well developed S&T framework in many of these countries.[67] Industry based studies of firm performance in sub-Saharan Africa have pointed to the malignant and widespread lack of

[67] Interview with Dr. Raj Bardouille, Economics Affairs Officer, Office of the Special Coordinator for Africa and the Least Developed Countries, June 27, 1997, 9:00-12:00, New York.

technological effort in many industries there. For instance, Oyeyinka (1988) examined the Delta Steel Company in Nigeria and found that it had not surpassed the 30% capacity utilisation barrier since its formation in 1982. Similarly, Mlawa (1983) found that the textile industry in Tanzania was subject to structural decay and increasing/sustained decline in productivity. These case studies of the manufacturing industry in sub-Saharan Africa are indicative and reflective of the situation that characterises much of the technological capability building efforts of industries throughout the continent. Consequently, African industries have been subject to a dismal productivity record and, as a result, limited or immature development of a capital goods sector. African industry has been characterised by "pervasive undercapacity of industry, the slow growth in productivity and the incidence of white elephantism (i.e. abandoned large-scale projects)" (Ogbu, et al., 1995: 10). Africa's weak industrial structure has been reflected in low total manufacturing output as a percentage of total GDP, low capital goods production as a percentage of total manufacturing, and the lack of a well developed machinery sector as a percentage of total manufacturing output. Production capacity is often poorly developed on the continent because of poorly developed technological capabilities which fail to facilitate for technical change, i.e. change resulting from product-centred and cost-reducing alterations to the techniques of the production process. These countries have fallen victim to a vicious cycle that continuously repeats itself, where low productivity affects the quantity and quality of production, therefore, sales levels are not substantial enough to warrant intra-firm R&D projects, and as a result, inefficient production continues, forcing a repetition of the cycle.

It is the lack of a technically skilled indigenous labour force in African industry and the lack of development of a capital goods sector, though, that has undermined the advancement of R&D and the structural transformation of technical capabilities in these countries (Bhagavan, 1990). Industrial progress in any significant form has been absent from Africa because of the failure of many African governments "to formulate and implement the strategic technology policies needed for economic and industrial development" (Mudenda, 1995: 45). The large majority of governments in Africa have not prioritised S&T as an integral component of their development process/plans. This is because, on the one hand, African policy-makers have failed to operationalize the management of international technology transfer, which as Mudenda argues, comprises the search for and selection of the most appropriate technical systems and terms of transfer. Neither have they executed and managed technical change in an efficient manner in order to ensure the effective replication and assimilation of acquired technologies at the firm level. And perhaps most important of all, these policy-makers have failed to develop appropriate methods of acquisition of technological and managerial capability, principally because of the lack of development of a satisfactory local S&T infrastructure. These policy failures in regards to S&T is reflective of African policy-maker's failure to implement implicit technology policies (e.g. appropriate educational systems) that reinforce explicit S&T policies. While these policy-makers have not been short on rhetoric regarding S&T, such articulated goal setting has failed to be translated into action.

It is quite apparent then, that the fact that the South does not more actively plan for its technological transformation is reflective of the lack of an adequately developed S&T institutional framework, especially at the following functional levels/organisational structure of the S&T system - a National S&T Council (closely affiliated to the executive branch of government, typically the Prime Minister's or president's Office; a Technical Advisory Committee of such a council typically chaired by various scientists and professionals; a S&T Commission in which planning, financing and coordinative efforts regarding S&T activities at the country level takes place; and, S&T institutes or centres where specific S&T activity such as education of firm workforce or R&D is promoted at the sectoral and industry level. In spite of the fact that Japan is in many respects a testament that technology capacity building initiatives are at the centre of any nation's economic and technological salvation, East Asia is by far the only region of the South that has learnt from the Japanese success with S&T policy planning, and earnestly implemented similar S&T initiatives. Perhaps though a more focused analysis of one South country's effort at developing its S&T capacities will lend a greater understanding to the current state of S&T capability building in the South countries. We turn, as a result, to a country case study. Our analysis in this regard is of Vietnam and its S&T effort.

4.3.5 S&T Policy Planning in the South: The Case of Vietnam

There is, as yet, no coherent S&T planning policy in Vietnam (Communist Party of Vietnam, 1996).[68] This is the case because little research or experimental development is evident in Vietnam's private sector. Secondly, the majority of current technologies in the country are imported via joint venture and FDI.[69] Although foreign investments of this sort are a common method of introducing technologies and technical know-how into the country, subcontracting and licensing arrangements are also popular. Therefore practically speaking, over 95% of the technology needed for Vietnamese industry is imported, only a limited number of technologies come from polytechnic universities and some government funded research establishments and universities (Annerstedt and Sturgeon, 1994).[70] As it currently stands, incremental changes made on those imported technologies by Vietnamese industry are extremely low, and not widespread throughout industry. The majority of these industries are reliant on technological advances in product and process that occur in firms in the North - hence, there is virtually no learning-by-doing by Vietnamese workers. Increasingly, though, Vietnamese firms have made attempts to foster closer ties with research laboratories and universities in the country in

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[68].Communist Party of Vietnam VIII National Congress, 1996 - 2000 Development Plan for Vietnam (Government of Viet Nam: Hanoi, June 28 to July 1, 1996), there is no concrete strategy apparent in this plan for building technology capacities in the Vietnamese economy. .

[69]FDI is a common method of international technology transfer (ITT) to the South, it accounts for 20% of the total net foreign resources entering the South. The FDI package typically includes equity or loan finance, management expertise and technology.

[70] The following discussion builds on their assessment of Vietnam's S&T effort.

an effort to develop indigenous technologies through incremental changes in imported technologies. Besides this effort by Vietnamese industry, little effort has gone into the creation of a coherent S&T policy in the country's economic reform effort. In fact, research at the Institute of Science and Technology in Vietnam has argued that in the 1990s Vietnam's capital stock remains qualitatively poor, old and technologically backward, partly because of its isolation from Western technology during the years of the U.S. trade embargo (Brundenius, 1991).

It would seem from this cursory discussion of the situation of technology development in Vietnam that the country has no coherent S&T planning policy. This assumption, though, is only partly correct. In terms of public policy issues related to R&D, and efforts to adapt and diffuse foreign technologies, these issues are receiving some attention by policy-makers in the country. However, we see that the country's economic reform effort is more focused on correcting balance-of-payments and budgetary problems, releasing controls over nominal prices and wages, therefore, tackling inflationary tendencies in the economy, maintaining real exchange rates, monetizing the fiscal deficit, removing distortions in relative prices and curbing deficit financing practices; and less focused on pursuing or promoting any large-scale S&T effort. Granted, if these macroeconomic policy issues are not addressed, the country's reform effort will surely fail, as these issues are significant obstacles to growth in one way or another as they distort relative prices and, therefore, negatively affect real interest rates and investment. However, this said, Vietnam is focusing on macroeconomic development alone, and not on S&T policy development. We will see in an up coming discussion of East Asian growth, while this is important, it should not be done such that the development of technology initiatives are totally abandoned in the country. What we should learn from the East Asian and especially the Japanese growth experience, if anything, is that a healthy balance has to be in South country growth strategies, where equal attention is given to macroeconomic policy, but also S&T policy.

Vietnamese policy-makers, perhaps because they seek so much for the country to emulate the NICs growth dynamic, are attempting to reverse the trend of lack of a S&T building focus in the country's development strategy. To reverse the trend of lack of R&D in industry, the government is attempting to get the private, and public sectors and universities more involved in the R&D process, by upgrading specialised technical units within government ministries, as well as increasing funding to university departments that are involved in research and experimental activity. The government is also increasing funding to research institutes, and in some cases, recently creating national R&D institutes like the Institute of Information Technology and the Institute of Technology. The National Centre for Natural Science and Technology is perhaps the largest and most well known of such institutes, and continues to receive government support. In the 1990s, efforts to consolidate resources and facilitate for a larger R&D effort was partly accomplished through augmenting and combining the National Institute of Technology and the National Laboratory for Atomic Energy, under the wing of the Ministry of Science, Technology and Environment.

Despite the fact that government has put in place several specialised R&D institutes, significant obstacles lie in the path of Vietnam developing the appropriate technology infrastructure to engage in innovation activities. One big problem is that because R&D is separate from commercial technological innovative activity in the country, institutes created are not well linked to industry. Therefore, Vietnam's economic performance is compromised because industry has no source of research into technologies. It can be surmised then that the country's R&D initiative at present is largely ineffective because it does not enhance industrial competitiveness, hence growth, as a result of these weak links. However, it is hoped that problems such as these will be addressed by the creation of institutions like the Hanoi Technology Centre, constructed to facilitate for an increase in research into new technologies, but also foster closer links between industry and research centres to ensure greater co-operation between the two. However, Vietnam still faces a significant problem, in the lack of co-operation between the private sector-universities-public sector research establishments. Until such co-operation occurs and an increased transfer of information is facilitated between these important players, a common goal and the success of Vietnam's technology capacity building initiatives will remain seriously compromised.

It is quite apparent from this analysis that Vietnam urgently needs a more proactive and focused approach to the advancement, diffusion and implementation of technologies if it hopes to sustain its current levels of growth. With this in mind the government in the nineties has attempted to cautiously build its technology capacities. Many such initiatives are in their infancy, however, one particular initiative has been in place since 1993. This particular initiative is geared at strengthening the country's information technology (IT) capacities, and it came into effect in 1993 by the creation of

Government Resolution No. 49/CP/1993 signed by Prime Minister Vo Van Hiet. This initiative seeks to put in place guidelines for government ministries to follow in their implementation of IT[71] throughout Vietnamese society, as in the information age, a population unfamiliar with computers and related hardware and software are at a serious disadvantage relative to the rest of the world. IT development and diffusion in Vietnam, relatively speaking compared to its other East Asian neighbours, is at best mediocre. In 1994, it was estimated that the number of micro computer PCS in Vietnam was around 45 000, a sizeable increase in itself from the number of PCs in 1989 that numbered just under 4 000. IT technologies have not been diffused in Vietnam because of exogenous factors (i.e. the U.S. trade embargo) and endogenous factors (i.e. the low pool of IT professionals, such as programmers, systems analysts, and other technologists - largely because of the lack of science education opportunities in the country at the graduate and PhD levels). Secondly, there is insufficient hardware and software in the country, such low technical levels are compounded by a lack of maintenance and technical advisory services.

The IT initiative in Vietnam is a response to the country's drive to become the next NIC by developing an export oriented economy specialised in computer software

[71]IT is definable as comprising microprocessors and a variety of manufactured electronics goods, including integrated circuits. The Berkeley Round Table on the International Economy suggests six ways of segmenting the IT industry - the end user market, sub-industry (automative and industrial electronics), physical composition (hardware and software), manufacturing technology (hand or automative technology), level of packaging (components to final product), market type (vertical or niche markets and horizontal or mass markets) and hybrid markets.

and hardware manufacturing - the fastest growing industry in East Asia. In order to establish an IT industry indigenous to Vietnam and a more coherent IT development strategy, a National IT Board has been established and is being chaired by the Ministry of Science, Technology and the Environment. In addition, the creation of a Council of Scientific and Technological Advisors is also being established to compliment the Board's activities. As Annerstedt and Sturgen (1994) point out, the Board and Council have been assigned a Secretariat, that as a national agency for IT development has the mandate to help sectoral efforts in a number of industries in developing ITs. However, much remains to be done in the development of IT in Vietnam. Annerstedt and Sturgen suggest a task force be set up comprising technology and policy specialists to monitor the pace at which the IT initiative is being implemented in Vietnam. The success of the country's IT planning strategy will depend on how effectively it is developed by industry, research institutes and universities, and how closely they cooperate in developing these technologies, and how effectively the government attracts new capital into the country by foreign companies.[72]

Why the government is pursuing and sees the need for a national IT strategy is related to the fact that it is a strategic industry, i.e. it is the fastest growing and therefore most lucrative market to be a supplier of (as discussed in the prior section on the Theory of Long Waves). Microelectronics and digital communications are products that are part

[72]The effectiveness of the government's bid to attract foreign investment will depend in large part on how the government reforms the country's financial system and commercial regulations and IP laws, as they largely remain ambiguous.

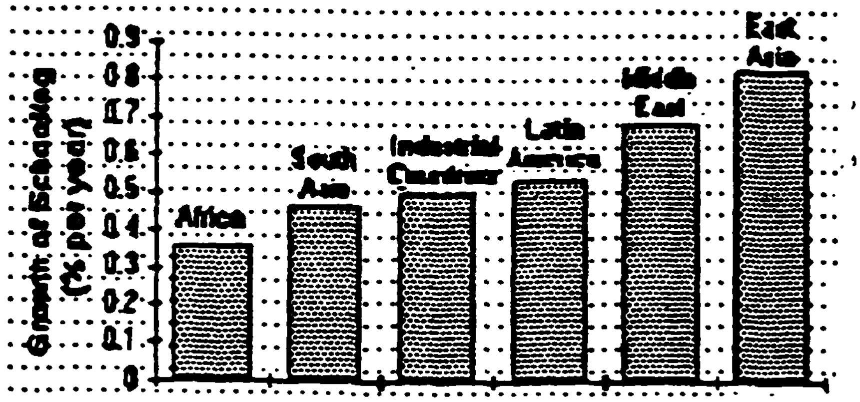
of a highly sophisticated industry whose products are in high demand Vietnam wants to be a part of this industry (UNCTAD, 1995). The IT program will in part, it is hoped, address Vietnam's aims of becoming technologically developed. By promoting IT diffusion at the national level, it is also hoped the country will industrially, infrastructurally and in terms of its human resources, develop. There is an increasing recognition by policy-makers that the success of the country's export led growth initiatives, will to a large extent, depend on how well the country builds its technological capacities, so as to introduce modern technologies to industry's production techniques and processes. Whether enough is being done by the government to respond to this recognition is as yet unclear. Vietnam's effort in building its technology capacities, as with its efforts to economically reform, though, many observers note are not being implemented fast enough and in the correct fashion or tradition of S&T and economic growth planning that has characterised the first tier-NICs of East Asia (Dollar, 1994) and (Fforde and deVylder, 1996).

If there is ever to be a coherent S&T policy in the South, the building of technology capacities, whether it be in economic reform efforts, like Vietnam is currently implementing, or any other growth strategy, S&T policy will have to take centre stage. We have found, unfortunately, that South countries like Vietnam do not place S&T as a priority in their development strategies. Much of the South's technology capacity building effort, including Vietnam's, will have to be based as Japan's was on the importation of technologies in their drive to technologically catch-up with the North (Headrick, 1988). This is a fact, because of the South's low capital stocks and largely unskilled/uneducated workforce. These country's technological transformation, like Japan's, will depend on how successfully they adapt and make imported technologies more appropriate to their country's industry. Such an initiative will be limited by two issues. First, whether the technology imported is highly unpackaged or highly packaged and the nature of the proprietary/patent restrictions surrounding those technologies. If the technologies are not unpackaged (as is often the case with the technology imports of choice in the South - FDI, turnkey investments, etc.), industry management and labour force will not have the opportunity to understand the patents and the technology itself, hence not facilitating for an environment of learning-by-doing and dynamic firm-based technology assimilation. Secondly, how well educated a workforce is (and how well S&T policies develop education systems and pedagogical aids) will have a direct bearing on how well the technology is diffused and understood by a particular workforce.[73] The application of a given technology inherently implies, a learning of that technology - which is near impossible without an understanding of physical, mechanical, chemical and electric phenomena, behind the technology. Therefore, in order for the technology to be supplanted, and for generic techniques to be made part of the S&T policy of any developing country must involve the high level technical education of a population. That skill creation and science competency will have to take place at primary, secondary and tertiary education levels, but also in OJT. A country that is neither highly numerate or literate will continue a dependency on TNCs, for not only technologies, but technical

[73] Interview with Mr. Fahri Boumechal former TNC Affairs Officer, United Nations Center on Transnational Corporations, July 1, 1997, 10:00-11:15, New York.

expertise. We can see in Graph 1, East Asia has consistently led both countries in the North and South, in the growth in schooling of its population, during the period 1960-1992 - a testament to the importance of an educated workforce in this region's remarkable economic growth.

Graph 1 - Growth in the Education level of the Working Population (1960-92)



❒ Please note as in this illustration and upcoming illustrations, the data presented for East Asia, excludes Japan and China.

Source: adapted from, World Bank, World Development Report (1991, 92 and 95 editions, New York: Oxford University Press).

How committed a country like Vietnam will be to developing a coherent S&T policy will also be reflected in the extent to which its leaders have a vision for the country's future development. It will encapsulate how much they want their nation's development to be as much a development of its human, as well as physical capital capacities. A committed S&T policy will be concerned with building technology capacities, but even more so investing in the country's most important factor of production - labour, through higher level education grounded in a theoretical knowledge of the sciences, that in the next millennia will prove invaluable in the application of complex capital technologies to industry. Policy-makers in the South would do well to heed the example set by Japan and the rest of East Asia, that recognised at an early stage in their development that sustained economic growth in real per capita income is not a function of physical capital accumulation alone, but of human capital accumulation.

This being said, the success of a human capital centred technology policy is an expensive, and financially taxing exercise. The degree to which that exercise may be made less expensive and more effective will depend on the prudence and practicality of policy interventions by policy-makers. Meaning, those policy interventions must be appropriate to the level of technological advancement in a particular country. Typically, as we have seen from the above analysis, countries of the South have very low technology capacities. They are very much dependent on technology imports. Consequently, S&T policies vis-a-vis education must reflect these realities. For instance, often policy-makers will send university level students overseas to universities in the North, or train such students in Universities in their countries to be engineers. Such policies though should not be relied upon entirely as: a.) it takes a longer period of time and more resources to train an individual to be an engineer, b.) engineers are primarily familiar with the design and not the application of technologies - this is a critical point, as many nations in the South rely on imported technologies and not endogenously created technologies in their initial stages of industrialisation. Hence, technicians are needed in the South, it is relatively inexpensive to train them and they have operational, maintenance, science and mathematics skills (mainly middle level skills) essential in applying foreign technologies. While we do not argue engineers and scientists should not exist in the South (as they are needed to engage in R&D), not as much resources should go to educating too many, at least in the initial stages of an S&T effort.

It is perhaps premature to argue that Vietnam will become the next *Asian Giant.* As we have seen from the previous discussion S&T policy planning in Vietnam is as yet in its infancy, and there are questions surrounding whether its a committed initiative. S&T policy, sadly, has taken a back seat to macroeconomic austerity measures in Vietnam (as in most other countries of the South), which while important, cannot be sustainable without equal priorities given to the development of human and technology capacities. Let us compare vital data in order to substantiate this argument. We look at data of the strength of the education system in Japan and Vietnam (refer to Tables 4a and 4b). This comparison highlights the immense obstacles Vietnamese S&T policy has yet to overcome in its effort to build a technically competent workforce that can contribute to the technological transformation of the country.

Table 4a - The Education System in Japan (1992)

	Institutions	Teachers	Students
Primary Schools	24 730	440 769	8 947 226
Lower Secondary Schools	11 300	282 737	5 036 840
High Schools	5 501	284 409	5 218 497
Technological Colleges	62	6 439	54 786
Junior Colleges	591	56 974	524 538
Graduate Schools and Universities	523	227 697	2 293 269

Table 4b - The Education System in Vietnam (1993/94)

	Schools	Teachers	Students
Pre-Primary	6 870	65 691	1 659 247
General	18 856	442 608	13 540 947
Primary	13 092*	275 640	9 725 095
Secondary:			
First Cycle	4 616V	132 722	3 101 483
Second Cycle	1 148V	34 246	714 369
Vocational Training	187	4 469	49 498
Technical Secondary	264	7 728	87 909
Higher Education	104	20 648	118 589

* Includes 2 995 institutions that provide primary and the first cycle of secondary school.

V Includes 534 institutions that provide both the first and second cycle of secondary education.

Source: adapted from The Far East and Australasia 26 edition (Europa Publications Ltd., 1995: 315 and 345).

In looking at the two tables, we can see the tremendous gap in the number of institutions, teachers and students in the two countries. Vietnam is far from the educational capacities of the Japanese system, this is evidenced at the primary levels, and especially at the higher education levels. Looking at the Japanese data, we can see the sheer number of the country's human capital being educated at the graduate level. These individuals will go onto the workforce with a far superior technical education and in larger numbers (than their Vietnamese counterparts) to contribute to their country's technological transformation.

4.3.6 S&T Policy in Japan and the Republic of Korea: Lessons for the Developing Countries

There have been two important actors in Korea's industrialisation strategy - the government and the *chaebols*. "The government has played an important role in managing and facilitating the transfer of foreign technology by regulating collaborative agreements concerning direct foreign investment and foreign licensing, and by providing incentives and preferential financing to those who acquire foreign technologies through means other than collaborative agreements. The government has also contributed significantly to technology transfer through the development of an R&D infrastructure such as public R&D institutes and technical information centres, which have played an important role in helping local firms acquire better bargaining power in technology transfer negotiations, and also in the reverse engineering of foreign technologies" (Kim, 1991: 232). This has been the experience of many East Asian countries. However, Korea has developed a comprehensive and dynamic S&T infrastructure, the activities of which were closely monitored and guided by a well developed S&T policy. Korea's S&T effort, as does Japan's, stresses the commercial or economic value of a highly trained workforce. These country's S&T policies argue such training enables the workforce to better understand the transfer of sophisticated technologies and more effectively assimilate those technologies into the firm environment and in a relatively short time be able to engage in local firm based R&D. There are important lessons for South country efforts to plan for S&T in this respect. Namely, policy-makers in the South, in building a proactive S&T policy, must have a common recognition of what the nation hopes to achieve by utilising specific technologies. This perhaps best explains what the thesis refers to when it discusses a coherent S&T policy. If a nation wants to be a principle exporter of a specific set of products, it has to import technologies and consistently build its technological capacities, such that the product can be produced efficiently, and that production be sustained, and the product itself be of the highest standards. Secondly, policy makers and top executives in industry must work together intimately with a unified view of where they see the country technologically and economically in a decade or two, then they must plan around this vision, never deviating from that vision so as to ensure continuity of policy. Subsequently, these officials must work together implementing appropriate policies and supporting one another with the common goal of advancing the nation. This goal and priority setting is perhaps the most fundamental of themes in a coherent S&T policy.

Much of the South, like Japan in its race to industrialise, during the early years of this century, will have to import foreign technologies in order to develop. Those technologies, despite their proprietal restrictions, are the only way much of the South will develop in the next few decades. Because these technologies are plagued with proprietal restrictions and are extremely expensive, policy-makers in the South would do well to regulate the types and quantity of technologies entering the economy and allocate scarce resources effectively in the technologies application to industry. Secondly, because technologies are expensive, technology professionals, both in the private and public sectors, must be encouraged to make maximum use of the technologies. Only when these technologies have been fully exploited, should industries import other technologies. So as to ensure this policy is followed, governments, through agencies similar to Japan's MITI, should be involved in the importation process, on one the hand, through granting or rejecting applications by industries to import a technology, and on the other, by being involved in the actual negotiations between the TNCs and firms, so industry and government have more control over the nature and types of technologies that enter the country. Implicit in these recommendations is that the government agency must actively aid the potential technology importing firm when it shops around for technologies, to ensure the firm acquires the *best-practice*, most appropriate technologies.[74] If those imported technologies are to be utilised effectively, it is critical that it comprise *embodied* elements that are complimented by *tacit* elements, as this often never occurs. These tacit elements that include specific information that can be learned by a firm's workforce often never accompany the technology - this in effect significantly reduces the efficiency with which that technology can be utilised, but also incrementally improved.

In addition, as with Japan's MITI, the South in forming agencies like MITI must limit the number of firms entering new markets with new technologies via 'staggered-entry-formula', so as to curtail curtail competition in industry and ensure the development of large firms capable of enjoying economies of scale. This exercise, in effect, is a

[74] It has been established in a prior discussion that this will be a difficult task as the global technology markets are highly fragmented and oligopolistic.

regulatory tool to ensure that those firms that do acquire the technology are the most efficient, and hence, most likely to optimally utilise the expensive technologies. Such policies must be complimented by government support of private and public sector research,[75] through supporting research institutes, investing in capital equipment and programs designed to send scientists abroad to attend symposia, etc., so that they can keep abreast with current technologies and have an intimate and detailed knowledge of patents and their performance. Governments must also invest in relatively inexpensive sources of scientific information, i.e. science journals for libraries, etc. Equally important as a policy is that government's must encourage OJT[76] that facilitates for workers to be familiarised and sensitised to a specific technology and better be able to learn-by-doing, but also be involved in a process of learning to 'learn' (Stigiltz, 1987).

Kim suggests a number of stages for the development of industrial technology in the South (Kim, 1980). First, there should be the importation of foreign technologies dependent, to some extent, on foreign expertise for its diffusion in industry. Subsequently, capacities should be built where indigenous experts are able to understand

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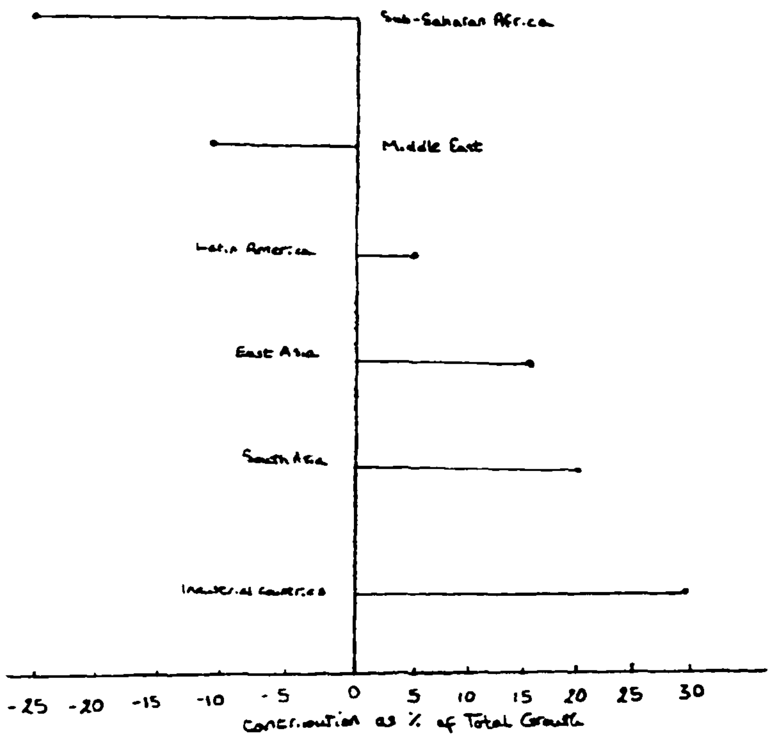
[75]The rationale in complimenting imports of technology with indigenous research is to promote technological deepening, because of its significant externalities. Such technological deepening strategies can be strengthened by policy-makers encouraging majority ownership of foreign investment by local business, and by encouraging TNCs to move some of their design and R&D work to subsidiaries based in the South, so as to stimulate local learning especially in joint venture arrangements/contracts (however, it is often very difficult to encourage TNCs to carry out R&D in the South).

[76]OJT in Japanese firms is so important in maintaining these firms competitive edge because of workers intimate familiarity with firm technologies, that Japanese employee training expenditures are larger than national expenditures on formal education.

the technology, assimilate, and in turn, diffuse and incrementally change it at the industry level. Kim also argues these technologies can only be incrementally changed effectively if technology specialists are adequately trained and some level of indigenous research is taking place - a point reaffirmed by Sen (1979). As was indicated in the discussion of Japanese technological transformation, the country utilised non-proprietary technologies in its initial stages of industrialisation. Nation's of the South would be wise to do the same. They do not have the technical expertise to comprehend modern technologies, they would be better of importing standardised, non-proprietary, unsophisticated technologies. However, as mentioned in a prior section, the extent to which a South country can make this choice is significantly undermined by the superior negotiating position the TNC has in the negotiations over the terms and methods of transfer of the technology.

Many of these recommendations have been suggested to governments in the South, however, while they have been acknowledged as critical to growing a nation, Southern policy-makers have failed to translate what they acknowledge as important policy into implementable action. This, despite the insurmountable evidence of the benefits of instituting committed capacity building technology initiatives. Consider that technical progress in both East and South Asia have contributed tremendously to economic growth. More outputs have been able to be produced in these regions from a given level of inputs. In fact, total factor productivity (TFP) growth, as a measure of technical progress, has accounted for 12% output growth in East Asia (excluding China and Japan) and accounted for over 15% output growth in South Asia (see Figure 10 and Table 5). These regions have taken the cue from the industrialised North where the contribution of technical progress to economic growth has been a staggering 29%. Sadly, sub-Sahara Africa (SSA), the Middle East and Latin America have chosen to ignore this quantitative evidence of the importance of concentrating on technical progress, and hence, TFP in these regions have especially small.

Figure 10 - Contribution of Technical Progress to Economic Growth



Source: Bosworth, B., Collins, S.M., Chen, Y.C., "Accounting for Differences in Economic Growth", Paper Prepared for Conference "Structural Adjustment Policies in the 1990s: Experience and Prospects", Nov. 5-6, 1995, Tokyo, Japan.

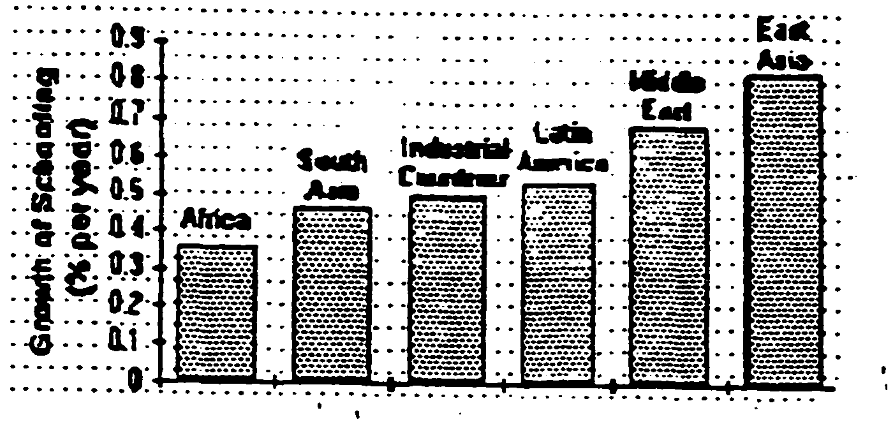
Table 5 - Contribution of Technical Progress to Economic Growth

	Labour Force	Output/Wkr.	TFP	TFP Share output of growth
SSA	2.5	0.5	-0.7	-23.3
Middle East	2.8	1.8	-0.4	-8.7
Latin America	2.8	1.4	0.1	2.4
East Asia	2.6	4.1	0.8	11.9
South Asia	1.9	2.3	0.7	16.7
Industrial Countries	1.2	2.4	1.0	27.8

Source: (Same as Graph 1)

Education is an integral part of any S&T capacity building initiatives By developing the skills of a given population, a policy-maker is building capital - human capital. Countries of the South must learn from the East Asian experience and develop high rates of human capital accumulation. Human capital formation has been extensively promoted by East Asian policy- makers through "a.) increasing investments in education in general (not only by the government but also private individuals and families); b.) providing better access to education to all sections of society and greater information on the need for education; c.) raising the quality of education and improving staying-on-rates; d.) increasing the relevance of education and training to economic - particularly industrial - needs; e.) encouraging the establishment of good quality private training institutions to assess and meet the needs of industry; f.) coordinating the needs of skills for industry with the design of educational curricula; g.) increasing the emphasis on technical subjects at higher levels of education; and h.) getting greater industry involvement (including by transnational enterprises) in training at the vocational level and in encouraging in-firm training investments by offering tax incentives or training grants" (Lall/UNCTAD, 1995: 30-31). The graph below illustrates the high growth rate of the wage-weighted years of schooling of the working population in East Asia (Graph 2, also see Table 6).

Graph 2 - Growth in Education Level of the Working Population



Source: adapted from Bosworth, B., Collins, S.M., Chen, Y.C., "Accounting for Differences in Economic Growth", Paper Prepared for conference "Structural Adjustment Policies in the 1990s: Experience and Prospects", Nov. 5-6, 1995, Tokyo, Japan.

Table 6 - Growth in Education Level of the Working Population
(% per Year, 1960-1992)

Africa	0.36
South Asia	0.46
Industrial Countries	0.50
Latin America	0.53
Middle East	0.68
East Asia¶	0.82

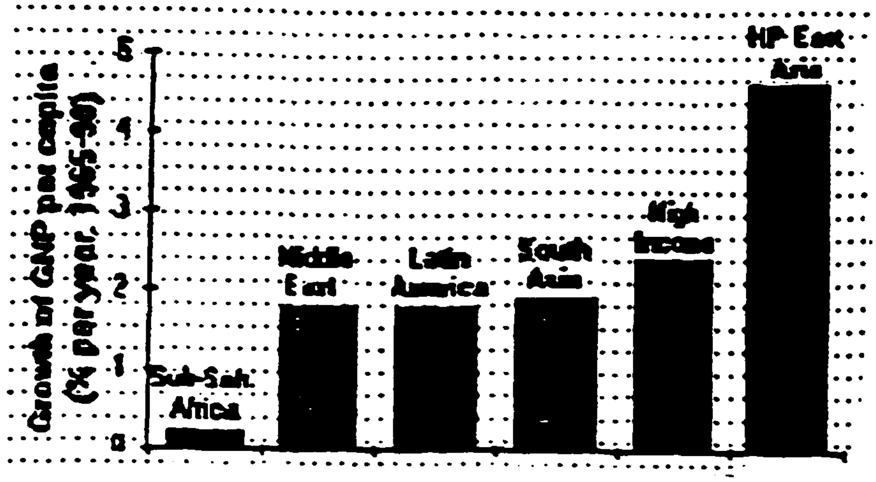
¶ Excludes China and Japan

Source: (Same as Graph 2)

As higher education level skills are not fungible, an active effort has to be made to train human capital in all aspects of the scientific professions. Secondly, scholarships should be awarded to graduate level science students, as well university departments that offer those programs should be heavily funded. Similarly, university research at large should be actively funded. Closer co-operation has to exist between firms and universities, one way to do this is by building a technology infrastructure for industry near universities. The American's have adopted such a strategy, for instance the high-tech Silicon Valley is next to several universities in California, this geographically places universities and industry next to each other hence, providing greater opportunities for co-operation in research, the exchange of ideas, etc. Perhaps it cannot be stressed enough that before all this can be promoted, there must be universal education with a science based curricula. While this may seem to be a tremendous undertaking (and no doubt it is for many South countries, especially LDCs) consider the merits of such a policy. East Asia, for example, has been described as a 'miracle' region because of its sustained growth rates over the past three decades.[77] Real incomes per capita have been increasing at astounding rates in these regions, even the high income, let alone the low income countries, have not been able to keep up with such dramatic growth in GNP per capita (see Graph 3 and Figure 11). Much of this growth has been made possible by a highly skilled work force in the region that are extremely comfortable working with sophisticated foreign technologies in the firm environment. As a result the sizeable increase in human capital accumulation in the region has in large part facilitated for the dynamic transformation of its technological and economic capacities.

[77]East Asia in this discussion includes eight economies, all transforming in groups after the initial Japanese transformation, i.e., Hong Kong, Singapore, Taiwan, and the Republic of Korea followed, and now the economies of Indonesia, Malaysia and Thailand are following.

Graph 3 - Growth in GNP Per Capita, 1965-90



Source: adapted from World Bank, World Development Report 1991: The Challenge of Development (New York: Oxford University Press, 1991), also see World Development Report 1992 and 1995.

Figure 11 - Growth in GNP Per Capita, 1965-90 (% Per Year)

SSA	0.2
Middle East	1.8
Latin America	1.8
South Asia	1.9
High-Income Economies	2.4
East Asia¬	4.6

High Performing East Asian Economies

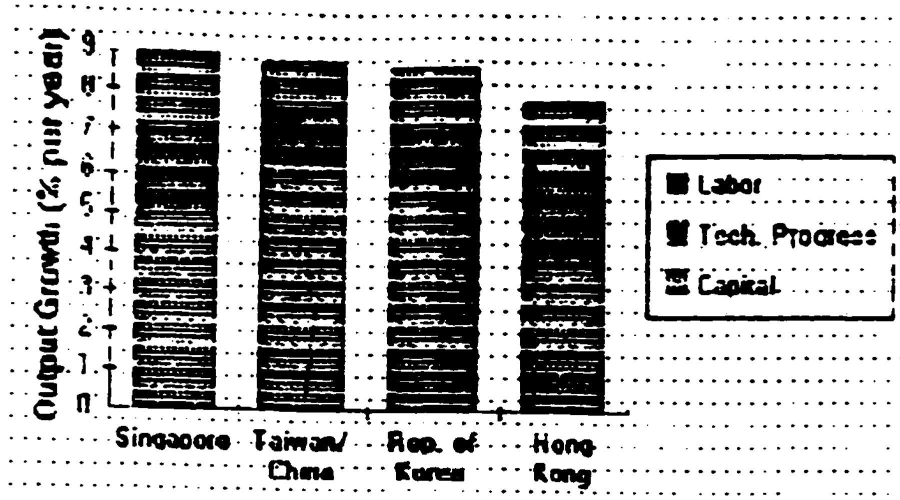
Indonesia	4.5
Thailand	4.4
Malaysia	4.0
Rep. of Korea	7.1
Singapore	6.5
Hong Kong	6.2
Japan	4.1

Source: (Same as Graph 3).

Because these countries followed a policy of investing in human capital, the proportion of skilled workers has been rising in these regions. Hence, labour as a factor of production has been critical for growth, as because of their increased skills, the nature and quality of their outputs have positively changed. There have also been significant contributions to growth by large increases in physical capital inputs (investments), such that the savings and investment ratios in the region have drastically risen over the past couple of decades. This in turn has had a tremendous impact on output per worker. These increases have generally, according to Kim and Lau's (1994) growth accounting exercise, been complimented by other factors that cannot be included in the measured indices for growth in capital and labour input, this factor is technical progress. Although increases in technical progress was important, it was not as critical in their study of East Asian growth as increases in labour/capital inputs. However, the importance of technical progress in these country's growth varied from country to country, ranging from 14% in the Republic of Korea to 35% in Hong Kong - so the importance of technical progress in growth cannot be dismissed[78] (see Graph 4 and Table 7).

[78]Consider that technical progress accounted for as much as 46% and 49% of output growth in Japan and the United States.

Graph 4 - Factor Contributions to East Asian Economic Growth



Source: adapted from Kim, J.L., Lau, L.J., "The Sources of Economic Growth of the East Asian Newly Industrialised Countries", *Journal of Japanese International Economics*, Vol. 8, Sep 1994: 235-71.

Table 7 - Factor Contributions to East Asian Economic Growth

	Data Coverage Period	GDP Growth	Share of Capital	Share of Labour	Share of Technical Progress
Rep. of Korea	1960-90	8.6	67	19	14
Taiwan	1952-90	8.7	72	13	15
Singapore	1964-90	8.9	55	23	23
Hong Kong	1966-90	7.8	48	17	35
Japan	1957-90	6.7	49	6	46
United States	1948-90	3.1	24	28	49

Source: (Same as Graph 4).

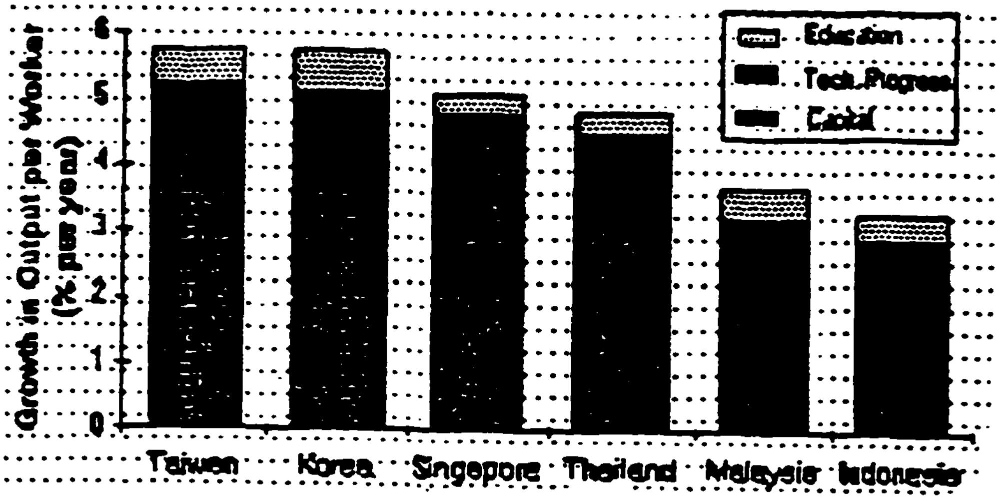
However, such growth accounting methods fail to account for the contribution of the East Asian regions investment in its population. East Asia, as has been mentioned before, was actively involved in increasing the stock of productive knowledge in its workforce through formal education, intrafirm training, and other forms of knowledge dissemination. The stock of knowledge in these economies were significantly increased because of the intensity of science based training and research in the region. It has been econometrically proven by economists studying the region that such education and knowledge accumulation has significantly contributed to productivity there (Behrman and Schneider, 1993). Take Korea, for example from the 1960s to 1992, education played a significant part in growth (see Table 8). In fact, education, which has taken a high priority in most of East Asia, has positively influenced economic growth (see Graph 5).

Table 8 - Sources of Growth in Korea

Period	Growth of GDP Per Worker	Contribution of: Capital	Education	TFP
1960-70	5.1	3.5	0.9	0.6
1970-80	5.9	4.5	0.5	0.8
1980-86	6.2	2.9	0.7	2.5
1986-92	6.6	3.9	0.7	1.9
1960-1992	5.8	3.8	0.7	1.3

Source: adapted from Bosworth, B., Collins, S.M., Chen, Y.C., "Accounting for Differences in Economic Growth", Paper Prepared for Conference "Structural Adjustment Policies in the 1990s: Experience and Prospects", Nov. 5-6, 1995, Tokyo, Japan.

Graph 5 - Human Capital's Impact on Economic Growth Through Education



Source: (Same as Table 8).

However, growth in these economies has been a function not only of exceptional policy efforts to increase the stock of productive knowledge embodied in human capital (hence closing the *idea gap*) and technology building capacity policies (hence, closing the *object gap*), but prudent agricultural, export, investment and savings policies. Good macroeconomic policies (such as stable real exchange rates, small government budget deficits, and stabilised, low inflation rates) have served to compliment S&T policies in these regions, this has accounted for much of the dynamic growth in the region (World Bank, 1993). However, other demographic oriented policy initiatives have also contributed to the regions high economic growth, like efforts to curb rates of population growth and lower fertility rates. For instance, between 1980 and 1993 the average p.a.

growth rate in population, in East Asia was just 1.5%, as compared with SSA, South Asia and Latin America, which amounted to 2.9%, 2.1% and 2% respectively.

Based on this account, is it fair to say that the South country's should attempt to replicate the industrialisation or development dynamic of East Asia? Such a question is common place in the development literature these days, however we should be cautious of questions and analysis in this tradition.

4.3.7 Can the East Asian Pattern of Industrialisation be Replicated?

First off, the East Asian strategy of industrialisation is not replicable; lessons may be learnt but certainly not replicated. Why? The industrialisation of the East Asian region was in a small, but very important way, attributable to the time period in which the regions industrialisation path climaxed, and the international economic conditions specific to that period hence, it is not accurate to argue the East Asian growth dynamic can be replicated. We must not be quick to argue replicability as we run the risk of championing a 'broad brush' approach to development that states Country A did this so Country B can too. South countries cannot emulate East Asia's industrialisation dynamic because external factors regarding Japan's patron role in East Asia's development is not apparent, for example, on the African continent where no one country can claim to be in any position to assume such a role (Castley, 1997).

In addition, the pace of East Asia's industrialisation was spurned by the rise in demand for electronics (the region's principle comparative advantage) in the latter part of the 1970s and 1980s by the West. The East Asian region capitalised on the increased demand for these products by gaining more and more of a share in the production market for them. And because electronics are primarily knowledge-intensive as opposed to capital-intensive, they had shorter product cycles, therefore, innovations in this area translated into the faster commercial use of these products hence, quickly factoring out the R&D expense associated with them. Secondly, because electronics are knowledge-intensive, they required little investment in production systems or system/firm-specific technologies. Therefore, East Asian firms/exporters quickly acquired the capital from quick sales to reinvest into innovative activities to create even more competitive and standardised, highly advanced exports which were even in more demand. This created a cyclical effect where firms engaged in the production of these products in East Asia were able to secure an incredibly short technological transformation period due to the very nature of the product they produced and the ease with which it could be assimilated, adapted, innovated on through generic methods, and eventually sold/marketed.

The unique structural dynamics of East Asian growth was also spurned by the unique production techniques employed in the region. Specifically, firms in East Asia have a unique way of organising production where there is flexible and interactive use of inputs such as capital, labour and technology. The system works on the concept managed improvisation; where all production inputs including human capital can be interchanged with capital equipment at specific stages of the production process, resulting in significantly greater adaptability of East Asian NIC production systems, i.e. technologies used can be used effectively without obstacles like appropriateness of technology proving to be significant bottle-necks to the production process. Therefore, at each stage of the production process the quality and quantity of goods produced is not compromised. At least theoretically, the rationale of the East Asian production process can be explained using the work of Libenstein that was all the rage in the 1970s and 1980s. Libenstein's work on managed improvisation became so popular that his argument that output gains can be achieved without necessarily increasing inputs became known as Libenstein's X-efficiency (Leibenstein, 1966). He argued that an enterprise's production function is often rarely predetermined and additional output gains did not necessarily occur from an increase in inputs. The production function of the firm contains adequate built-in variability to enable improvement in efficiency without a need for increased investment in human and physical capital - this output gain is what is known as X-efficiency. It just has to be harnessed in the correct fashion so as to enjoy or exploit these output gains. This is made possible as a result of managed improvisation techniques, popularised especially in East Asia because of firms that effectively or optimally utilised human and physical capital inputs, therefore, increasing productivity without a need to increase the supply of inputs..

Hence, because of these factors operating together and complimentary to one another at the right place and right time, East Asian countries were able to secure a fast paced technological transformation. The same experience cannot be found in African countries for example, who traditionally and historically have relied on the production and export of primary goods that are subject to the adverse terms of trade and tariff regimes in the international economy; not to mention needing a great deal of investment and expensive technology with which to develop the capacities to engage in R&D and hence, technological transformation. So African countries, for instance, may not necessarily be able to duplicate the East Asian industrialisation path because, as a region, it faces far greater and different obstacles than say the Republic of Korea did in the 1960s and 1970s. Korea, for example, industrialised under conditions specific to itself. Its post-war reconstruction in the 1960s, for instance, was largely successful in so short a period of time because of the large scale financial assistance and investment it received in key industries from the US and Japan. Secondly, the path of industrialisation Korea adopted reflected its resource endowments and other factor inputs in production (particularly its large reservoir of skilled human capital). In addition, Korea had access to a number of suppliers of credit for capital goods and large foreign loans guaranteed by the government were secured. In addition, Korea had a large labour market that often factored out any losses the country's exporting firms would sustain from shocks in the international market place. Almost all of these characteristics impacting the nature and trajectory of Korea's industrialisation efforts would almost certainly be lacking in many African countries. As a result, the East Asian industrialisation dynamic would not be easily replicable on the African continent but certain policy lessons and modifications of certain strategies to better cater to Africa's factor endowments could be learned and implemented to advance the S&T effort on the continent.

4.3.8 A Postscript on the East Asian Financial/Economic Crisis

The current financial upheaval in East and South East Asia first surfaced in the months of October and November of 1997, and is still on-going. The crisis has brought with it serious economic problems for the region, and in this regard has serious implications for the continued and dynamic technological transformation of the region.

As noted earlier in Chapter 3 the crisis has been precipitated by the effects of portfolio investment on the economies of the region and also bank financing or credit in the form of loans for mega-construction projects in the region that have not been paid back, resulting in the collapse of banks and other lending institutions. Because the crisis affects the economic situation in the region it affects the S&T policy framework there too. This is because a S&T policy is an integral part of an industrialisation effort or economic growth initiatives.

As the crisis is still developing, research and data on its causes and implications are not as yet readily or widely available. But from what little commentary is being provided on the crisis we know that it is affecting growth rates. Specifically, we have seen a slight decline in growth rates over the last few months in the region - this when Japan is still attempting to reverse the long drawn out stagnation it has experienced in the last few years.

While the crisis has not been directly brought on by the S&T effort in the region, it is definitely linked to it. Consider, we established in prior sections that a foreign investment regulatory regime is an integral and supportive component of a S&T effort. However, this investment policy regime has not been satisfactorily developed or managed in recent years by most every government in the region. Many South East Asian governments, for example, have certain policy weaknesses in their approach to foreign investment that have in part allowed for the schizophrenic behaviour of portfolio investments to affect their economies to the extent that they have. The weaknesses of the regions' investment regulatory regime (especially in South East Asia) have enabled outside financial flows, particularly short-term portfolio investments, to have the role they do and influence they have in their economies. This policy regime has become more relaxed in recent years hence, enabling these countries to increasingly depend on many types of investment that historically were not encouraged or to say the least relied on.

Similarly, the development strategy or growth dynamic of East Asia in recent years has become more influenced by the 'new orthodoxy', abandoning some of its statist approaches to encouraging the visible hand of the state in economic life. The weakening role of the state and state policies in place before these countries steadily acquiesced to the New World Trade Order coupled by the inability of foreign short-term investors to effectively judge the weaknesses of market developments and the international financial institutions (IFIs) having increasingly more of a visible role in the development of monetary policy in the region which has had the effect of the IMF supporting outside investors (as it did in Mexico) rather than supporting the weaker domestic lending institutions, have contributed to the crisis. In addition, while governments in the region have been successful in promoting a smaller degree of inequality in incomes among their people, they have done nothing about the large inequality in the ownership of capital goods. This again is a weakness with their development policy associated with the structural dynamic of the economies of these countries that tend to favour the formation and operation of massive firm based conglomerates. These weaknesses in their development dynamic and approach has in no small part contributed to the crisis. So while East Asia offers important lessons to the South countries aspiring to industrialise, they have shortcomings that South country policy-makers must be aware of, as these shortcomings will almost certainly have an increasingly more visible effect on the nature, pace and spread of technological transformation in East Asia in the coming years.

4.4 CONCLUSION

This chapter has served to provide us with best-practice strategies from East Asia that should be applied to a S&T policy framework in the South countries. We argue that any S&T effort in the South must be overseen by national agencies/infrastructures similar to those involved in Japan's S&T effort. Similarly, the role of education in the South's S&T effort must be prioritised as it has been in Japan and Korea. In reviewing the shortcomings of the S&T effort in Japan we attempted to present what the South must avoid doing once it has attained an initial or critical mass of S&T capabilities. To highlight what an S&T policy in the South must prioritise we looked at a best-practice and a worst-practice S&T effort, by engaging in a comparative analysis of Korea (to expand on the former point) and Malaysia (to expand on the latter point).

The chapter then reviewed the S&T effort in the South, by giving particular attention to sub-Saharan Africa. We maintained that the S&T effort there was very limited because of the lack of resources or capacities to do so, but also because of a lack of willingness by African policy-makers to operationalize their written commitments to implementing a comprehensive S&T effort. As a result we noted the pervasive undercapacity of industry in Africa and extremely low rates of technological advance in the region as a result. In order to engage in a more focused analysis of the state of S&T in the South we engaged in a case study of Vietnam and its technology building effort.

The analysis acknowledged that technology capacities are being built in the country but at an extremely slow pace.

In reverting back to an analysis of East Asia's S&T effort the chapter attempted to more explicitly review the policy implications and lessons that this effort offers for the South. While there are important lessons for the South in this regard, the chapter maintained that the East Asian industrialisation dynamic cannot be replicated. We then ended the chapter by a brief review of the current financial crisis in East Asia and the ramifications it has for the S&T effort in the region. In providing this account we highlighted the short-comings of the East Asian industrialisation dynamic, with the aim of emphasising that while the region offers important lessons that can be incorporated into the development efforts of the South there are important weaknesses associated with the East Asian industrialisation dynamic that the South country policy-maker must be aware of.

Chapter 5 - Obstacles to S&T Policy Planning in the South: The Effects of the International Trading System

5.1 INTRODUCTION

The first part of the chapter will discuss how and why technology has been subject to an international system of intellectual property (IP) protection. It will then go on to discuss the large number of restrictions that are in place regarding the use of technology by South countries and also UNCTAD's efforts to reform the system governing the transfer and IP protection of technologies. The chapter will then focus attention on the General Agreement on Tariffs and Trade (GATT) with the objective of charting its development and the seven rounds of multilateral negotiations under its auspices upto the Tokyo Round.

This analysis is undertaken with the objective of setting the stage for a more comprehensive discussion of one particular round negotiated under the purview of GATT - the eighth round called the Uruguay Round (UR). Specific attention will be given to five Agreements within the Round, namely the General Agreement on Trade in Services (GATS), the Agreement on Trade Related Investment Measures, the Agreement on Textiles and Clothing (with specific attention to the multi-fibre arrangement (MFA)), the Agreement on Agriculture and the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs). This account of the UR is undertaken in a fashion that seeks to identify the implications of the various agreements within the Round for the S&T policy planning capacities of the South countries.

5.2.2 Restrictions on the use of Technology by South Countries

We cannot discuss the acquisition, use and operationalization of Western technology by South countries without due attention to the issue of IP. Technological innovations have been protected, specifically, by legal provisions that came into effect after the International Union for the Protection of Industrial Property was created in 1883. This multilateral arrangement is otherwise known as the Paris Convention - the oldest agreement regarding IP (and the forerunner to the Berne Convention adopted in 1886) - it provides for a legal mechanism to be in place regarding IPRs to ensure and promote exclusivity in the exploitation of a body of knowledge over a limited period of time in a given country. The Convention views IPRs as including patents, trademarks, trade names, utility models, designs, copyrights, and neighbouring rights. Successive revisions of this convention have included protection over layout designs of integrated circuits, industrial rights, and even applies to trade secrets. The Paris Convention was been revised six times by 1967. Typically, legally binding monopoly rights over inventions are meant to act as incentives for inventions in the first place, but also promote prompt disclosure of such inventions because of profit/financial incentives that occur as a result of exclusive rights accorded to the inventor. Such prompt disclosure is also seen to benefit the public welfare as a result of the application of new technologies in the area of health, for instance. The importance of and connection between patents and technology, especially technological innovation, can only be understood by a further inquiry into the nature of patents themselves. As it is defined "a patent is a legally enforceable right granted by virtue of a law, to a person to exclude for a limited time, others from certain acts in relation to a described new invention; the privilege is granted by a government authority as a matter of right to the person who is entitled to apply for it and who fulfils the prescribed conditions" (UNCTAD, 1975). At the centre of the patent law is the desire both for exclusivity and hence, unique advantages both for the inventor and his nation. Hence, protection, and inevitably commercial profit, remains a central aim of the patent system. Patents as they evolved, even well before the Paris Convention, in their earliest forms in the 1600s, were primarily used as a form of trade tariff, and not to protect inventions as they were traditionally understood in the Paris Convention, *inter alia*, as novelty, invention and utility (Vaughan, 1972:18-20) and (Machlup, 1958). Now the primary criteria for patentability is novelty, the patent, therefore, plays the role of an instrument of disclosure and dissemination. Hence, there is a legal obligation to protect a particular technology, for no other reason than to prevent contrivance and to further intellectual thought.

Upon further reflection, we know that while patents inevitably serve to protect the inventor, they also serve to facilitate for the industrial/economic growth of a nation. This is because it gives the firms of a particular nation exclusive rights to the use of a technology that could potentially and radically alter production systems/processes. Furthermore, it is widely accepted that, increasingly, the inventors are no longer lone persons, rather large transnational actors, who for various reasons, but most importantly their ability to contribute large financial resources to R&D, have emerged as inventors (Noble, 1977). Patents, over the last three decades, have increasingly become concentrated in a handful of TNCs because of patent pools and, especially because of the TNCs' capacity to shoulder increasing costs associated with R&D. Noble (1977) notes that it is primarily because of the sheer size of the TNC in a particular industry that they are able to monopolise not only the nature of intellectual thought that goes into R&D, but also control what is being studied/researched in a particular field at a given time. Because of this attribute, TNCs have the unique ability to mute or encourage research that has the potential for new technological innovation, but also the potential to aid or compromise corporate agendas hence, TNC interest in controlling trends in R&D (Vaitsos, 1972). These authors also argue that it is precisely because of the TNCs predominant role in technology and technology development that R&D is increasingly guided not by creativity, but by the all mighty dollar and corporate agendas, which has resulted in retardation, rather than progress in technology. This has had perhaps two very profound effects: one concerning the advancement of technology and the other being the compromise of public welfare.

Because the technology transfer process subjects technologies to the international IP regime, it places a number of restrictive practices/clauses on how the South countries can acquire and use technologies. These restrictions are varied and can include export prohibition, grant-backs, tying arrangements, price fixing, field use restrictions, royalty payments, etc.. UNCTAD provides a cogent review of these restrictive practices[79], keep

[79]Commonly constituting tied purchases, exhorbitant royalties and elusive practices on the part of the TNC.

in mind, though, that they do not apply to every country, whose patent laws recognise only some of these restrictions (UNCTAD, 1982):

a.)*field use restrictions* occur where imported technologies legally are prevented from being utilised in multi-sectoral applications. These provisions also extend to restricting the use of industrial property, either in production or distribution;

b.) *restrictions after expiration* of arrangements are imposed on the HDC after the arrangement between the TNC and recipient nation expires. Common features of these restrictions are prohibitions on competition, R&D into that technology, etc.;

c.) *grant back provisions* generally make it mandatory that technology recipients have an obligation to transfer to the supplier any improvements on that technology originally supplied. Many of these provisions hold that it is only the recipient's responsibility to transfer such improvements back on a unilateral/non-reciprocal basis to the licensee;

d.) *non-competition clauses* maintain the technology recipient is prevented from manufacturing or selling similar products as the licensee and to not seek competing technologies, once having made an arrangement with a technology supplier;

e.)*tying clauses* hold that the recipient must purchase additional inputs for the technology acquired, from the supplier of that technology or a source referred to by that supplier;

f.) *exclusive sales arrangements* severely restrict the recipient from the liberty to structure its distribution system autonomously of the supplier;

g.) *export restrictions* prevent the recipient from exporting an imported technology outside its boarders;

h.) *price fixing* practices makes it mandatory for the recipient to sell products made from those technologies at (hiked) prices specified by the supplier.

The South not only faces significant obstacles to rapid technological transformation because of the problems of restrictions on the access to and use of Western technology but also as a result of the inequities that exist in the ownership of patents. For instance, well over 80% of patents in developing countries are owned by foreign, often, transnational interests. Perhaps an even greater problem is that over 90% of these patents, which are foreign owned, remain *unused* in production processes[80] (UNCTAD, 1975). There are additional costs associated with the international patent system on the South. In the case of pharmaceutical TNCs, for example, involved in pharmaceutical related R&D and production/output in the South,[81] a large body of literature argues that these elements factor significantly as obstacles to the independence of these countries, especially in drug related manufacture. Because of their market power, benefits from economies of scale and sheer dominance of drug manufacturing, production and R&D - domestic industries are unable to compete, especially because of the lack of indigenous chemical processing industries to produce generic drugs (Penrose, 1973). Many authors argue that it is precisely because of the international patent system that the drug TNCs have the power that they do in the South. This dominance is

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[80]This trend has been facilitated by the successive revisions to the Paris Convention, which have done away with requirements for patentees to invest in and produce the patented invention.

[81]The largest pharmaceutical TNCs are based in the United States, Switzerland and Germany.

compounded by the fact that their products are in ever high demand because of disasters associated with wars and rampant disease in these countries, which are a feature of their mal-development. It is because TNCs are so much a part of the drug industries in these countries that they threaten the development of pharmaceutical firms indigenous to those South countries. This is because many of the indigenous pharmaceutical firms are restricted from acquiring and replicating foreign technology and also because the limited technology transfer that does occur in this industry is subject to restrictive practices like tied purchasing and international cartel arrangements, transfer pricing, etc. which further restricts the building of local production and R&D capacities in the industry (Taylor and Silbertson, 1973) and (Wortzel, 1971).

Pharmaceutical TNCs own the majority of patents in the South because of their immense influence on the system of production, trade and technology, and the legal framework that supports this status quo, by restricting the importation and in most countries - but not all, as most South countries do not allow patenting activity in pharmaceuticals - the manufacture of cheaper generic drugs in the South (Lall/UNCTAD, 1975). As a result, South country pharmaceutical companies are crowded out of the market, as they are unable to compete and cannot mature in a market environment that does not provide a conducive environment for them to do so. Consider that foreign owned patents are significantly large - especially in the pharmaceutical area - in the South, however the majority of them remain unused, which encourages mal- or incremental-industrialisation, precisely because much of the South is not able to make use of the technology it needs to develop. As they relate to the non-use of patents, the costs include surplus labour being compromised because it is legally unable to use indigenous resources for its nation's development as production processes have been patented. Similarly, patents that are used, and in a limited fashion, do contribute to technology transfer, still harm the South because of the over pricing of patented exports to the South. This practice, especially by the pharmaceutical TNCs, puts an unfair burden on balance-of-payments in South countries because they have to pay more foreign currency to these TNCs. This is principally because of restrictive and limiting clauses that accompany the exports of TNCs that are an additional cost to the South country because of the markedly higher foreign currency that has to be paid out for patented goods, especially where patents are the basis for licensing contracts. These licensing contracts give the TNC (on top of advantages provided by the IPRs system - such as the exclusive monopoly of that patent -) exclusive rights over the management and marketing of the exported good (UNCTAD, 1975).

So, from a benefit-cost analysis point of view, one can only surmise that the South is the net loser from these arrangements. However, it is not as simple as this. The fact remains that, like it or not, the way the technology market, transfer process and IPRs system is structured provides for maximum benefits to TNCs, but is also the only means by which much of the South can acquire technology. The South has no choice but to shoulder these vast disadvantages that come from the procurement of foreign technologies, as long as the system surrounding technology remains asymmetric, and as long as it turns a blind eye to TNCs that often infringe on national sovereignty (Khor Kok Peng, 1990). Has anything been done, however, to address these concerns of the South and if so who has taken on this responsibility? The answer to this question is yes, efforts have been attempted to deal with these issues in an organised and representative fashion not only by more vocal South countries like Brazil and India, but also by such organisations as UNCTAD.

Despite the voluminous evidence that technological acquisition by South countries from the developed world without the commodification but rather free transfer of technology could very well ameliorate their economic and social underdevelopment. The free transfer of technology is unlikely going to occur as the sale of technologies to the South account for literally billions of dollars of profits for TNCs each year. So short of this occurring, UNCTAD has strenuously been arguing over its thirty year history to relax the global system of IPRs affecting how, where and under what terms technology can be purchased. However, this issue is contentious, not only on moral grounds that half of humanity is being consciously denied the key or engine of growth to unravel their technological and economic potentials, but for purely monetary reasons related to profits for the TNCs[82]. Although important ground has been broken by UNCTAD in advancing the South's interests through the Code of Conduct for the International Transfer of Technology, the provision of technology is unlikely to be totally free of costs for the South. There is just too much at stake both for TNCs and the North countries from which they operate. Pressure (in the form of lobbying efforts) from Northern TNCs has made

[82]Consider that in 1991 it was estimated that TNCs generated total sales of $4.8 trillion, of which $1.5 trillion was ammassed as a result of intra-firm trade (UNCTAD, 1994). This tremendous sales figure is in fact higher than total world trade in goods and services, which amounted to $4.5 trillion (UNCTAD, 1994).

this an untenable option that is not even open for discussion. Although issues regarding IP have recently been included as a trade issue as a result of the multilateral negotiations in the UR, issues such as the equitable or fair transfer of technology did not receive any consideration during these negotiations. Hence, the concerns of the South in this regard have been ignored by an international economic system that actively promotes such inequities, for example, the negative terms of trade that South countries have historically been subjected to.[83]

5.2.3 UNCTAD's Efforts to Change the System of International Technology Transfer

UNCTAD has had a long history of attempting to address these outstanding and unfair issues in the process of technology transfer through its involvement in the advancement of a Code of Conduct for the International Transfer of Technology. Along with the Economic Commission of Latin America (ECLA) and other Dependency Theory scholars/advocates - the most famous of which was Raul Prebisch - UNCTAD has had a prominent voice in this code of conduct and the advancement of the new international economic order (NIEO) debate.[84] Other forums, however, have also proved to be

[83]Terms of trade refers to the ratio of the average price of a nation's exports relative to the average price of its imports, i.e. the amount of imported goods acquired by the nation per unit of goods exported. Typically the international trading system has favoured and historically worked in such a way that the South country's comparative advantage in and hence exports of raw materials are such that these nations have to export more of their goods at prices that are increasingly decreasing - because they are decided in financial markets in London, Paris, etc. and not their markets of origin - to attain enough foriegn exchange to import the capital good exports of North countries which historically have been supplied at increasing costs for decreasing quantities of those goods traded.

[84]While UNCTAD's role in articulating the NIEO is widely recognized debates over issues comprising the NIEO argument namely the economic and cultural

platforms on which to advance a code of conduct on the transfer of technology between North and South. These forums include the Charter of Economic Rights and Duties of States, the Lima Declaration and Plan of Action on Industrial Development and Co-operation, as well as the United Nations Convention on the Law of the Sea. The primary reason for UNCTAD's involvement in efforts by South countries to challenge the issue of unfairness of the technology transfer process and to take up the cause of championing the development aspirations of the South within the context of the global system of international trade have occurred because, historically, South countries have viewed GATT as being unable or un-willing to do so. South countries tend to see GATT as structured to accommodate issues and interests more pertinent to industrial countries and their products. In addition, South countries have also had concerns over two principles of GATT: i.) non-discrimination and, ii.) reciprocal trade action. It was out of the South's frustration with the GATT system and process that UNCTAD was born.

The GATT, however, has not been totally oblivious and unresponsive to the South's concerns. Trade concessions have been instituted, as a result, in the GATT framework for many South countries, these trade concessions are known as special and differential (S&D) treatment (however, during the UR, North countries called for a phasing out of the S&D treatment the South received so that those countries could reciprocate in the liberalisation measures begin negotiated in the Round, particularly as they concerned agriculture). The S&D treatment was reinforced by the creation of a

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dependency of the South on the North were more comprehensively discussed during the Afro-Asian Conference at Bandung (Fitzgerald, 1979).

generalised system of preferences (GSP) championed by UNCTAD and geared at exempting certain South countries from two principles of GATT - non-discrimination and reciprocity. Although this has resulted in certain South country exports receiving special treatment in the way of reduced tariffs, these tariff reductions, however, do not apply to the South's comparative advantage exports, i.e. most metals, agricultural products, and textiles.

Views, however, on the inequities in the transfer of technology between North and South have been articulated largely as a result of the actions of developing countries themselves in the General Assembly of the United Nations as far back as 1961. During this period the countries in the assembly requested that Secretary-General of UNCTAD direct his organisation to conduct a series of studies on the effects of the patent system, IP and technology transfer on the South countries.[85] The findings of these studies were reported to the Secretary General of the United Nations, they pointed to *significant impediments* in the structure of the international patent system/patent protection, i.e. appropriateness of technology problems, costly nature of technology (e.g. high royalty payments and long periods for payment of the technology), limitations on the number of TNCs the South country can approach once it has negotiated a technology with a particular TNC, restrictive business practices - i.e. grant-back provisions, challenges to validity, price fixing, patent pools and restrictions in the use of technology after expiry of agreements - , restrictions on how the technology can be used, lack of bargaining

[85]The source of this information are the class lectures of Dr. Surrendra Patel.

power/strength on the part of South countries in technology negotiations with TNCs - that collectively contributed to the lack of technological development in South countries. Additional studies that were commissioned under UNCTAD in the 1970s supported these earlier findings, that in many respects served if not to lay the foundations for UNCTAD's effort to devise a Code of Conduct on the International Transfer of Technology, then at least to illustrate the necessity and urgency for such a Code.[86]

Such a Code, then, would strike a balance between the interests of Northern TNCs and those of South countries (Fairley and Rowcliffe, 1980). Under the auspices of UNCTAD, the proposed Code was drafted in the mid-seventies; but with great difficulty associated with differing understanding between the negotiating parties (OECD, the former Soviet bloc and Group of 77 countries) as to what constituted technology, technology transfer, restrictive practices, methods of dispute settlement and the legal status of the Code. To illustrate these difficulties, we can refer to the example where the Group of 77 in the preamble to the code wanted technology defined as *the common heritage of mankind*, however, because of significant opposition from the OECD countries to this definition of technology, it was re-worded as *the key to the progress of mankind* (Thompson, 1982). However, in formulating this Code, it was perhaps the legal status of the Code which proved to be the greatest point of contention. No consensus could be reached as to legal nature or characteristics of the Code. For example, the OECD countries had argued the Code be voluntary and non-binding, while the Group of

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[86]For a list of these studies please refer to UNCTAD (1964), (1972), (1973), (1975) in the bibliography.

77 argued that it be mandatory. Because of the significant implications to the nature of technology transfer and the provision of technology in general to the South countries from the North, if either position were accepted, little consensus was established among the negotiating parties. Finally, through the compromise of the South countries (because of the North countries refusal to give a compromise on their position), it was agreed after much negotiation during and up until the fifth session of the United Nations Conference on an International Code of Conduct on the Transfer of Technology held in Geneva in 1983, that the Code would only come into effect if it would not obligate the signatory parties to *strict* and *specific* jurisdictions or *legal obligations or commitments* to accommodate the concerns of the South countries as articulated in the studies commissioned to UNCTAD by the South countries (Roffe, 1984). The only real concession in this regard was that the Code would be approved as a General Assembly resolution. Sadly, GATT has done precious little to advance the South's concerns with these issues, but nevertheless, as noted earlier, has served to provide some concessions to the South. UNCTAD has remained very vocal on such issues even though South countries like India, Brazil and others who traditionally have been very adamant on advancing the cause of the South, have acquiesced to pressure from the North and have slowly relaxed their position on many issues related to and revolving around IP, technology transfer, etc.

5.2.4 The Origins and Evolution of GATT till the Tokyo Round

The origins of GATT can be found in the Atlantic Charter issued on the 14th of August 1941, by both the President and Prime Minister of the United States of America and Britain, respectively. The document - *Proposals for Expansion of World Trade and Employment* - championed by the USA, in 1945 recommended the formation of an International Trade Organisation (ITO). At a convention in Geneva two years following this GATT was negotiated in April 1947 and fully operational in January 1948. The impetus for the negotiation of such an agreement was driven by efforts to use GATT as a mechanism and forum to liberalise trade. GATT proved to be quite forthcoming in this regard as shortly after its creation around 45 000 tariff concessions (accounting for $10 billion in trade) were reached amongst negotiating parties. This was a significant accomplishment as these concessions impacted one-fifth of world trade. After this success in promoting free trade at a global scale, this movement toward free trade met with a large obstacle - namely, the US Congress which refused to ratify the ITO charter in 1950. The reason why the US refused to ratify this charter was because US policy-makers argued it dealt with issues that were not necessarily trade-related, and those issues that were deemed trade related were not in the interests of the US especially to its TNCs. As a result GATT has remained in place, all be it as a provisional body, as the multilateral instrument governing and overseeing global trade.

"GATT is the main forum for debating and negotiating the rules and standards of international trade" (Coote, 1996: 105). Contracting parties to GATT must respect four principles of international trade: i.) 'tariffs', are the form that protectionist practices should take - they should not take non-tariff form (however this is the case in theory and not practice, as NTBs are used quite often); ii.) 'Reciprocity', i.e. if Country A reduces its tariffs on imports from Country B, Country B then must also reduce its tariffs on particular product exports from Country A; 'Most favoured nation' (MFN) principle states that preferential treatment between a group of contracting parties is strictly prohibited hence those contracting parties are obliged to extend to all other GATT signatories any favourable terms that they may have negotiated among themselves. Exceptions to the MFN apply to regional trade agreements/arrangements like the Lome convention between the EC and certain developing countries in Africa, the Carribean, and the Pacific. GATT aims at promoting a stable and universally accepted trading regime with a set of accepted rules, disciplines and procedures. It also aims at promoting trade in a non-discriminatory fashion, i.e. no special trading practices can be given by one country to another, if such a practice is done it must be applied to all other countries. However certain signatories to GATT have been able to successfully lobby for and secure several derrogations from GATT rules/disciplines, namely in the area of textiles and clothing made possible by the Multifibre arrangement (MFA) and in the area of agriculture, largely as a result of subsidies to farmers in US and European markets. GATT however has also made allowances and exceptions to its rules for most South countries especially the LDCs, as they are allowed to enjoy (because of their relative mal-development) or be party to favourable conditions, especially in terms of access to foreign markets for their primary product exports, made possible as a result of the GSP[87].

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[87]Import preferences were established under the GSP for the South countries as it makes available certain concessions for this region. Namely the GSP allowed for South country exports to have preferential access to North country markets. However restrictions still apply to these preferences, for instance the European Community (EC) countries apply ceilings to or quantitative restrictions on the volume of GSP commodities entering their markets. This is a major criticism of the GSP, another one being that most of the net gains from the GSP go to the NICs in East Asia and Latin

There have been several negotiated rounds under the purview of GATT - eight to be precise. The first round of GATT was held at Geneva in 1947 with the objective of putting in place GATT and also engaging in negotiations over the elimination of some duties and preferences. The second round of GATT was held at Annecy in 1949, where literally thousands of concessions were negotiated and hundreds of bilateral negotiations finalised. The third round of GATT was held at Torquay in 1951, again thousands of concessions were negotiated, but only less than half of the estimated 400 agreements that were to be negotiated were actually completed because of prevailing differences amongst negotiating parties during the round. The fourth round of GATT held at Geneva in 1956 were by far the most unsuccessful of all the negotiating rounds to that point. This in large part occurred because of the lack of consensus amongst negotiating parties as to the scale of individual tariff rates that should actually be put in place. The fifth round of GATT held at Geneva in 1960-61 (also known as the Dillon Round) saw new linear tariff

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America, LDCs are rarely the beneficiaries of this scheme although the scheme is principally devised and directed at them. This is partly because tariff barriers for LDC exports of manufactured goods and NTBs, like the MFA, increase as those exports become more processed. In addition certain South country exports are excluded from the GSP. Also as of late conditionalities have been applied to GSP beneficiaries, which is a clear violation of the understanding that GSP beneficiaries should not be subject to reciprocity of concessions. Such criticism has been extremely vocal in recent years becuase exports from non-petroleum and primary export based countries of the South cotinue to make up a relatively small (some argue declining) proportion of overall world trade. Consider that in 1987 only 17% of world trade came from South countries, i.e. US$ 490 billion of a total US$ 2, 900 billion in global trade. In addition much of these South country exports are in the area of petroleum, from the Middle East, and machinery, from East Asia, leaving only a miniscule portion of that export volume to come from LDCs and middle-income countries in the area of textiles and primary product exports (Aggarwal, 1994).

reduction techniques being put in place to replace the traditional tariff negotiation practice that was based on a commodity-by-commodity or country-by-country basis. The sixth round of GATT from 1964-67 (also known as the Kennedy Round) was brought about as a result of the sweeping powers the US president obtained under the US Trade Expansion Act of 1962, that enabled him to significantly reduce on a reciprocal basis a vast array of US tariffs on entire groups of products. In this round significant tariff reductions and concessions were made by the North on their dutiable imports from the South. The seventh round of GATT (also known as the Tokyo Round) from 1973-79 was perhaps the most successful of all rounds prior to it, because it was so comprehensive. It eliminated or reduced a number of tariff barriers and NTBs for both agricultural and industrial products. For example the Round secured a one-third cut in customs duties amongst the North's nine largest industrial markets. In addition the Round significantly improved the legal framework under which international trade was conducted. However it also had its shortcomings. Namely the Round failed to address free trade in agriculture, and it did not provide for a new agreement on safeguards or emergency import measures.

The eighth round of GATT negotiations was negotiated between 1986 to 1994. The round has important implications for the dynamics of world trade in the coming decade, hence specific attention to it will be given in a section all of its own. Suffice it to say the seven GATT rounds did significantly increase the volume of trade especially during the 1950s and 60s, largely as a result of the success of liberalisation efforts, i.e. tariff cuts under the Dillon and Kennedy Rounds. However these liberalisation efforts were significantly undermined as a result of the rising anti-free trade and protectionist sentiment in America in the 1970s as a result of the shocks in the international monetary system. The US, in this period, actively pursued restrictive trade practices to respond not only to an overvalued US dollar but also the Bretton Woods system which had begun to disintegrate as a result of an adjustment mechanism that was no longer workable. The US as did the rest of the world, had to contend with a devastating recession in 1975 which set the stage for heightened protectionist activity, especially in the form of the increasing use of NTBs[88] (Aggarwal, 1994).

Such rising neo-mercantilist and protectionist[89] sentiment could not be contained even by the Tokyo Round, and the inability of this round to deal with NTBs in any satisfactory manner was sighted as a major reason why the round was not as successful as it could have been. Free trade in the 1990s is still threatened by NTBs that are now in use more than ever before, largely because the North country governments, especially in the recessionary period of the 1980s, attempted to address or reverse inflationary tendencies in their economies by pursuing tight monetary policies so as to stem rising wages and flush out high inflation, through protectionist trade strategies. In addition policy makers

[88]NTBs constitute voluntary export restraints (VERs), anti-dumping measures, countervailing duties, and orderly marketing arrangements. The most famous NTB is the MFA which still remains in effect so as to protect North country textile and clothing manufacturers from the comparative advantage that many South and East Asian countries have in textiles and clothing.

[89]Authors have argued that protectionism is inefficent, and significantly reduces world welfare gains, becuase of the lack of choice consumers have in what they buy. The MFA is a much sited example of this, becuase by protecting US textile and clothing manufacturers from Asian clothing and textile manufacturers the cost the consumer in the West has historically had to pay for these products has been quite high (Salvatore, 1987).

in the North advanced protectionist trade policies, especially in the 1980s, as they attempted to protect and grow their country's high technology industries. This has led many skeptics to argue that free trade is a phenomenon and a practice undertaken on set terms, at set times, and complimenting particular economic and political agendas. In other words North countries advance concepts of free trade under their own terms and when it is convenient for them to do so.

Nevertheless, just three years after the completion of Tokyo Round the US was already clamouring for another round of multilateral negotiations on trade. Many countries of the South as well as Europe were opposed to this move by the US. Despite this opposition the Round went ahead four years later. This has led many observers of international trade to point to what they see as countries having been involuntarily coerced into the Round by the US, through the threat of trade retaliation, by the use of Special 301 and Super 301. These are the two clauses in the US Trade and Competition Act 1988 that provide leverage for the US to unilaterally get an opposing trading nation to do what they want them to do or otherwise threaten retaliatory action. What warrants such unilateral action is if a country's trade policy or practice denies the US "a.) fair and equitable opportunities for the establishment of an enterprise; b.) adequate and effective protection of intellectual property rights; c.) market opportunities for US goods (including government where governments are seen by the US as tolerating anti-competitive activities of private firms)" (Raghavan, 1990: 87).

5.3 The Uruguay Round - What was it a response to?

Michael Bruno, Senior Vice President and Chief Economist in the World Bank, argues in the forward to Martin and Winters (1996) book that the completion of the UR will enable the developing countries to "operate in the world economy on more or less the same terms as industrial countries" (Martin and Winters, 1996: xi). Is such an assessment warranted? Is it in fact accurate? And will the UR actually enable increased growth rates, even increased S&T planning capacities in the South? These issues are critical to the development of the South countries into the next millennia, and as a result are the subject of the up coming analysis.

Many North country economists have praised the UR and predicted wide spread global welfare gains as a result of the Round. A number of studies have been conducted that seek to reinforce the argument cited by Bruno above and to claim quantitatively and modularly substantiate the assessment that the welfare gains, i.e. increases in real income as a percentage of GDP, will increase at a global level as a result of the UR. For instance it has been argued that world wide welfare gains would amount to $258 billion or 0.89% of projected 2005 expenditure levels. Such welfare gains, it has been argued, will result from reductions in tariff and export subsidies as well as from the elimination of certain NTBs such as the MFA. However, Hertel (1996) is quick to point out that the percentage change in welfare for both sub-Saharan Africa and Latin America will actually fall substantially from present levels to US$ million - 1, 233 and 1, 258 respectively in the wake of the Round. These two regions would be loosers because textile suppliers to North America and Europe from these areas would be displaced from this market because of the increased competition they would get from Asian textile and clothing manufacturers with a comparative advantage in this industry, acting without the impediments to free trade in these goods as a result of the dismantling of the MFA over a ten year period. Similarly, Agosin et al (1995) note that the UR does facilitate certain gains in terms of market access for South countries, but there are significant "costs in terms of more stringent disciplines on trade and industrial policies.....There are three areas in which developing countries will loose degrees of freedom in policy-making: export subsidies, and other subsidies having an impact on export prices, will practically have to be eliminated; the ability to impose quota restrictions (QRs) for balance-of-payments purposes will be curtailed; and developing countries will come under much greater pressures to bind and reduce tariffs. Domestic content and trade balancing requirements, in the past imposed mostly (but not exclusively) on foreign investors, have also been banned by the TRIMs Agreement; this will reduce the scope for active industrialisation policies" (Agosin et al, 1995). So is the Round really an advantage or disadvantage for the South, especially concerning the S&T building capacities of the South?

First, we should review the UR itself. It was the eighth round in a series of multilateral negotiations under the purview of GATT since the 1940s. The Round was launched in September of 1986 at Punta del Este and came up for ministerial mid-term review in December of 1988 in Montreal, which was completed in April of 1989 in Geneva. After the seeming impasse of the ministerial meeting in Brussels in December of 1990, the first draft of the Final Act was submitted in Geneva in December 1991.

There were fifteen agreements to be negotiated in the UR, once this process was completed the Agreements were signed in April 1994 in Marrakesh - and subsequently in January of 1995 the WTO was created, and the Agreements came into effect. There were the usual issues of market access, but also the unusual and unprecedented issue of agriculture - an area once excluded from GATT disciplines, but also textiles and clothing, which as a result of the MFA, had also historically been excluded from GATT disciplines. Then there was the inclusion of systematic issues about the agreements and their provisions and in a third category there were the 'new' issues - TRIPs, TRIMs, and Services. It was the United States of America that actively lobbied for another round of trade negotiations as early as 1982; and although this lobbying effort did not meet with a good response by South countries but also by the European Union and Japan, a consensus was established amongst the North over the need for a new round of negotiations, under the purview of GATT that would deal with outstanding issues like agriculture, but also new issues such as TRIMs, TRIPs, and trade in Services.

The UR, which was launched in Punta del Este in September 1986 and completed in 1994 at Marrakesh, had a varied, controversial, and comprehensive agenda (Reichman/UNCTAD, 1993). There has been a lot said about bilateral United States pressure prior to and during the UR, and about the politics of it we, however, will not go into this account. Suffice it to say, the Round was marred with controversy, nevertheless, it was a watershed in international trade, especially because of the nature of its agenda and the scope/implications of its successful completion, but also because a new body emerged or metamorphisized out of GATT - the WTO. The WTO comprises a series of rule-based regimes which encourages member states to follow its disciplines or face retaliatory action and as such the WTO provides "the common institutional framework for the conduct of trade relations among its members in matters related to the agreements and associated legal instruments included in the annexes to this agreement" paragraph 1 of Article II. Further Article III (5) of the Agreement establishing the WTO maintains the WTO will serve to promote "greater coherence of global economic policy- making [...and as such will...] cooperate, as appropriate, with the international monetary fund and with the international bank for reconstruction and development and its affiliated agencies".

The UR was a response to growing pressure by the US to include issues like IP, investment practices, services - traditionally thought of as non trade-related activities - under the oversight of GATT. These issues however were deemed to be appropriate to be added to the GATT framework by attaching the words *trade-related* to such issues as investment, IP and services. The UR from the outstart dealt with goods and services separately.[90] The fourteen groups of negotiations dealing with trade in goods included: tariffs; non-tariff measures; products based on natural resources; textiles and clothing; agriculture; tropical fruits, GATT articles; examination of agreements and arrangements stemming from multilateral trade negotiations (Tokyo Round); safeguard measures; subsidises and countervailing measures; TRIPs; TRIMs; settlement of trade disputes; functioning of GATT (FOGs). The one group of negotiations concerning services, was a

[90]The Agreements under negotiation in the UR were presented to GATT Contracting Parties in a fashion where either all the Agreements were to be accepted/ratified. One Agreement could not be refused by the parties as that would signify a refusal of the entire package itself (Jackson, 1990).

critical new addition to the GATT framework. Services were included in the negotiating mandate of GATT as trade in services had been increasing faster than trade in goods in the last decade. In introducing services into the GATT framework there was a recognition that GATT rules had to be modified to adequately protect and cater to advances in information/data processing and communications, as well as banking and insurance.

5.3.2 General Agreement on Trade in Services

The services sector comprises a broad range of intangibles or invisibles. This sector includes advertising, construction, data processing, education, franchising, health, information, insurance, investment banking/brokerage, management consulting, telecommunications, software, transportation and many more (McCulloch, 1990). Up until the UR "trade in services had not been subject to a multilateral set of rules governing its fair and non-discriminatory conduct. Global trade in services in recent years has amounted to $1 trillion and world-wide services exports grew at an annual rate of almost 15% from 1982-1992, compared with a 9.8% annual increase in merchandise exports over the same period" (Schott and Buurman, 1994: 110).

The General Agreement on Trade in Services (GATS) serves to establish multilateral rights and obligations in the context of trade in services. GATS creates a number of principles, rules, commitments on national treatment and multilateral disciplines that influence access to service markets. By discussing issues related to trade in services in the forum provided by GATT the North, could address the difficulties in regulating services as a single sector (Hopkinson, 1989). Services are a critical sector for the North which is the primary exporter of this sector, so it was in the interest of the North to include it in the UR so as to negotiate the removal of barriers to services especially in the South countries. The GATS creates a framework for trade in services similar in principle to the framework already in place for trade in goods (i.e. the principle of national treatment where imports and domestic supplies are treated equally in a given market and the principle of MFN which prohibits any discrimination amongst goods from a variety of exporting countries) are upheld for trade in services as they are for trade in goods.

5.3.3 The Agreement on Trade Related Investment Measures

The issue of the regulation of foreign investment also prompted the inclusion of TRIMs as a central component of the UR. Historically TNCs efforts to engage in RBPs has been counteracted by South countries through regulatory systems/mechanisms they have in place to deal with how and under what terms the TNCs can operate in South country markets. RBPs have historically taken two forms - horizontal RBPs, which include market access, refusal to supply, price fixing, collusive trading; and vertical RBPs, which include exclusive dealing, differential pricing, tied selling, resale price maintenance, predatory pricing and transfer pricing. South countries had a variety of tools to deal with such practices, from trade-balancing and local content requirements to remittance and exchange restrictions. The Trade Related Investment Measures (TRIMs) Agreement deemed the regulatory powers of South country governments over investment entering their countries, as undermining or distorting trade. This in large part was a result of Northern TNCs that placed Northern governments under intense pressure to push for such an agreement because the investment activities of TNCs prior to the negotiation of the TRIMs Agreement were severely curtailed and restricted by the investment laws of South countries that obliged them to invest in such a fashion that the investment relationship would be mutually beneficial. This of course undermined the profits of TNCs, as a result the TRIMs Agreement makes it illegal for host developing countries (HDCs) to demand local content requirements, trade as well as foreign-exchange-balancing and domestic sales requirements that South countries have historically placed on TNCs. And also TNCs are no longer obligated to design production in such a manner that offers backward and forward linkages to the HDC. The TRIMs Agreement was largely secured because of pressure from TNCs that such practices went against the GATT national treatment principle and served to distort trade. A review of TRIMs will in fact take place in the next few years to consider the possibility of including investment and competition policy in the TRIMs framework.

Low and Subramanian (1996) maintain that the TRIMs Agreement establishes an understanding that GATT disciplines such as Article III dealing with national treatment and Article XI dealing with prohibiting quantitative restrictions (QRs), will be adhered to and followed by South countries. South countries will no longer be able to deny TNCs such treatment, as they will be unable to impose a regulatory systems or impose restrictions on investment entering and operating within the country based on:

- ❑ Local content requirements - requiring that a minimum volume/value or percentage of the value of local production be bought by the TNC from suppliers of materials needed in its production process from HDC suppliers;

- Manufacturing requirements - place limitations on the nature and volume of products that a TNC's affiliates can produce, so that local firms producing similar goods can also have access to the market for those goods;
- Product mandating requirements - ensure specific markets, both within and outside of the HDC, are supplied with products from the TNC from particular areas and facilities within the HDC;
- Local equity requirements - ensure that nationals of the HDC own some portion of the TNC subsidiary's equity;
- Remittance restrictions - limit the TNCs ability to repatriate earnings from investment outside of the HDC;
- Trade and foreign-exchange-balancing - requires the TNC subsidiary to maintain a trade surplus level decided by the HDC government;
- Domestic sales requirements - require the TNC to produce a given level of products for sale in HDC markets.
- Technology transfer requirements - if the TNC wants to invest in the HDC it must engage in a *quid pro quo*, i.e. be committed to helping the HDC reach some of its technological advancement goals by providing a certain type and level of technology both on commercial and non-commercial terms.

As a result of the TRIMs Agreement it has been agreed that such practices by the South countries are a violation of and inconsistent with Articles II and XI of GATT (Low and Subramanian, 1996). This raises several issues related to how the South country would be able to ensure the TNC serves the interests of the country it is investing in and not just its own. For example many South countries stringently enforced technology transfer or licensing requirements, where TNCs were required to provide technology to the country on reasonable terms. The Agreement, however, significantly undermines the South country's ability to make such a demand, as it would be viewed as inconsistent with and in violation of GATT provisions or articles.

5.3.4 The Multi-Fibre Arrangement[91] and the Agreement on Textiles and Clothing

"The multi-fibre arrangement (MFA) is a framework of voluntary export restraints regulating textile and clothing exports of most developing countries entering nearly all major industrial markets. The main instruments of the MFA are bilaterally negotiated quotas in narrowly defined product categories. Although the first MFA was signed in 1974, its origins go back to 1937, when the US imposed trade restrictions on Japanese textiles under the guise of a 'gentleman's agreement'. In the 1960s, similar but more encompassing arrangements on cotton textiles were concluded which were extended to include the major developing country suppliers" (Erzan and Holmes, 1990).

Textiles and clothing were excluded from the free trade rules/disciplines of GATT because the North was attempting to build the competitive capacities of its industries in this sector, utilising protectionist controls. As a result the MFA is a derogation from GATT rules. As an NTB it was supposed to be in effect for four years so that North country textile industries could structurally adjust to the competitive advantage that South countries especially in Asia had. However the fact was, if the industry was subject to

[91]The MFA applies to man-made fibres, wool, silk, vegetable fibres and cotton.

GATT disciplines, the East Asian region - which had a comparative advantage in this area - would have overtaken the North's ability to remain competitive in this industry. The textile industries of the North were protected by QRs - imposed on exports of these products especially from Asia - that took the form of the short-term arrangement (STA) enacted in the early sixties. This arrangement was progressively made more permanent through the seventies and eighties with the implementation of the long-term arrangement (LTA) and then the MFA. The Agreement on Textiles and Clothing (ATC) was negotiated in the UR so that over a ten year period these quota restrictions on textiles and clothing exports from the South would be phased out. Hence trade in textiles and clothing will fall under the purview of GATT. The implications of the ATC, however, are not all good for the South. Granted the South will get increased market access for its exports of textiles and clothing; however there is a provision in the ATC that enables the North - in the event that there is a sizeable influx of these products into their own markets - to make use of a safeguard clause. The clause exists under Article XIX of GATT which is to be used in the event that textile and clothing exports from the South poses a significant threat to domestic textile and clothing industries in the North. So in effect the ATC has a clause that provides the North with a back-door to be used in the event that the free trade in these goods begins to pose a significant threat to their textile and clothing industry. However the fact remains the ATC is perhaps the only visible/concrete gain for the South in the UR.

5.3.5 An End of the 'Timeless Waiver'? - The Agreement on Agriculture

For decades, temperate agricultural products from the North countries - like textiles and clothing - were not subject to GATT disciplines and did not fall under the purview of GATT; while South country tropical agricultural products did. This was because the agricultural sectors especially in the US and the EU were heavily subsidised. However this timeless waiver - as trade in agricultural products has become known - abruptly, although with a great deal of opposition from the EU[92], ended with the passing of the Agreement on Agriculture. This occurred because competitive export subsidies for a long period of time, had had the effect of depressing and distorting the world price of agricultural goods. These products were in oversupply in world markets and consequently dumped in those markets. Since the price of these grains became artificially depressed because of being dumped, the price of local agricultural products from the South like sorghum, maize meal, etc., had to be reduced (at a significant loss to those farmers) in order to compete. Hence, there was a call to address this situation by converting many NTBs into tariff barriers based on tariff bindings. New disciplines were introduced in GATT concerning agriculture that limited export subsidies by obliging most North countries to abstain from creating new export subsidies, but also to reduce existing ones. However, that said the new rules on agriculture are significantly undermined as individual agricultural commodities can still receive government

[92]The EU had a different interpretation as to what constituted a direct export subsidy than did the US (supported by the Cairns Group of countries) which was pushing for disbanding subsidies altogether. This had obvious ramifications for Europe's common agricultural policy (CAP), hence Europe's initial opposition..

assistance. In addition, although the Agreement on Agriculture exempted LDCs in particular from commitments to tariff reductions, the reductions in tariffs for North countries were not significant because the base levels upon which tariff reductions took place were inflated and not realistic. The UR's breakthrough in November of 1992 in Washington, known as the Blair-House Agreement attempted to address the issue of dumping of North country agricultural products on international markets, however in reality it was only a token effort, with limited results which has done little to solve the problem. However, the inclusion of agriculture in the UR was a calculated move by the North countries, because they had achieved self-sufficiency in agricultural production and its contribution to GNP now is minimal. So what has happened is the North countries have developed their agricultural systems under intense protection, but now as agriculture has become less important to national growth, but is still critical to the South's development, agriculture has been liberalised under multilateral disciplines.

5.3.6 The Agreement on Trade Related Aspects of Intellectual Property Rights

The Trade Related Aspects of Intellectual Property Rights (TRIPs) Agreement incorporates the majority of the provisions of the Paris Convention for the Protection of Industrial Property (1883), the Stockholm (1967) and Berne Convention, as well as its Paris Act (1971), and the Rome Convention (1961); but also the Treaty on Intellectual Property in Respect of Integrated Circuits (1989). The TRIPs Agreement came into effect in January of 1995. To enable the implementation of the TRIPs Agreement an agreement or understanding of cooperation between the WTO and WIPO was established in January of 1996. The TRIPs Agreement is the most comprehensive multilateral agreement on IP thus far. The Agreement comprises seven parts and seventy-three articles (see Table 9). These parts make up the body of the TRIPs, they include:

Table 9 - The Seven Parts of the TRIPs Agreement

PART I	General provisions and basic principles
PART II	Standards concerning the availability, scope and use of intellectual property rights which include - copyright and related rights, (including service marks), geographical indications (including appellations of origin, industrial designs, patents, *sui generis* protection of layout designs (topogrophies) of integrated circuits, protection of undisclosed information (including trade secrets and test data), control of anti-competitive practices in contractual licenses
PART III	Enforcement of intellectual property rights, including - general obligations, civil and administrative procedures and remedies, provisional measures, special requirements related to border measures, criminal procedures
PART IV	Acquisition and maintenance of intellectual property rights and related interparties procedures
PART V	Dispute prevention and settlement
PART VI	Transitional arrangements
PART VII	Institutional arrangements; final provision.

Source: GATT, Final Act Embodying the Results of the Uruguay Round of Multilateral Negotiations (Geneva: GATT Secretariat, 1994: 365).

The TRIPs Agreement enables IPRs to be subject to the principles of national treatment, i.e. a signatory country will afford nationals of other signatory countries the same treatment as they afford their own nationals. The MFN aspect of TRIPs stipulates that all member states have to give equal treatment to nationals of all other countries unconditionally. Minimum standards are placed on the protection to be provided by each

Member in the protection of IP, as a result individual members - if they choose - have the descretion to go beyond the minimum requirements for the protection of IP. As well another set of provisions is associated with procedures for the enforcement of IPRs in Member countries. Disputes between Members regarding IP can be addressed through a dispute settlement provision in the Agreement. In addition transitional arrangements have been devised in the Agreement where North countries were given one year, and middle income countries four years and LDCs eleven years, respectively, to implement the TRIPs. Although the TRIPs Agreement deals with seven forms of IP it is one form in particular that has significant implications for the South - and that is patents. The patent system has been strengthened, as the conditions governing the working of patents have been drastically modified as has the definition of what constitutes patented subject matter. In addition the standards of patenting will now be applied uniformly in all signatory countries and the duration over which a patent can be in place has been lengthened. Article 27.1 of the TRIPs Agreement states "patents shall be available for inventions whether products or processes in all fields of technology". Of particular concern for the South countries is the fact that the Agreement covers processes involved in producing a product.

The Agreement reinforces what the Berne Convention had already established when it comes to copyrights, i.e. 'adequate' and 'basic' standards should exist for copyrights protection. Copyrights, the Agreement reiterates, will include computer programs, as will literary works, expressions of ideas, procedures and methods of operation, and databases. The Agreement is quite explicit as to what qualifies to be protected under IPRs protection. We shall review a few examples listed below. TRIPs takes trademarks into consideration, arguing that they include any combinations of signs that distinguish goods and services of different producers, and that it is illegal to use those signs without the owners consent. Similarly geographical indications identifies the geographic region from which the good is coming from, and thus must be protected the exception to this being geographical indications that are generic terms. Industrial design are also protected under the Agreement provided that they meet two criteria - they are new or original designs. Patent protection is given when inventions are made to product or process technologies. The only exceptions to inventions being patented are moral considerations (i.e. because the invention in some way is harmful to humanity), therapeutic or surgical methods and biological processes. Provisions concerning lay-out designs and integrated circuits are also reinforced under the Agreement, hence building on the Treaty on Intellectual Property in Respect of integrated Circuits (IPIC) negotiated under the purview of WIPO in 1989. Protection of all the above IP is made possible through general obligations Members must follow concerning the protection of such property and what action (i.e. civil judicial procedures) shall be taken by them if such obligations are infringed upon - such as the exercise of broad ranging penalties, from criminal convictions to authorities confiscating and destroying counterfeited materials.

"Recent GATT negotiations have consequently sought to bring patent protection under the purview of GATT" so as to stem the effect of the widespread abuse of IPRs and to establish a mechanism to hold these abusers legally accountable for such actions (Vishwasrao, 1994: 15). The UR for instance established minimum universal standards concerning IPRs, as well as multilateral dispute settlement arrangements, which have gone a long way to supplement the Paris, Berne, and Washington agreements, especially because the UR harmonised *substantive* and *procedural* rules concerning IPRs. Why? It was always recognised that there were widespread abuses of IP by countries in the South - especially in Asia - and hence a need for establishing globally recognised standards regarding and the upward harmonisation of IP protection. Such infringement on IP, it has been argued, has made for significant losses to innovating firms in the North. For instance a survey by the united States International Trade Commission in 1988 of over 700 US firms found that aggregate world wide losses, in firm earnings, as a result of inadequate protection IP amounted to $23.8 billion. The US, especially, has actively lobbied for the inclusion of IPRs as a critical international trade issue in the UR, as "the absence of strong intellectual property rights protection in foreign markets carries serious economic costs for US industries. These costs include lost sales in third-country markets, diminished incentives and capital to fund new research and development, and distortions in trade flows" (US General Accounting Office, 1995:4).

Many of the North countrys' approaches to IP protection though are governed by certain theories which we must explore if we are to understand the theoretical and ideological underpinnings of the structure and dynamics of IP protection and the terms and conditions governing the global transfer of technologies. We borrow from the writings of Abbott (1989) and Sherwood (1990) to accomplish this task. There are six theories that account for why technology is protected the way it is by IP laws. *Reward Theory* argues IP protection protects the rights of the inventor of the technology; while the *incentive theory* argues that innovations would not occur were it not for certain monetary rewards the inventor knew he/she would get in return for his/her contribution to new knowledge to society. So this theory speaks to incentives to engage in R&D in the first place. *Risk Theory* on the other hand argues that because of the risks involved in engaging in innovative activity, i.e. that the invention process or even the invention itself could be a success or failure, the inventor needs to be aware of the protection that can be afforded to his/her invention. By risks 'during' the process of innovating we refer here to the project possibly 'going bust' midway through a research effort. By risks occurring 'after' the invention is produced we speak to imitation by competitors attempting to duplicate the invention so as to incur less R&D costs.[93] Hence, the inventor has to be comforted that only he/she for a period of time will be the sole beneficiary of any and every monetary or profit rent the invention gets once entering the market. *Expanded Public Knowledge Theory* speaks to the fact that although monopoly rights are guaranteed or afforded to the inventor, society gains immeasurably because registry and publishing of patents offers interested parties the opportunity to learn the dynamics or methods employed in the creation of that invention - as a result adding to the pool of knowledge and scientific understanding of society. The *Public Benefit/Social Rate of Return Theory* argues that strong IP protection in the South countries will in fact

[93]The US Publishers Association argues that such imitation or 'piracy', i.e. the illegal commercial use and duplication of a product protected under IP laws, is excessive in South countries, especially those in South and South East Asia. For instance piracy rates or 'free riding activity' of software amounted to 95% and 82% of all commercial activity in Pakistan and Malaysia respectively (Elmer-Dewitt, 1994: 44-45).

contribute to the economic growth of South countries because foreign technology suppliers will be more inclined to transfer technology to countries with a strong IP framework. The *Recovery Theory* argues that monopoly privileges for the inventor over his/her innovation will enable them to recover the immense costs they incur as a result of R&D.

A GATT document published in 1993 reinforces such views on and theories concerning IP, arguing that TRIPs and its effect of establishing new rules for the protection of IP, were spurned by four major issues. The first being "the protection of intellectual property has become a key element in international competition....second, the scale of trade in counterfeit products has reached alarming proportions and it involves a very broad range of products...third, the protection of intellectual property is a factor in technological progress...[as well as encouraging] technology transfer between countries...fourth, the protection of intellectual property has become a source of trade tensions in recent years, owing to the differences in the levels of protection in competing countries. [Hence the inclusion of the TRIPs Agreement in GATT as] bilateral agreements can sometimes temporarily end conflicts, however, a multilateral agreement would have the merit of preventing such conflicts by providing a stable and comprehensive set of agreed standards and rules" (GATT, 1993: 17). The argument advanced here for the further protection of IP under TRIPs Agreement advances the notion such protection will facilitate for greater technological innovation, transfer and dissemination. It is the latter two arguments that the North argues most caters to the South's gains from the strengthening of the IP system - namely, the increased transfer of technology and the more effective dissemination of technology will be an offshoot of this.[94] Advocates of the inclusion of the TRIPs Agreement in GATT argue that added advantages go to the South as a result of the Agreement namely it will limit the use of 'grey area measures' like voluntary export restraints (VERs). In addition because the dispute settlement mechanism has been improved as a result of TRIPs, the likelihood that disputes will be able to be settled in a more efficient and equitable manner. These same advocates of the TRIPs Agreement argue most South countries will be given added leeway as they will have an eleven year transition period to implement the TRIPs Agreement.

Other authors have approached the issue differently. In an article in *Third World Resurgence* Verzola equates 'brain drain' with abuse of the current system of IP. He argues "the advanced countries of the West routinely pirate from the third world our best professionals and skilled workers, but begrudge the people of the third world if they engage in some piracy themselves. They accuse the third world of piracy of intellectual property, yet they themselves engage in a piracy of intellectuals" (Verzola, 1993: 57). Verzola maintains that the brain drain of doctors from the Philippines is actively promoted by the US and costs the Philippines thousands of dollars to replace those personnel who leave the country. He further argues "pirating a computer programme (a common practice in the Philippines) is not quite as different from pirating a doctor.

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[94]However many authors have argued that just becuase IP frameworks are strengthened at the national level, this will not automatically trigger or guarantee increased technology transfer (UNCTAD, 1991). So we must be cautious in implying a causal link between a more stringent IP framework and increased foriegn investment.

When the US pirates our doctors, it doesn't take a copy and leave the original behind. Instead, it takes the original and leaves nothing behind" (Verzola, 1993: 57).

Verzola raises an interesting point. However, there is a larger issue that must be considered. The theories on IP protection clearly imply that technology is *owned*. However, is it in fact accurate to advance the notion that technology is owned by a particular individual or group of individuals because they contribute the funds for R&D into creating it? While the legal regime protecting technology from illegal appropriation claims that it is accurate to claim ownership over technology, at a basic level it takes knowledge to create technology. That knowledge has been passed down through the ages from many cultures, many peoples and many nations - to use these techniques in the creation of technology and then to claim ownership on the derived product because it is viewed as novel and hence eligible for patent protection, is fundamentally wrong. Knowledge belongs to no one or no group, it is the result of humanities collective contribution, in the form of technique, of ways of enabling humanity to live a better life. The IP system has conveniently neglected this concept of collective ownership of what is really humanities knowledge and not one group's knowledge.[95] While patents and other forms of proprietary protection over innovations enable groups of persons to claim ownership over technology, because of the nature of the IP system, technology really belongs to no one group in particular, it is the common heritage of humanity and so collectively is humanities as a whole. It belongs to no one yet is owned by everyone.

[95] We must thank Dr. A. O'Malley for expanding on this very important conceptual clarification.

However, because technology is so important to the advancement of a whole peoples and because the IPE is structured the way it is, so that a few prosper at the expense of many, technology belongs to a few and is *not* owned by everyone.

However, it is the advances in technology and continued and wide spread abuse of IPRs that have resulted in IP emerging as a contending issue in trade and the related issue of comparative advantage. It has become a national priority for nations of the North to pursue technological development and control of such technology for commercial ends and the application of such technology for national development/growth (Morford, 1989). These issues are inextricably linked to the North scrambling to meet the demands of and maintain a competitive edge in global markets (Drahos, 1992) and (Office of Technology Assessment, 1986). A causal link has been recognised to exist between innovation and wealth. It is the effective utilisation of technologies, more so than factors of production that ensure global competitiveness, continued market share/access and the growth of future value-added industries (Bifani/UNCTAD, 1989). The TRIPs Agreement in the UR attempted to establish a harmonised set of standards regarding IP globally. TRIPs monopolised the UR as they did because of the increasing importance of IP in international trade. This was the case because transnational and government interests in the North had every thing to gain from the legal validation of ownership, through IPRs, of technology products/services and processes that would *ensure* not only the continued and exclusive control (monopoly) of comparative advantages that come from such control, but also ensure the continued dominance of the TNC system globally. The South countries on the other hand had everything to loose as a result of TRIPs because of the low social rate of return these countries have regarding IP protection. Indeed, it can be argued that with the increasing importance of IPRs, especially in international trade, as it was recognised at the close of the Tokyo Round (TR) of multilateral negotiations in 1979, that the UR aimed at bringing to an end the GATT which had limited provisions for the protection of IPRs. Hence, it can be further argued that multilateral talks over TRIPs in the latter half of the 1980s and into the 1990s, for the most part, took place in order to incorporate more comprehensive legal protection for IP. These talks took place primarily as a result of the United States' and Japan's, and later the European Communities' (ECs) interest in comprehensively including IPRs in international trade, via GATT at the conclusion of the Tokyo Round (Bradley, 1987).

5.4 The Implications of the UR for S&T in the South

The UR altered the international trading system in unprecedented ways. IPRs have emerged, as a result of their inclusion in multilateral trade negotiations in GATT, as the dominant issue in trade policy in this decade and into the new millennia. IP has taken over the forum of international policy discussion. This new trend is indicative of larger forces at work in the IPE. Specifically, the changing nature of wealth, labour, and power structures/relations, all of which have been largely a function of globalization (Drache and Gertler, 1991) and (Stopford, Strange and Henley, 1991). Consequently we must analyse the framework or context in which these issues have emerged.

The UR, negotiated under the auspices of GATT, helped pave the way for the establishment of the world trade organisation (WTO). At the heart of the WTO is a new commercial and economic contract that will result in the WTO to becoming the new security council on trade related matters. Many authors argue that the UR was a result not necessarily of a willingness to advance the cause of free trade, but rather as a means of substituting domestic structural adjustment of the US economy for external adjustment by increasing markets for US exports, especially in the area of services (Dubey, 1996). The fact is many countries including North countries were hesitant to enter another round of multilateral negotiations over trade issues so soon after the Tokyo Round and with so many issues outstanding, however under intense lobbying effort begun by the US in 1982 some North and South countries in opposition to another round of negotiations acquiesced. There did however remain lingering doubts especially amongst the G-77 nations over entering this round of negotiations. It is widely believed that these countries were coerced into the round through blackmail tactics employed by the US, such as threatening unilateral trade action under the Special 301 section of the US Trade Act and also by the US threatening to pull out of the GATT and provide exclusive trading arrangements (and hence access to US markets) to countries supporting the US. There were still other views on how some of the South countries were forced into the UR, for instance it is argued that the US threatened that the International Monetary Fund (IMF) and World Bank (WB) would seize giving monetary and financial assistance to South countries that did not enter the UR.[96] Archer further argues that such a view is plausible as the future development of most of the South countries is being held hostage by the

[96] Interview with Ms. Joan Archer, Regional Officer for Africa - Special Unit for Technical Cooperation Among Developing Countries, United Nations, July 7, 1997, 4:15-5:15, New York.

Bretton Woods Institutions that significantly influence the nature and type of trade/economic policies in the LDCs. According to Archer the LDCs in particular are on a short leash and a lot of the time are forced to do what the IMF and WB instruct them to do via conditionalities attached to the austerity programs.

These issues aside we must approach any assessment of the effects of the UR on the South countries by viewing its advantages and disadvantages vis-à-vis the South countries. In terms of advantages, the Round did secure significant tariff cuts/reductions, which will undoubtedly be beneficial to certain South country exports. In addition because of the increase in the world price of agricultural goods as well as the removal of domestic subsidies and barriers to trade in agricultural goods, the price of the South's agricultural exports are likely to increase. The phasing out of the MFA will enable free trade in textiles and clothing, which as a result of East Asia's comparative advantage in this area will benefit the regions textiles and clothing industry. Among the most significant gains from the UR some authors claim is the Round's effects on world welfare. Several authors have developed elaborate computable general equilibrium models used to forecast the economic effects of the Round on global welfare. Francois et al (1994) used a computable general equilibrium model and estimated that the economic effects of the Round would be a $500 billion increase in global GDP by the year 2005. Similarly OECD (1993) and GATT (1993) both estimate that global trade will increase to $745 billion and world GDP will increase to $230 billion by 2005 as a result of the UR. Are these estimates accurate though? We may even ask how was the data acquired for these studies and was the objectives of these studies impartial?

On both counts scepticism is justified. Consider that the estimates of these studies are varied. There is in fact a wide margin of difference as to what the GATT and OECD studies predict to be the gains from trade and what economists like Francois predict to be gains from trade. Skepticism is also warranted when we consider who collected the data and how the data was collected; furthermore was such data collection and analysis impartial - indeed could it actually have been objective considering the parties who modelled the data had an interest in the results showing positive gains to world-wide welfare as a result of the UR. Archer argues that these studies are largely rosy predictions that either fail to or purposely ignore to come to terms with the significant losses to the South that will occur as a result of the inclusion of the so called 'new areas' in GATT. Raghavan questions the extent to which the Round actually represents or champions the interests of the South, baring in mind that many South countries were not even allowed the opportunity to negotiate an already non-transparent TRIPs Agreement before the text of the Dunkel Draft came into effect. Furthermore, Raghavan argues that "rules in the WTO system are ambiguous particularly in areas where the industrialised nations and the major trading partners have to undertake their obligations; and several areas where the obligations are cast on the countries of the South, the rules are quite onerous, strong and unfair and thus oppressive" (Raghavan, 1994: 3).

5.4.2 The Implications of the TRIPs Agreement

Historically, the flexibility of national patent systems as a result of the lack of ratification by many countries of the Paris Convention has enabled such countries to implement industrialisation policies they deem necessary, even if they impinge on IPRs legislation. This has gone on over the decades to the great dismay of the Metropolitan powers, especially the US, because it views the national patent systems of South countries as being unable to prevent widespread piracy and counterfeiting activities that occur in these countries. The solution in the minds of the North countries to this was the TRIPs Agreement. However the Agreement undermines the Draft Code of Conduct on the Transfer of Technology negotiated in UNCTAD as well as the Draft Code for Transnational Corporations negotiated in the United Nations. This is because the Agreement adversely affects the requirements of TNCs to function in conformity with the patent legislation of the Paris Convention that strenuously attempted to strike a balance between the interests of the public and the interests of the patent holder. However, the views on IP protection have been mixed and open to controversy. This is because "proponents of a less stringent protection [...of IP...] suggest further controls of intellectual property would harm imitation-cum-innovation development strategies and constitute a barrier to legitimate trade in imitative products. In contrast, proponents of more stringent protection suggest lax protection distorts natural trading patterns" (Taylor, 1993: 626). According to Taylor neither view is accurate at least in terms of economic theory. However, the experience of East Asian countries with S&T planning has shown that there is significant validity to the former point. That is there has been a significant connection between imitation-cum-innovation, regarding the practise of reverse engineering in the industrialisation experiences of East Asia would appear to validate this. However, because the TRIPs Agreement enables the upward harmonisation of national legislation regarding IP, this more stringent global IP protection regime will compromise the extent to which South countries can employ industrialisation techniques and technology building techniques that were common practice in East Asia for decades. Namely the reverse engineering techniques as a means of technological mastery at the firm level will be severely restricted by the current international IP regime. Several authors like Deardorff (1992) and (Chin and Grossman, 1990) have argued that extending patent protection and more stringently enforcing such protection will in fact reduce the welfare gains of the South countries. Deardorff argues that to maintain world welfare levels we may very well have to reduce the levels of patent protection and exempt certain South countries from certain obligations that occur as a result of the use of IP, simply because of the effect of a patent in creating a monopoly situation where prices for the products are increased and the consumer has to pay more.

As regards the TRIPs Agreement's specific effects on the S&T capabilities of South countries, these include (as mentioned before) the common practice by which South country firms achieve technical mastery - reverse engineering - being curtailed. As has already been noted a common practice of many East Asian firms in order to attain technological mastery was reverse engineering techniques. The merits of such techniques are that imitation of products and production processes often bring about faster results for the commercial application of appropriated technologies. But also those firms engaging in imitation did not have to incur the large R&D costs associated with developing new technologies as they simply duplicated techniques already researched. Although such activities are a critical component of firm based technology building activities such activities have historically been viewed as 'free riding' by South country firms not adhering to the provisions of internationally accepted IP agreements. The TRIPs Agreement acknowledges such concerns of North country TNCs and has put in place certain enforcement mechanisms that seek to curb such illegal appropriation of technologies and as a result has undermined South country firm's ability to master technologies through imitation. This in turn has a significant effect on how South country firms can engage in bottle-neck breaking, as well as modifications to product design and product mix.

TRIPs will have yet another effect on technology capability building efforts in South country firms. This is because the strengthening of IP legislation throughout all signatory country legal systems will curtail reverse engineering. As a result South country firms will be unable to effectively modify imported Northern technologies, hence those technologies could very well remain inappropriate to the firm environment. If these firms are restricted from making incremental or generic changes to production techniques they would not be able to engage in petty inventions (or small scale indigenous R&D activity) to which these firms could apply a utility model. The ramifications of this are self evident - i.e. technical change is spurned by adaptation or modification to production systems, if such change becomes less common industrial stagnation or under-capacity could very well occur as a result of production costs per unit rising or improvements in production techniques remaining stagnant or even declining. This situation will have a larger effect on skill formation and information acquisition especially by firm engineers. Specifically these employees would not be familiar with how to utililize the technology to its full potential because under the restrictions imposed by the TRIPs Agreement on the acquisition and use of technology in a firm environment the way in which these employees could engage in learning-by-doing and learning-by-using techniques on the 'shop floor' would be significantly undermined. Because the use of technologies would be severely restricted imported technology would not be able to be used in such a way that contributes to capacity stretching, bottleneck-breaking, improved by-product utilisation, modifications on product design and expansion of product mix in the South country firm environment. This will occur because the TRIPs Agreement legally requires an internationally transferred technology be utilised, and the elements of that technology manipulated in a certain way. As a result the extent to which a South country firm can utilise technology capability building strategies illustrated in Figure 8 of Chapter 3 will be significantly compromised.

In addition, because the TRIPs Agreement affords the principle of national treatment to be applied to IP regarding all signatory countries regardless of their level of development countries are put on a level playing field. The South is afforded no concessions or exceptions to TRIPs provisions. In fact South countries will loose the positive discrimination and special privileges they once had under Part IV of GATT, as it will be eroded if not altogether removed. Similarly privileges enjoyed by the South under Article XVIII will be negatively effected as the ability of the South to implement restrictions for balance of balance-of-payments purposes as a result of the TRIMs Agreement will be phased out. Some authors, though, argue that there are indeed concessions for the South in this context as middle-income and LDCs are given an eleven and four year grace period respectively after which time they are obliged to implement the provisions of the TRIPs Agreement. However these concessions are not substantive and the Agreement itself fails to accommodate the development needs of the South, many of which require these countries to have relatively unfettered and fair access to technologies. They however are not subject to such a treatment and instead are subject to an IP framework that does not accommodate their need for technologies that are free of restrictive IP obligations that negatively affect both the terms under which the technology is negotiated and how it is used. This has a direct bearing as a result on how South countries are able to address their technology deficiencies using freely accessible technologies and using those technologies in such a manner that maximises their technological transformation goals and caters to the needs of their technological trajectory or general S&T plan. The fact that the UR does not address these issues is reflective of its failure to cater to the development and S&T advancement aspirations of South countries.

Furthermore, because, the Agreement has such stringent IPRs regulations a larger proportion of South country GNP will have to go to the payment of royalties and other remunerations for the use of foreign technology, hence further undermining the already precarious balance-of-payments problems in the South. An additional and major expense associated with the TRIPs Agreement will be costs of the expensive restructuring of South countries patent acts and legal framework. All these points speak to the additional costs the South will be obliged to shoulder and as a result which takes away from its capacity to use its already stretched resources (that are already severely taxed by their austerity obligations) for such S&T activities such as building its social sector, or using resources to encourage local R&D, the creation of centres for technology research and diffusion and other activities so critical to an S&T effort. Further, under TRIPs various plant varieties are protected, this has important implications for the agriculturally dependent and driven economies of the South. Specifically, plant breeders rights are protected under the Convention for the Protection of New Varieties of Plants in both amendments 1978 and 1991, however the rights of farmers (as a result of TRIPs) are not. For example commercial and large-scale farmers are prevented from re-using the same seeds from previous harvests. This compromises the freedom farmers have in how they conduct their activities and who controls the productivity of their yield and the volume and type of grain available to plant their crop.

5.4.3 The Implications of TRIMs Agreement

Similarly, as a result of the TRIMs Agreement more lenient controls over the entry and terms of investment packages into South countries will adversely affect South country's ability to implement supportive economic policy regimes to an S&T effort. For example South countries will be obliged to refrain from implementing selective infant industry policies as such action will be deemed as going against the TRIMs Agreement, that in effect makes it illegal for countries to ensure the protection of infant industry, but as well undermines these nation's ability to protect investment regulatory regimes that enable them to counter RBPs, impose remittance restrictions, demand local equity, manufacturing and product mandating requirements on TNCs. The TRIMs Agreement undermines what had long been a sacred argument of the South countries, i.e. they should have the discretion to use national laws and regulatory capacities, regarding foreign investment the entry and behaviour of TNCs and their investments in the HDC. Such regulatory mechanisms are an integral way of ensuring indigenous industrial and technological capacities are built amongst local firms, without such controls South countries are helpless to actions by TNCs that are based on securing and reflecting their own interests as opposed to the development objectives of the HDC in which they are operating. However, these regulatory laws of South countries concerning investment were deemed by the TRIMs Agreement to be 'inconsistent' with GATT provisions and therefore will be significantly undermined and/or eliminated.

As a result of this TNCs will be free to engage in the practice of horizontal and vertical RBPs. South country firms will be unable to impose regulatory restrictions on investment entering and TNC investment behaviour in, the country by stipulating local content, manufacturing, product mandating and local equity requirements or by various remittance restrictions, trade and foreign-exchange-balancing, domestic sales or even technology transfer requirements. The effect on an S&T strategy in a South country would be devastating. Local or indigenous equity participation requirements being undermined by the TRIMs Agreement for example would hinder how technology is acquired, assimilated and researched into in a South country firm. In addition indigenous technological capacities of these firms would be substituted instead of reinforced as local capacities to operate and maintain a production system would not be a requirement in a negotiated technology transfer package. Similarly, because the TNC's activities in the South country market place will be unrestricted the TNC could move to dominate the supply of a particular product or set of products in a market place and as a result undermining the growth and perhaps very existence of local infant industries. Or the reverse could occur, because the TNC not being obliged to produce a given level of products for sale in the HDC market could just utilise cheap labour in the HDC and export all its products to foreign markets as a result the HDC will have to use scarce foreign exchange to import the very same product exported from its borders. This would undoubtedly lead to added strain on the countries foreign exchange reserves to purchase a product that otherwise could have been purchased with local currency if their were regulatory restrictions obligating the TNC to sell a certain volume of products in domestic markets to be bought with local currency. In addition, TNCs as a result of the TRIMs Agreement would not be obligated to provide as comprehensive OJT packages as they were obligated to (by South country investment regulatory mechanisms) before the Agreement came into effect. The TNCs would have an interest in supplying the least amount of help in OJT or no help at all, as this would only increase a firm or industry's dependence on know-how, training, technology and personnel from the TNC.

5.4.4 The Implications of the GATS

GATS will also result in unfettered access by North country service based TNCs into the service sectors of South countries. This is disadvantageous to the South because their service sectors are underdeveloped and hence hold the most promise for or will be flooded by the entry of Northern TNCs. The indigenous South country firms that service this industry are relatively underdeveloped (or in their infancy), hence the concern that they will be crowded out by more developed service based firms from abroad is justified. Secondly, the international trade in services will change traditionally arms length relations between the effects of traded goods on the South to a closer relationship where the South country's industrial, social and economic policies will be directly influenced by North country interests. GATS will ensure the continued liberalisation of all economies, that are signatories to GATT, where market access is fully given to every economy, by arguing that member states shall not limit the levels and types of foreign capital entering their economies. Article XVI of GATS therefore would give TNCs the discretion to invest the amounts they wish in firms throughout the South as they wished. This goes against a series of resolutions adopted in the United Nations over two decades ago in the Charter of Economic Rights and Duties of States in 1974, where it was stipulated that each nation had the right to both 'regulate' and 'exercise authority' in regards to the amount of foreign investment entering their economies.

5.4.5 The Implications of the ATC

It is too naive to suggest the ATC is a positive outcome for the South countries from the UR. While the MFA will be phased out over a 10 year period the fact is the North countries still have the option of renagging on the Agreement if the export of textiles and clothing - now subject to GATT provisions - especially from East Asia begin to pose a significant threat to the textiles and clothing industry of the North. This 'threat' is defined as any large influx as a result of a sudden shock or increase in the volume of sales from East Asia of textiles and clothing. This option that the North countries have available to conveniently turn to if the free trade arrangement in textiles and clothing does not work in their favour has serious implications for an S&T effort in a South country. Specifically, because of this free trade arrangement South countries with a comparative advantage in this industry will now increasingly direct more resources to this industry with the expectation that increased exports will lead to pay-offs regarding increased foreign exchange. However these countries are putting themselves under a false sense of security, because even if their exports begin to grow this will not guarantee more foreign exchange for them because North countries could suddenly renagg on their commitments to the ATC and return trade in textiles and clothing to operate under the purview of NTBs. If this occurs South country efforts that were directed at training the majority of their workforce on the use of textile manufacturing equipment will be a waste as with decreased demand for South country exports of textiles under a QRs system will result in a large majority of workers either being laid off or under-employed - either way the country's effort to train that workforce using OJT methods as part of a S&T effort would have been a waste of scarce resources.

Even if the South countries were to appeal to the dispute settlement body if such a turn of events were to occur, it is unlikely the body would do much to appease or address the South's concerns. We can say this because we know from experience that the dispute settlement body rarely sides with the South. The dispute settlement mechanism is reviewed in the Understanding on Rules and Procedures Governing the Settlement of Disputes; the Dispute Settlement Body enforces this understanding. This understanding provides an effective *sui generis* system of rule enforcement concerning dispute settlement, similar to that provided in Article XXIII of the GATT. The dispute settlement body is supposed to keep things running smoothly in the international trading system where disputes are settled between 12 and 15 months after submission of an appeal.

However the dispute settlement body has come under particular scrutiny as it is argued it al most invariably favours the interests or point of view of major trading nations. Hence it is unlikely the dispute settlement body will work for the South countries. It is fair to make this statement as there is only one real case where a South country won its appeal, challenging the imposition of the USTR which made use of Section 301 against Brazil. In this case of the USA vs. Brazil, Brazil was accused of providing insufficient legal protection of industrial property regarding its pharmaceutical industry. In Brazil pharmaceuticals are non-patentable products, as is the case in many South countries, for example Turkey (Pablo, 1991). Brazil contested what it saw as the unfair and uncalled for US action against its pharmaceutical industry to GATT insisting that imposition by the US of tariffs on Brazilian exports in retaliation was discriminatory. GATT sided with Brazil, as a result Brazil won its appeal and the retaliatory action by the US was withdrawn (Frischtak, 1986).

The Brazilian case, however, is an example of tensions that have been resolved under the auspices of the dispute settlement body; other disputes have been settled outside of it. For example the disagreement between the US and Japan over automobiles was settled in such a fashion. In 1995-96 the US and Japan were in the midst of a highly publicised misunderstanding over the export of Japanese luxury cars to the US. The US unilaterally implemented a 100% duty on those imports of Japanese luxury vehicles, completely side-stepping handling the dispute through the dispute settlement body. Such action was a clear violation of Article I and XXVIII of GATT, that deal with non-discriminatory practices. However GATT turned a blind eye to these events - it is plausible to believe it might do the same in the case of misunderstandings over trade in textiles and clothing between a North and a South country.

5.4.6 The Implications of the Agreement on Agriculture

As is the case with the ATC that now liberalises trade in textiles and clothing, the Agreement on Agriculture allows for the free trade in agricultural products. A South country may be inclined as a result to invest significantly more resources into its agricultural sector, however the South's agricultural products still remain subject to significant tariff barriers. Now that the GSP and S&D treatment has in effect been undermined as a result of the UR South countries will have to pay even more tariffs for exported goods that previously fell under GSP protection. This means one less dollar in an already over-stretched fiscal situation in the South will go to an S&T effort either toward building schools and other related infrastructure or money for R&D activity, because more has to be paid out in tariffs.

However, critics of the move to include agriculture under the provisions of GATT argue it was not done to help the South. There is an increasing recognition that the South countries have no choice but to develop the capacities necessary to move into the manufacturing sector as advances in certain technologies - namely bio-technologies are making many of the South's exports of agricultural products obsolete. Consider that advances in biotechnology in the area of genetic engineering into breeding new species of plants, but also recent efforts at enzyme and tissue culturing threatens to make the traditional source of sugar - sugar chain, not the only source of sugar anymore. Now it is possible to extract sweeteners from starch based sources, Coote (1996) gives the example of high-fructose corn syrup extracted from maize or corn. This extraction method is widely used by US firms, hence resulting in a decreased demand for sugar-chain.

5.5 CONCLUSION

The chapter began by reviewing the various IP restrictions governing how the South has historically had access to and use of Western technology. We reviewed the various international legal conventions developed to oversee various provisions to protect IP and in this context also reviewed what some of the implications of this have been. Specifically, we examined how patents and the nature of the international IP system have in effect allowed those who use humanities knowledge to lay a claim on the ownership of technology. We expanded on this debate through our discussion of the pharmaceutical TNCs and their role in the South and the IP system. The chapter then reviewed UNCTADs efforts to restructure the IP system after which it then reviewed the origins of GATT and the evolution of this multilateral body till the Tokyo Round. This account served as an important back-drop to a more comprehensive analysis of the third argument of the thesis; in that the account enabled us to acquire necessary background knowledge to engage in a focused and technical discussion of the UR and an analysis of the implications of this Round. Our analysis paid particular attention to the GATS, the TRIMs Agreement, the ATC, the Agreement on Agriculture, and the TRIPs Agreement.

In the analysis of the TRIPs Agreement we further expanded on the implications of the international IP system having evolved the way it has and the significance of the theories devised to account for and support the protection of IP. So as to provide a counter argument to these theories we delved into the debate over whether it is accurate to argue for ownership of technologies through proprietal or legal means. Because the chapter engaged in a comprehensive assessment of the implications of the UR for S&T in the South, we were able to reinforce the third argument of the thesis. This set the stage for some rather sobering conclusions we reached in chapter six as to the future of the S&T effort in the South as a result of the hard reality this region must now face in an increasingly hostile IPE.

Chapter 6 - CONCLUSION

Three arguments are advanced in the thesis. The first stated that it is critical that a S&T strategy/policy framework be in place in the South. We identified what those strategies are and examined why they are important to the industrialisation or economic growth aspirations of a nation and also explained how they contribute to an S&T effort. By reviewing the role of technology in economic growth in the second and first half of the third chapter we established the theoretical foundations for the first argument of the thesis.

Chapter three examined the specific features of an S&T policy and also analysed the importance of supporting economic policy regimes to an S&T effort. We established that such economic policy regimes were important for the success of an S&T policy because these policies collectively work together for the common goal of economic growth. We know then that an S&T policy if viewed as something not part of an industrialisation policy is doomed to failure simply because building technology capacities is not the *sine qua non* of economic growth. The second argument of the thesis maintained that important lessons can be learnt on the dynamics of an S&T effort from the East Asian experience with S&T planning by South countries. This is because the process of technological transformation of a nation from traditional capabilities to islands/enclaves of modernisation (i.e. utilisation of modern, mechanised technologies in certain pockets of industry in a country), to mastery of conventional technology, then industrial technologies and finally the position of NIC status or technology export capability at internationally competitive standards, is complex. In order to analyse and explain these complexities it was critical we analysed Japan's and Korea's experience with S&T and extracted best practice techniques for S&T capacity building from this region for the South.

The third argument of the thesis concerned the impediments to effective S&T policy planning in the South countries. The third argument of the thesis maintained that among the most significant impediments to the South's technological transformation is the international trading environment specifically the UR negotiated under the purview of GATT. We argued why this is this case by giving specific attention to five agreements within the UR. We have seen in this thesis that the multiplier effects of a coherent and committed S&T policy as regards economic growth are enormous. The degree to which a nation of the South can benefit from such policies lies in how well it can extract best-practice S&T policy planning techniques from countries that have had a successful track-record with S&T and industrialisation; but also how well it can overcome the obstacles, arising from the UR, to successfully conduct its S&T efforts. This is no easy task, as the South country policy-maker faces significant challenges to the successful implementation of S&T initiatives. However, it is a necessary task - a task that must be pursued in a committed, professional and urgent fashion.

We know that in order to develop their capabilities in the management of technology and technological transformation, South countries must significantly invest both time and resources. This effort must be spearheaded not by government alone, but through a collaborative and synergistic relationship between the public and private sectors. An institutional and policy framework must be devised under the discretion of a

Planning Ministry or Ministry of industry to coordinate the activities, projects and programs of an S&T infrastructure. The role of the government is critical so as to implement the appropriate regulatory, financial systems (e.g. risk capital institutions) and communication/transportation, social and economic infrastructure necessary to support local firm efforts at building their technological capacities. There is also a major role for the North countries, though, in the South's S&T efforts. This role is not based so much on help being given for the formulation of S&T policies, but rather in providing a supportive international economic/trade and IP environment. However, we have seen from the UR that the developed world has made it quite apparent that they are more concerned with advancing their own interests, at the expense of those of the South - and hence are not willing to promote such an environment. Many North countries, for instance, have refused to consider the possibility of not obliging every country to be subject to the rules and provisions governing the protection of IP. Although this would actually increase the marginal benefits for these poorer countries because welfare would not be transferred from the poor to the rich countries in the form of greater monopoly rents for technology suppliers, it is not a consideration for North countries.

The thesis does acknowledge that there is evidence that the technological transformation of the South is occurring but at an agonisingly slow pace. This is because there has been much rhetoric about S&T capability building in the South with little action. In the 1960s the Lagos Ministerial Meeting held under the auspices of UNESCO suggested goals be set for scientific and technical human resources and be met - but they were not. In the 1970s the OAU and UNESCO jointly attempted similar initiatives, a

UNESCO meeting at the Ministerial level recommended a number of initiatives and policies to be followed to promote national and regional S&T capacities which again were never followed. The Lagos Plan of Action in the 1980s, although littered with rhetoric and policy recommendations in S&T met with the same fate. The real tragedy is that while a commitment to S&T appears to be visible in paper, many South nations have failed to translate these commitments into implementable policy. Countries like Vietnam, heralded as the next 'tiger', it appears will not be for this precise reason. Vietnam, like so much of the South has failed to learn from the successes of East Asia. The country has as yet, to deal with a growing population. Agricultural output still comprises a large proportion of GDP. Although a majority of the country's people are literate, many still are not adequately being educated in large numbers at the university level. Kasper (1995) an economist who has extensively travelled through Vietnam, has said that education and health facilities in the country are 'appalling'. The gulf between rich and poor he argues, is getting ever wider, to the extent that in the mid-nineties, two-thirds of the population only shared one-fifth of the country's GDP. While GDP per capita remains extremely low. Kasper sites a study of 91 700 households done in 1994, that pegged income p.a. of the average Vietnamese person to be $ 132, indicating the GDP in the country is *not* increasing significantly, and raises doubts as to whether GDP per capita levels can be doubled, as the government suggests it can, by the end of millennia.

By reviewing the malignant problems of current and past S&T efforts in sub-Saharan Africa and South East Asia we can establish that policy-makers in the South have not only failed to recognise the importance of a coherent S&T policy in their country's development strategy but have failed to devise and implement one. Such lack of effort to devise and implement a coherent S&T effort is reflected in how South countries rank, relatively speaking, in Table 10. We can see from this table the difference in priority given in the development of a comprehensive S&T policy. Where in level 2c government policy especially in terms of investment in applied R&D skyrocketed, over the past couple of decades as a percentage of GDP, this was not the case in government technology strategies in level 1a. Similar grim statistics tell the story of private sector investment in R&D in countries in level 1 as a whole. Countries in level 2 far outmatch those in level 1 because they have actively implemented coherent S&T policies. Such coherent S&T policies in level 2 are reflected in significantly higher scientists and engineers than in level 1. If we look at patent indicators in the table (which for all intents and purposes are a reflection of inventive activity) again level 2 countries have significantly more patents than level 1.

Table 10 - Technological Capability Indicators for Eight Synthesised Levels of Technological Development

Indicators	Level 1 Developing countries			Level 2 Developing countries			Recently industrialized	OECD industrializ
	1a	1b	1c	2a	2b	2c		
	Traditional technology	First emergence	Islands of modernization	Mastery of conventional technology	Transition to NIC-hood	NIC-hood		
I. Real Growth (1965–1990)								
GDP per capita	.5	.5	1.5	2.4	2.5	7.1	2.8	2.5
GDP: Aggregate	2.5	2.6	2.8	4.7	5.3	8.1	4.0	3.5
Agriculture	2.5	2.5	2.6	3.8	3.0	3.1	2.5	1.5
Industry	5.0	5.0	4.5	5.1	6.0	9.1	3.1	3.1
Services	5.0	5.0	4.8	5.0	6.0	10.0	3.5	3.5
II. R&D intensity								
R&D/GDP (1990)								
Aggregate:								
Public	.2	.2	.3	.4	.6	.6	.7	.7
Private	0	0	.02	.05	.2	1.0	1.2	2.3
Agriculture:								
Public	.4	.4	.5	.6	.7	.8	.8	1.5
Private	0	0	0.01	0.05	.1	.2	.5	1.5
Industry:								
Public	.05	.05	.1	.2	.4	.3	.3	.3
Private	0	0	.02	.05	.05	1.0	1.2	2.3
Services:								
Public	0	0	0	.01	.05	.05	.1	.3
Private	0	0	0	0	.05	.1	.2	.5
Science/GDP (1990):								
Public	.02	.02	.03	.04	.10	.20	.25	.40
Private	0	0	0	0	0	.02	.04	.05
III. S&E intensity S&E/GDP (index)	.2	.2	.4	.6	.8	1.3	1.0	1.0
IV. Invention indicators								
Inventions/S&E*	0	0	0	.05	.1	.5	.3	.2
Invention import share	0	0	.9	.95	.81	.64	.80	.31
Invention export share	0	0	0	0	.05	.10	.20	1.70
V. Intellectual property rights								
International recognition	0	0	1	2–3	2–3	2–3	4–5	5
Domestic use	0	0	0	1	2	4	4	5

* Number of inventions per scientist and engineer engaged in R&D, in 1989.

Typical Countries:

1a: Yemen, Laos; 1b: Nepal, Ethiopia; 1c: Sri Lanka, Kenya; 2a: Malaysia, Turkey, Colombia; 2b: India, Thiland, Mexico; 2c: Korea, Taiwan. Recen industrualized Greece, Portugal, Spain.

Source: adapted from R.E. Evenson, L.E. Westphal, "Technological Change and Technology Strategy", in J. Behrman, T.N. Srinivasan, Handbook of Development Economics Vol. IIIa (Amsterdam, North-Holland, 1995).

The lack of development of a regulatory environment for property rights in level 1 is significantly reflected in the lack of an IPR system there - this however, is not the case in level 2 countries. This begs the question, what incentives are their for inventions to take place in level 1 countries if a basic IPRs legal framework is not in place to protect inventors from copycats? As a result of these constraints, investment in technological transformation in level 1 countries (representative of the least developed countries (LDCs)) is seriously lacking, and will continue to be meagre for quite some time yet. Hence, the potential for growth in these regions will remain dormant. The only part of the South that is showing promise is South Asia and, of course the NICs, as compared to industrial GDP in these regions, industrial R&D has significantly increased. Bell argues growth is occurring in these regions because these countries have understood the importance of technology in economic growth, and increases in productivity in these regions have largely been a result of efforts to increase technological activities, especially in the area of raw materials extraction, product and process quality control, production scheduling, changes in product mix (Bell, 1984).

However, the failure of South country policy-makers to implement comprehensive and coherent S&T policies is particularly reflected in the extremely low number of students pursuing not only primary and secondary but also tertiary level education. We can see from Table 11 that relatively speaking South countrys have accorded very low priority to the formal training of human capital.

Table 11 - Percentage of Age Groups Enrolled in Primary, Secondary, and Tertiary Education

Country	*Primary*	*Secondary*	*Tertiary*
United States	101	99	57
Japans	102	96	30
Canada	105	103	55
Ethiopia	36	12	1
Pakistan	47	17	5
Ghana	66	39	2

Source: adapted from World Bank, World Development Report, 1988 (Oxford University Press, 1988: 25).

This low priority given to education in the South (because of the lack of well developed S&T capacities) has translated into extremely low numbers of scientists and engineers available in the South to engage in R&D their (see Table 12). The South suffers from a chronic lack of a qualified pool of scientists and engineers, and as a result indigenous technical expertise are not available to engage in critical technology building activities that are such a critical part of an S&T effort. We can see that compared to the North the number of scientists and engineers in the South are very low, this is similarly the case regarding the ratio of scientists and engineers per million population. Countries in East Asia, though, that actively pursued a S&T effort have an extremely large scientist/engineer to per million population. Consider that in Korea in 1994 there were 2, 636 scientists and engineers per million population, while in Japan in 1992 there were 5, 677 scientists and engineers per million population. We find on the other hand though that a typical LDC country - like Gabon - that historically has not pursued an S&T effort can only boast a paltry 217 scientists, engineers and technicians as of 1987 engaged in experimental and science based R&D (UNESCO, 1998).

Table 12 - Number of Scientists and Engineers in the North and South

	Number of Scientists and Engineers (Thousands)	*Scientists and Engineers*	
		Per Million Population	*Engaged in R&D (1980) Per Million Population*
Africa	1 623	3 451	91
Asia	32 670	11 686	272
Latin America/ Caribbean	4 746	11 759	252
Europe	37 369	48 600	1 732
North America	33 247	126 200	2 678
Oceania	1 105	48 213	1 483
Developed Countries	*81 247*	*70 452*	*2 984*
Developing Countries	*29 513*	*8 263*	*127*

Source: UNESCO, Statistical Yearbook (Paris: United Nations Educational, Scientific and Cultural Organisation, 1988).

We have argued throughout this thesis that at the root of economic growth should be a national strategy to build the educational and technological capacities of a nation. We have also argued, if the South is to be part of the dramatic transformation in technologies and economy in the next millennia, a comprehensive S&T policy is the conduit or catalyst for such growth. President Truman was quoted once as saying investments in S&Ts would be the means of liberating the South from the shackles of underdevelopment. However, as we know, because of the South's lack of technological capacities and the nature of the international economic system this region of the world faces significant obstacles in its bid to technologically transform. The East Asian industrialisation dynamic, though, offers important lessons for the South in this regard. That said South countries will find it hard to emulate East Asian growth because of small domestic markets, weak technological capacity, lack of development of infant industry programs, weak entrepreneurial system, lack of international marketing networks, pressure from exogenous forces, e.g. World Bank/IMF brokered austerity or SAPs. In addition the synergistic interaction between Japan and the rest of East Asia because of the close trade relationship is hard to replicate especially in Africa. Consider that half of Japan's $13 billion overseas development assistance (ODA) budget goes to the East Asia region (Jomo, 1996). Which African country will be willing or able to assume such a responsibility? The answer ofcourse is none of them.

We can infer from the analysis in the body of the thesis that technology, as it stands today is a *right* in one society and a *privilege* in another. This trend, coincidentally or not, is a reflection of the inequities in our global family. It is also indicative of a disturbing trend; a trend that maintains, it is absolutely acceptable that some of humanity has the right to develop, however, it is equally acceptable that another does not. It is because the primary goal for many on this planet is the acquisition of wealth, that the status quo, not only in technology, but every other aspect of North-South relations will be ongoing for quite sometime. Nevertheless, the importance of technology globally has been accepted in trade policy. This is both a testament of its importance and an indication of a larger phenomenon at work here, i.e. the interests of transnational actors to monopolise international markets. IP protection has, it has increasingly been realised, replaced its traditional function of encouraging inventions primarily for the public welfare and individual profit, to now signify a mechanism to sizeably increase profit margins.

Advances in technology have resulted in the internationalisation of the world economy because of technology's impact on global trade, on the one hand, and the TNC system, on the other. Globalization can no longer be thought of narrowly as the transnationalization of capital and the interdependence of economies. Rather, it must be thought of as a *process* as opposed to a phenomenon. It is a process that began in the 1950s when international and sub-global trade regimes began to liberalise. As a result of this, trade related multilateral negotiations ensued in successive rounds of GATT. In 1970-80, as a result of exogenous shocks associated with the Organisation of Petroleum Exporting Countries (OPEC) increasing the price of oil, and as a result a decrease in total factor productivity, deregulation systems were introduced. Presently, globalization is at a stage where by the mid-1980s investment flows (IF) changed significantly and strategic firm based alliances became the norm (OECD, 1991:42-45). This process and, inevitably globalization itself, has been facilitated by the internationalisation of finance and the deregulation of international trade. This internationalisation itself, however, has been a function of the proliferation of technologies and technological innovation, which have enabled increased cross border trade and financial services (Agosin and Tussie, 1993:11). Why discuss globalization? We are attempting to elucidate that because advances in technology remains at the root of globalization, and has largely been a feature of societies of the North, the South remains excluded from the benefits that accrue and will continue to accrue, from globalization. In addition, because technologies have been the key to economic growth, they will remain zealously protected. Access to technology will be fiercely guarded as has been proved in the UR, which provided for more stringent international provisions for the protection of technology. Technology even more so than ever will be viewed as a commodity, a right, not subject to the laws of the market - this is both a tragic and ironic fact.

The North has a continued interest in the marginalization of the South. The South's access to technology, reviewed in previous sections, highlights the gross inequities the South faces in this regard. Technology is yet another area in which the South will lose out, more so now than ever, as the UR has further served to stifle North-South dialogue and the dynamic technological transformation of the South. Patel even goes so far as to say, the international patent system has emerged as the most unequal and iniquitous of all relations between North and South (Patel, 1989:986). Restrictions on technology and access to technology have significantly increased for the South, the effects of which lie in further curtailing the trade and industrialisation options available to this part of the world. Without choice/options for development, the South becomes increasingly more likely to blindly follow on the coat-tails of transnational actors and the North's development agenda.

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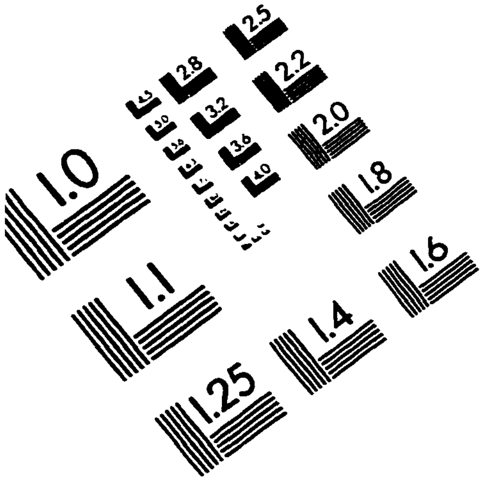
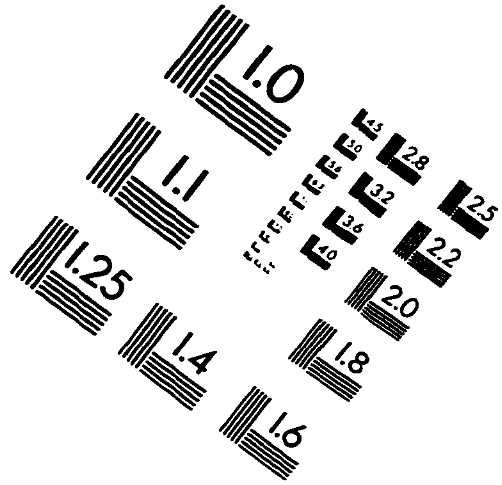
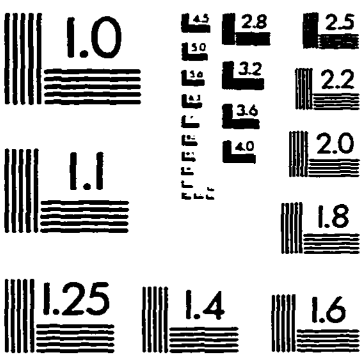
IMAGE EVALUATION TEST TARGET (QA-3)







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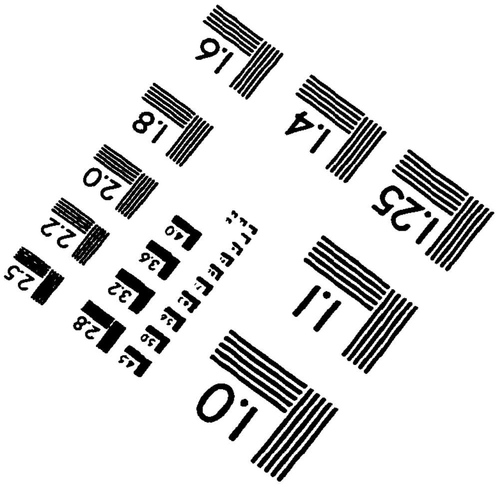

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