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KNOWLEDGE ENHANCEMENT IN THE SMALL ECONOMIES OF CENTRAL AMERICA: REFLECTIONS ON BUILDING A STRATEGIC APPROACH

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PREFACE

This document advocates better mechanisms for ongoing learning and better access to knowledge in small economies. Its objective is to raise awareness about two issues related to science and technology projects that are relevant for the small economies of Central America, namely that: (1) there are insufficient knowledge-based innovations to support rapid economic growth; and (2) the size of the investments in technologies appropriate for the poor are too meager to be effective in enhancing the opportunities and capabilities available to disadvantaged groups. The paper takes the position that understanding these issues will allow greater emphases in certain aspects of science and technology project design. Moreover, greater attention to these issues contribute to the institutional objectives of the Bank such as competitiveness and poverty reduction. The paper concludes that a greater investment is needed to diffuse knowledge, taking into account weaknesses associated with learning within a context of rapid technological change.

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I. INTRODUCTION

A. A need for assessing outcomes

> *The poorer countries can be expected to exploit their current comparative advantage – low-skilled labor – through labor-intensive production technologies. They may also concentrate production in a narrow base of product. However, over the long run, this approach will end in low technology, low productivity and low income. In the knowledge-based world, strengthening human capital and related research will be as fundamental for poorer countries as for the more advanced ones. The IDB will therefore increase its S&T lending to smaller, poorer countries as a means of helping to ensure that they can also participate in knowledge-based development, in accordance with their evolving comparative advantages.*

This quote from the Bank's Science and Technology (S&T) Strategy (GN-1013-2) defines the basis for the support that the Bank has provided to Region II countries in recent years. It underscores a new focus on smaller and poorer nations, which had been de-emphasized in the past. I have contributed to this definition and have dedicated most of the past six years to interpreting and enhancing it in numerous operations for countries interested in using knowledge to boost economic and social objectives. The goal has been to identify ways for the Bank to finance technological knowledge that contributes to viable productivity-led growth, including among less-advantaged groups.

This essay will highlight some of the lessons I have learned about the economic, institutional and policy frameworks needed to channel knowledge into growth and poverty reduction in the small, developing economies of Central America. These are issues I have found particularly interesting and important. I have not attempted to cover all aspects of the discussion.

The conceptual and operational lessons suggest that there are fundamental aspects that have not been sufficiently emphasized. Certain peculiarities of the economies under consideration determine their scope for knowledge diffusion, much more strongly than expected. They constrain some S&T activities and require additional attention. Similarly, negligence in facilitating the adaptation of appropriate technologies in poorer communities has imposed unnecessary boundaries on development and production possibilities.

For these reasons, I hope that the present paper will set the tone and strategic orientation for further reflections and analyses that will be carried out by the Bank's partners, which have been directly or indirectly involved with me in the design and implementation of S&T projects. Indeed, I have recently started a series of meetings and brown-bag seminars for this purpose that will continue into 2003. I expect that the conclusions of this essay will raise questions that should be dealt with in these fora.

With this in mind, the essay embarks on a broad sketching of issues and experiences, rather than a focused deliberation on specific questions. S&T by its very definition cuts across many disciplines. Sometimes it is a source of inputs for research or economic productivity analyses; other times it provides tools for creating, expanding, applying or diffusing various types of knowledge. This wide range is justifiably bewildering when placed within the context of small economies, where the core macro and microeconomic conditions and mechanisms for fostering change are not in place, and the average capability of national human capital is quite low.

But that is the nature of the task at hand. The only possible simplification is in setting priorities and determining the appropriate sequence of actions in given countries, which will be the subject of future papers. To reach a wider audience in the Bank and Central American countries, however, including potential stakeholders that may be unfamiliar with various topics, some basic definitions and arguments will be presented first below.

B. The operational context for science and technology lending programs

A new generation of S&T projects at the Bank was conceived in 1997, starting with Region II approval of the *Guidelines for Technological Knowledge Diffusion in the Central American Isthmus*. The first step was to raise awareness of technological applications that could increase business productivity and/or alleviate poverty. This stage was critical, given the dismal track record in S&T activities in the region, which had suffered through protracted civil wars. Central America has also upheld a tradition of widespread disregard for knowledge and innovation (other than "guerilla"-related technologies). It seemed expedient at first to grant higher priority to country programs geared toward developing technological innovations in small and medium enterprises (SMEs); improving the system of quality, standards and testing; piloting new approaches to teaching science, mathematics and technology in schools (K-12); and reducing the digital and communications divide through information technology.

In this first phase, research and development (R&D) activities were de-emphasized, although not fully excluded, under the assumption that the Bank would pursue these once awareness began to grow among both researchers and entrepreneurs about how knowledge is critical for reaching economic and social development objectives. This assumption included the conviction that science can become a major force for change. For that to take place, however, countries first need to better acquaint producers and scientists about areas of knowledge where mutual interaction would be particularly productive.

To date, policies for increasing macroeconomic stability and investing in human and physical capital have been prerequisites for all of the Bank's S&T interventions. These parameters have often been weakly defined on purpose, however, given the great difficulties that smaller, poorer countries face in reallocating physical and human resources. Markets have not proven flexible enough to allow smooth and rapid reallocations, even when some good incentives have been introduced. In most cases, signs of serious attempts to change policies in the right direction have proven sufficient

for the Bank to justify putting in place some facilities and incentives to assist countries in starting to acquire and master technology.

With these considerations in mind, the Bank has approved a number of lending programs, forms of technical cooperation and dialogues. Five particular lending programs are significant: Panama (PN-0109) "Support for the Competitiveness of Productive Sectors," Guatemala (GU-135) "Promoting Technological Innovation in Small and Medium Enterprises," Panama (PN-134) "Support for the Development of a Science and Technology Park in Panama," Nicaragua (NI-147) "Support for Technological Innovations," and Honduras (HO-203) "Enhancing Capability Through Technology in Poor Communities of Honduras."

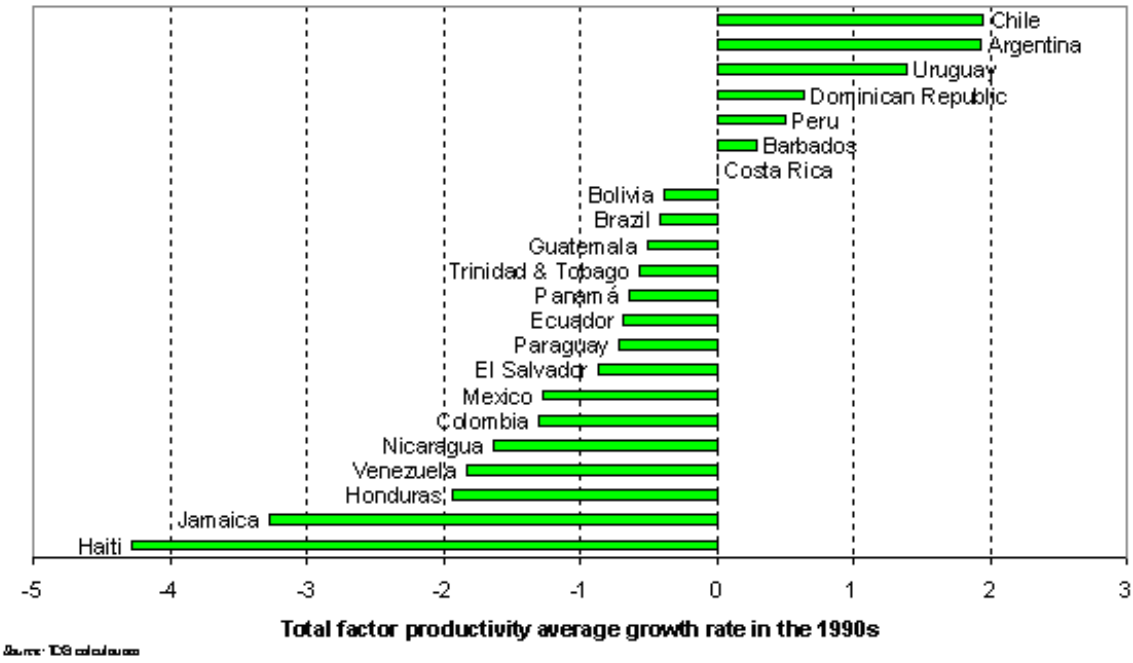
In these projects, we have aimed to strengthen S&T functions identified as priorities by governments, but unlikely to be funded by other sources. Some activities promise great social returns, for example, but monetary returns may be too low for private economic agents. In other cases, markets may not be able to provide proper incentives because they are too small, too incipient, or too full of distortions.

Each of the projects has supported efforts to design new or strengthen existing science, technology and innovation strategies, with a specific emphasis on policy formulation and better resource allocation. Normally, projects have represented the initial stage in such an effort, becoming a de facto first five-year strategy. They have underscored the need for compatibility with existing macro and microeconomic as well as sectoral (education, environment, etc.) policies. The projects have also assisted governments in providing specialized advisory functions, supported or complemented by external expertise. This expertise normally has been offered through training or workshops, or in the redesign of the provision of services such as laboratories. There has also been an emphasis on strengthening public institutions that coordinate or regulate national quality accreditation systems (including metrology, standards and testing).

Weaknesses in private sector productivity and competitiveness provided the main justification for these initial projects. As the Figure 1 shows[1], productivity has lagged seriously behind during the 1990s, a situation that is particularly troubling given that the economies of Central America in particular were struggling to emerge from protracted civil strife and institutional chaos. As a result, the growth record here between 1975 and 1999 was much slower than in Latin America as a whole. As the Bank's 2002 sectoral study, "Las Economías de los Países Centroamericanos y Republica Dominicana," points out, instead of convergence to growth rate levels of the more advance countries, "in fact, what can be observed in Central America is non-convergence in those countries with the best economic performance and absolute divergence in the laggard economies."

[1] IPES 2001: Competitiveness. IDB Press

Figure 1
Productivity Growth *(in percent)*



Source: IDB calculations

The Bank's reasoning for supporting attempts to link technology and productivity has been based on the assumption that in general, private firms in Central America, especially smaller ones, have a limited or nonexistent track record in terms of technological innovations and transfers. Given that financial markets in the region are often biased against technological innovations, particularly for small and medium-size firms, financing for innovations has often been highlighted as strongest component of projects assisted by the Bank. Other important aspects have included: social impact on poverty (HO-203), strengthening education in primary/secondary schooling (GU-135 and PN-135), and development of a well-networked private technology park/academic center (PN-134). Table 1 highlights the aims of the projects.

In three projects (PN-134, HO-203 and NI-147), the Bank allowed flexible loan instruments ("innovation loans") to try out schemes considered novel within the countries. Regardless of the type of loan instrument, however, all of the projects have piloted mechanisms stimulating the supply and demand of pertinent knowledge, and set in motion programs for knowledge diffusion and/or financing mechanisms to connect providers and users of S&T services.

Table 1: Different projects, different goals

PN-109	GU-135	PN-134	NI-147	HO-203
Promotion of technological innovation in SMEs via matching grants; research and development in selected fields with a potential for comparative advantage; national system of innovation; telecenters for poorer communities; design of a methodology to improve S&T education in primary and secondary education (with the Ministry of Education).	Promotion of technological innovations in SMEs and service providers through matching grants; design of a new five-year plan to strengthen the National System of Innovation; support of a new method to incorporate IT for S&T in selected technical secondary schools; design of a better method to improve S&T education in primary and secondary schools (with the Ministry of Education).	Financing of a targeted international marketing campaign that assists existing and attracts new tenants in the City of Knowledge science and technology park; design and implementation of a new organizational structure consonant with the mission of the City of Knowledge; renovation and upgrading of the park's key installations.	Setting up of a matching grant fund for promoting technological innovations in SMEs and for the supply of technological services; establishment of technology diffusion centers.	Diffusion of technologies (information and communication) that facilitate and connect smaller, distant communities to the modern economy; design of a methodology to transfer appropriate technologies that remedy some obstacles to development opportunities; design and promotion of a new S&T Plan that incorporates the S&T needs of the poor.

The Bank also invested in three technical cooperation operations to orient S&T policy in El Salvador that did not end in a loan. One particularly interesting scheme featured affordable and easily accessible technological advice for small and medium enterprises. Inspired by the Canadian system of technological extension advisors, the project intended to train local consultants with adequate technical expertise in using diagnostic kits. They could then regularly visit small and medium enterprises to provide quick and effective diagnoses of technological deficiencies. The program would also have offered a matching grant fund for SMEs wanting to innovate in some aspect of their production/organization processes. Due to internal politics, however, the proposal lost priority and was never funded.

C. Defining a future agenda

> *In his valuable article on international trade and world distribution of income, Paul Krugman (1979) takes the patterns of trade and economic growth to be governed primarily by two activities: innovation and technology transfer… It is clear that the growth of developing nations is highly dependent on the success and speed with which they can acquire and put to effective use new technology from the industrialized countries. But even growth in the industrialized economies is highly dependent on the effectiveness with which they can adopt new technology from sources foreign and domestic.*[2]

As can be gathered from this discussion – as well as the numerous cases of dialogue and technical cooperation surrounding the design of past projects – much has been said and done since the Bank´s knowledge diffusion guidelines first appeared in 1997. These debates and experiences have fed into two new S&T projects being prepared in the Dominican Republic and Costa Rica. Yet even as the Bank continues its commitment to

[2] William Baumol, 2002. *The Free-Market Innovation Machine*. Princeton: Princeton University Press, p. 74.

assist Central America in using science and technology to spark economic growth, and even as the demand for this form of support increases, the challenges in the region have escalated, spurred by the international market´s rapidly growing dependence on knowledge-based competition. These trends, along with the lessons learned in the past, must now inform the direction and dimensions of future Bank lending.

Long familiarity with the preparation and implementation of S&T projects suggests that there are some serious weaknesses in economic foundations that must be repaired before an economy can benefit from knowledge enhancement. In Central America, the following two issues are of particularly grave concern. They bear associated constraints that the Bank, as a development institution, needs to understand more clearly, and for which we need to develop new and better technical and policy instruments:

1. Issue one

Insufficient knowledge-based (i.e., S&T-based) innovations to support rapid economic growth.

Immediate cause: Poor comprehension of the economics of the knowledge-productivity connection and its implications for a national system of innovation.

Constraints: Presence of an economic structure and policy environment that neglects developing and/or disseminating knowledge that is tailor-made for local economic conditions; absence or weakness of catalytic institutions that reduce transaction costs associated with acquiring appropriate information and knowledge; unbalanced economic rhetoric emphasizing competition but neglecting cooperation and coordination in setting up basic rules and infrastructures; too many economic agents that are not yet poised to become aggressive entrepreneurs.

Consequences: Incentives for inhibiting innovations. Very low labor and/or total factor productivity in the production/value chain, which leads to low exports and limited economic growth.

2. Issue two

Meager investments made in technologies enhancing communications, and the opportunities and capabilities of poorer communities and individuals.

Immediate cause: Inadequate comprehension of the poverty-knowledge connection – including weak understanding of the links between the expansion of education and science and technology.

Constraints: Low bargaining power of the poor;[3] lack of a set of trustworthy technology-based tools to enhance their capabilities (for example, too much emphasis on formal

[3] The poor can be regarded as a negligible economic agent, since they do not command much influence in regular market channels.

education in contrast to massive diffusion of practical know-how); inadequate grasp, due to little research, of the character of local economies and entrepreneurial activities.

Consequences: Excessively large opportunity and transaction costs incurred in the alleviation of poverty, and prevention of the widening and deepening of production possibilities as well as larger growth and welfare improvements

Elucidating these issues will break down some of the formidable obstacles facing policy makers who want to pursue knowledge-related policies to complement and enhance macro and microeconomic policies. This discussion may also produce an outline for international financing institutions to more effectively aid the management of technological and scientific change for development purposes.

In general, our underlying aim should be to develop a detailed agenda for discussing, gathering and applying knowledge that will help: (a) to define the questions that need to be better answered in order to effectively confront the challenges in this field; and (b) to suggest lines of research over the next six months to revise the Bank's approach to S&T projects in the smaller, poorer countries of Central America. An emphasis needs to be placed on why domestic and global efforts to promote S&T have not been more successful.

I will reflect here on the policy implications derived from pursuing knowledge as a key development objective, especially from placing knowledge enhancement at the base of the economies under consideration. But first I will digress a little to discuss the definition of knowledge and small economies used in this essay, as this has been a source of semantic arguments in the past. Then I will address each of the two critical issues noted above, looking at how the Bank can improve its approach to S&T projects. Lastly, I will sketch the elements of a strategy for knowledge diffusion in Central America that will attract further comments and contributions, thus deepening the debate.

II. DEFINITIONS OF KNOWLEDGE, ITS ROLE IN DEVELOPMENT AND SMALL ECONOMIES

This essay touches mostly upon the role of knowledge in development and growth. Yet the notions of "knowledge-based economies" or a "knowledge economy" seem rather vague at first. For some people, a knowledge-based economy simply involves the introduction of information and communications technologies throughout the market exchange process. For others, the term refers to economies directly based on the production, distribution and use of pertinent knowledge and information.

When applied to smaller, poorer economies, which normally have very low educational attainment, the confusion is even greater. That is why I refer to the goal in Central America as being the creation of knowledge-enhanced economies, instead of knowledge-based systems. This approach acknowledges the difficulty these countries have in gaining access to the full spectrum of technical sophistication and services available in advanced economies.

A generally accepted philosophical definition of knowledge is that it is justified true belief. That is, a belief that is supported by facts and explanations consistent with established expertise. For example, a reliable ordinary eyewitness offers grounds for believing in an accident, or a physicist provides reasons for believing in the indeterminacy principle.

There are three types of knowledge that will interest us here: knowing how, knowing that and knowing why. **Knowing how** refers to the skills or capacity of an individual or organization to accomplish a well-defined task – in other words, it is tantamount to technology or technique. There are gradations: For instance, Judy knows how to skate, and her knowing how makes her better or faster or more graceful than John (degree is determined by rules). Or firm A is more productive in producing X than firm B. **Knowing that** has to do with upholding the occurrence of an event as true based on a fact. An accident occurred and eyewitness A saw it, for example. Or knowing that 2+2=4 based on mathematical axioms and rules. **Knowing why** is normally related to scientific theories from which explanations may be derived and predictions refuted or corroborated by people trained in the discipline. For example, we know why Judy can skate so smoothly because of anatomy, physics and chemistry.

It is important also to distinguish information from knowledge. Information consists of facts or data that have been assembled or encoded in a form easily understood by those familiar with the context. The definition has been taken to an extreme within electronic network parlance, where information is anything that can be digitized.

For the purposes of this essay, it may be most relevant to think of development in terms of access to and processing of knowledge. In this vein, the World Bank has

devised a two-pronged definition of knowledge associated with two key development challenges:

a. *Knowledge about technology* also called technical knowledge or simply know-how. Examples include nutrition, birth control, software engineering and accounting. Typically, developing countries have less of this know-how than industrial countries, and the poor have less than the wealthy. These unequal distributions across and within countries are referred to as *knowledge gaps*.

b. *Knowledge about attributes,* such as the quality of a product, the diligence of a worker or the credit-worthiness of a firm, which is crucial for effective markets. The difficulties posed by incomplete knowledge of attributes are "information problems." Mechanisms to alleviate information problems, such as product standards, training certificates and credit reports, are fewer and weaker in developing countries. Information problems and the resulting market failures especially hurt the poor.[4]

I would like to emphasize, along with the World Bank's *1998/99 World Development Report,* that "…it is the lack of knowledge that causes markets to collapse, or never come into being. When some producers began diluting milk in India, consumers could not determine its quality before buying it. Without that knowledge, the overall quality of milk fell. Producers who did not dilute their milk were put at a disadvantage, and consumers suffered."[5]

Finally, a definition of small economies: In this essay, they are referred to as countries with populations between 2 and 10 million, and a GDP per capita of US $1,000 to $4,000 per year. They display seriously high transaction costs in identifying, creating, adapting and diffusing knowledge, mixed with a widespread ignorance of the content and potential benefits of technology policy. These factors combine to reduce options for competing in global markets. While economies of scale are now possible in small economies, in principle – due to technology in the advanced economies that could allow international networking, outsourcing and partnering – it is no easy task to actually bring these technologies to the attention of policy makers and businesses, determine their costs and benefits, and decide to transfer them.

[4] World Bank, 1999. *1998/1999 World Development Report: Knowledge for Development*. Washington, DC.
[5] Ibid, p.1.

III. UNDERSTANDING THE ISSUES

A. Issue one

1. Insufficient knowledge-based (i.e., S&T-based) innovations to support rapid economic growth.

To say that knowledge, technology and science are important to economic growth raises no eyebrows. After all, Adam Smith's emphasis on the specialization of labor was, from today's vantage point, a call to improve production technologies. Later, Joseph Schumpeter made a strong mark in the economics profession with his theory of innovation (creative destruction, as he called it) as essential to growth. Robert Solow then won a Nobel Prize partly by shedding light on the significant role of the unexplained residual when accounting for observed factor contributions to production (mostly explained in terms of improved technology). Recently, Paul Romer has highlighted ideas and knowledge as endogenous determinants of national economic growth.

A particularly influential argument is associated with the ‘‘Hecksher-Ohlin” theory of international trade. It supports a widely held position: If cutting-edge technical and organizational knowledge is available to any country that wants to purchase it, and if countries consider this knowledge a public good, as they should, their governments can introduce “correct” policies to make the knowledge accessible to economic agents. With correct policies in place, technology would eventually become the same in all countries.

The application of such theories to smaller, poorer nations, however, has been rather difficult, often leading to conclusions about the irrelevance of free markets for developing countries. Many nations, including those in Central America, have sometimes jumped to extremes, wholeheartedly embracing import substitution or outward orientation policies. The first approach required holding off on essential elements of the free market while infant industries developed. The second approach, particularly in its Washington Consensus form, went to the opposite extreme of accelerating the introduction of free, open market flexibilities without establishing an adequate learning environment first. In many cases, these strategies did not yield desired results and actually produced retrogression in certain sectors.

Despite the blatant failure of alternative economic systems tried in socialist countries, Central Americans still hotly debate policies involving free market type solutions. As indeed, they should: Witness the plethora of misguided policy advice that Joseph Stiglitz[6] has brought to their attention, and that may account, at least partly, for their failure to attain sustainable growth. There are well-known and important restrictions related to entering certain local and international markets, as well as other conditions for competition that have not quite been met. Little has been done to counterbalance both the

[6] Joseph Stiglitz, 2002. *Globalization and Its Discontents*. New York: W.W. Norton & Co.

government and the market failures with public goods and instruments less prone to contamination from vested interests and rent seeking.

This is not an indictment or a defense of either inward or outward orientation policies. When properly mixed and implemented by disciplined government interventions, these policies can be effective. Recall, for instance, the performance of Japan and some of the highly productive East Asian economies such as Korea and Taiwan, whose governments protected import substitutes, picked and protected some key new industries, targeted credit to them, imposed floors and ceilings on bank interest rates, and provided substantial investments to applied research, among many other strategies.[7]

The crucial missing element in the Latin American experience has been negligence in realizing and accepting learning and knowledge accumulation as essential components of any effort to restructure an economy. Studies have pointed out that "Firms do not move along a well-established isoquant as the capital-labor ratio rises. They must find their way by developing and applying new knowledge that enables the full exploitation of the new resources."[8]

In East Asia, the orientation on non-traditional exports became not only a major source of earnings and a source of new technical knowledge, but also a fundamental building block of a structure to learn, in a sustainable manner, how to adapt and manipulate foreign technologies. Local institutional and historical evolution (path dependence) allowed governments to partner closely with the private sector and impose a discipline of excellence and achievement, comparable to what competition imposes in free market economies. These governments had the disposition and capacity to learn from mistakes and successes, correct misguided policies and foster best practices. Thus, to facilitate progress in manufacturing, for example, the governments of South Korea, Taiwan and Singapore promoted close cooperation between foreign and local firms. As Michael Hobday explains, "TNCs (transnational corporations) and local East Asian firms engaged in a painstaking and cumulative process of technological learning: a hard slog, rather than a leapfrog."[9]

In Central America, the issue is whether countries can follow such paths given their very weak institutions. Manuel Agosin, Roberto Machado and Paulina Nazal have extensively documented as well the specific barriers of faulty legal systems and corruption. Strategies that depend on strong institutions must be carefully reconsidered as options here.[10] The free market in particular encounters difficulties in being introduced in the region, even as

[7] The financial crisis of the late 1990s showed that the system eventually encouraged cronyism among the most powerful industrial conglomerates, which in turn gave rise to serious flaws in the financial architecture. But this took place at a later stage of development.

[8] Henry Bruton. "A Reconsideration of Import Substitution," *Journal of Economic Literature*, Vol XXXVI, June 1998, p. 930, footnote.

[9] Ibid, p. 930.

[10] See M. Agosin et. al., 2002, for an ample discussion of the institutional set up in Central America. "Las Economias de los Paises Centroamericanos y Republica Dominicana," Serie de Estudios Economicos y Sectorales, Inter-American Development Bank, Region II.

it is considered a desirable option because of its long history of yielding superior and sustained economic successes in Western economies.

William Baumol[11] notes that in its simplest form, a free market economy can be thought of as a machine whose primary product is economic growth. Not that it is the only machine available for such purposes, but it is the most effective one. The incredible growth experienced by truly free market systems can be explained by built-in incentives that require agents to innovate frequently in order to compete and ultimately survive. Mechanisms have been devised to spur the spread of innovations and fulfill the subsequent demands for new technologies. Furthermore, "the extraordinary growth record is not fortuitous. Once capitalism (is) in place and fully operational, a flow of innovation and the consequent rise in productivity and per capita gross domestic product (are) to be expected."[12]

The following table contrasts the salient features of the free market against those typically present in the Central American developing economies:

Table 2: Comparing markets

Essentials of a free market	An advanced free market	A defective free market (common in Central America)
Main enabling condition: Democratic political system and rule of law	There is a solid democratic political structure and a strong property rights system. Enforceability of contracts and immunity of property from arbitrary expropriation is a pervasive characteristic.	Democracy is weak, political representation is not clear, and the agent/client relationship is largely absent. Property rights are very poorly assigned, and usually subject to protracted legal debates – frequently with corruption overtones.
Innovation	Mandatory for survival.	Fortuitous or optional due to many decades of protectionism and rent seeking, which allows the elite easier income.
Financing of innovations and R&D	Financial markets are mature. Prudential regulations provide trust in equity markets. Risk capital, e.g. venture capital, is one of the pillars of innovative activities. R&D spending gets a large contribution from direct private investment within in-house facilities or through contracting R&D institutions.	Financial markets are rather risk averse, requiring larger collateral, which is a barrier for smaller firms requiring significant innovations. Equity markets are geared to large investors, who meet and exchange important information in restricted, often privileged locations. Availability of credit or lending for technological innovations in small enterprises is next to nil. National R&D spending is negligible.
Diffusion of technologies	Fast (aided by licensing agreements). Trade promotes technology diffusion and creates a virtuous circle of demand and supply for new and better technologies in a two-way fashion, where both importers and	Very slow paced, often requiring decades. Trade is much more strongly tied to social networks, which are more common where there are ties of nationality and language. Thus, despite information and telecom

[11] Baumol, 2002.
[12] Ibid.

Essentials of a free market	An advanced free market	A defective free market (common in Central America)
	exporters of goods and services are demanders and suppliers of technologies.	technologies, the "borderless" is less accessible. Furthermore, legal labor mobility (passports or legal permits), both within Central America and extra regionally are excessively costly.
Labor in the information sector	60% of the labor force is engaged in the knowledge sector. For example, a substantial percentage of the economically active US population is at least peripherally engaged in running the growth machine.[13]	5%, at most, of the labor force is engaged in the knowledge sector.
Level of competition	Strong competitive pressures compel firms toward unrelenting investment in innovation, and provide incentives for the rapid dissemination and exchange of improved technology throughout the economy.	Weak competitive pressures (slowly coming out of a protracted noncompetitive period characterized by protectionism and rent seeking).
Level of cooperation	Once legal rules and rights are established, there is substantial cooperation to follow and enforce the law, ensuring protection from corruption and crime. This leads to overall systemic coherence and economic progress. Furthermore, clusters of firms within a particular value chain normally come together (or merge even) to exploit complementarities.	Rules of the game (economic) are not well known or are debatable. Cooperation is significant but lower than in Western free markets. Corruption, ways to "beat the system," and private and government cronyism abound. Note also that cooperative arrangements such as networks, clusters or communities of interest do not emerge spontaneously or easily (not when you are more likely to seek and get rents than profit by productive activities).
Oligopolistic competition	Large, high-tech firms use innovation as a prime competitive weapon, ensuring continued innovations and their growth. (Very frequently, innovation replaces price as a market signal.)	Large, low-tech firms are normally protected from competition using infant industry or regional integration arguments (however low tariffs are now, the effect is not sufficiently strong yet). There are few incentives for innovation.
Routinization	Innovative activities are regular and ordinary. 70% of US R&D spending now comes from private industry.	Innovative activities are rare. Routines are unlikely to develop because technical services and laboratories are largely absent or obsolete, researchers are hard to find, and their reliability is often questionable. Therefore, transaction costs to incorporate innovations are very high.
Productive entrepreneurship	Plenty of incentives for entrepreneurs to devote themselves to productive innovation rather than to innovative rent seeking (the unproductive pursuit of economic profits	Plenty of incentives for "clientelism," protectionism and rent seeking. Slowly changing as globalization forces economic liberalization.

[13] The knowledge sector includes the processing, recording, analysis and dissemination of information that economic agents require for productive or analytical processes. It also encompasses the training of those who will carry out the nation´s R&D in the future. Of course, much of the activity of the knowledge sector has little connection with growth, but it is implausible that its growth-supporting work constitutes a negligible share of the total. Thus, whereas the core activity of the growth machine (R&D) is hardly enormous in size (about 2.6% of GDP in 1998, and growing slowly at 1.4% per year over the past 45 years, 1953-1998), a very substantial part of the US population that is economically active outside the household is at least peripherally engaged in running the machine.

Essentials of a free market	An advanced free market	A defective free market (common in Central America)
	such as interbusiness lawsuits).	
Technology selling and trading	Firms voluntarily pursue opportunities for profitable dissemination of innovations and rental of the right to use them, via licensing, even to direct competitors.	Opportunities for innovations compete with rent seeking. Information about appropriate technology, the hardware-software prerequisites, and maintenance and technical support is hardly available.

Advanced capitalist economies display dynamic efficiency, i.e., efficiency in the growth process. In terms of technology diffusion, there is a common belief that these economies limit diffusion through patenting laws or other devises to perpetuate monopolies. But this is not consistent with the evidence of their unrivaled speed of growth, despite imperfections in their applications. Instead of reducing or restricting innovative activity, with benefits accruing only to the inventor, these economies offer incentives for spillovers that pass on technological innovations.

Depending on relative prices, it is often more profitable for the monopoly owner of an innovation to specialize in the business of renting the input to others, rather than using it as an input to its own final product. Many firms do not fight to keep innovation technology to themselves, and some actively promote it as a profitable business. Such dissemination helps to spread the use of the latest techniques and production of the newest goods and services. It speeds the elimination of obsolete economic activities, while the financial rewards help to internalize the externalities of the innovation process.[14]

One can learn some of these lessons from studying the cooperation role played by technological consortia in advanced nations. The benefits of sharing offer clear gains, with firms acquiring a competitive edge over those depending only on their own R&D investment resources. Moreover, membership in a technology consortium reduces risk and fosters investments in innovative activity. (See box 1 below).

[14] Let me clarify, with Baumol, the contribution of other inputs to the growth process, lest there be a perception that we are exaggerating the role of innovation. These include human capital (education, training etc.) and investment in plants and equipment. Note here that with the very limited resources available to the extremely impoverished societies of earlier centuries, there was little possibility of diversion of any substantial quantity of resources to either of these types of investment. In our times, human and physical capital investment took great steps in the Soviet Union without that country obtaining the spectacular growth of the West. "For the bulk of the population of earlier periods of history, bare survival was the critical problem, and it left only minimal resources for investment in education and productive capacity. Only the productive surpluses that innovation began to make possible, first in agriculture and mining and then in manufacturing, made feasible the enormous increases in investment in inanimate and human capital that are widely judged to have contributed greatly to economic growth" (Baumol, 2002).

Box 1: Cooperation and competition in the R&D race for finding a cure for cystic fibrosis

Cystic fibrosis (CF) is a fatal genetic disease that clogs the lungs and other organs with viscous mucus that interferes with breathing and digestion. It is a common illness that has escaped medical treatment for decades. Even with the development of better DNA research tools, scientists have spent long hours hunting for the combination of multiple gene mutations responsible for the disease – without much success.

Working alone, individual researchers around the world were taking years to analyze hundreds of DNA fragments. Then Lap-Chee Tsui of Toronto´s Hospital for Sick Children (who had earlier discovered, along with other colleagues, the errant gene responsible for CF) noticed a short report in an international journal describing a possible link between CF and one of the markers (recognizable variations in DNA) they had identified. The research group noted that they needed more families (specimens) to confirm their link. Tsui called them up and offered them his families. A link was later established with the help of the larger family set.

Tsui then wrote a report that attracted the interest of Collaborative Research, Inc., a biotechnology firm in Massachusetts. The company offered Tsui a deal: It would provide him with probes for some 200 additional markers that its researchers had developed, if Tsui would provide samples of DNA from the white blood cells of his CF families. Tsui accepted, and within three weeks, he found a definite link between one of the new markers and the patient´s DNA. Soon afterwards, Collaborative Research mapped this marker to one specific chromosome. It was a key finding. There were other findings that subsequently simplified the search, as now researchers had a place to start.

Finding the gene was still a long way off, however. Seven independent teams had been racing to discover it. Now they saw that none of them could do so large a study alone. At a meeting in Toronto, they decided to pool their families (211 in all), their probes and their data. It was a lucky but very wise move, because key findings soon followed. Yet the distance the researchers still needed to walk toward the gene was huge.

At this point, imagination and ingenuity were the way forward, and the need for collaboration waned. The higher rewards for individuals acting alone and the lower costs of doing research prompted the groups to stop collaborating. The seven research groups scrambled to be the first to discover the CF gene. And the gene was found.

Many technical hurdles remain before a surefire treatment is developed. But it is clear that financing for the development of such a treatment is best done privately through the competition of pharmaceutical firms, as the profits from patents would provide the incentives to get it done faster and cheaper than through public, collaborative funding. At the same time, without the collaboration and cooperation that preceded any thought of individualism, competition would not have had a chance.

Howard Hughes Medical Institute, 1999. "Exploring the Biomedical Revolutuion." Baltimore: Johns Hopkins University Press.

2. Development implications for Central America

What does all of the above have to do with science and technology in Central America? In the context of globalization, we define technology not just broadly as a method to get a task, product or service done, but in terms of its potential to dictate productivity and competitiveness. In terms of Central American economies: The inability to link up to cutting-edge technology reduces the chances for economic growth (see the table 4).

Opportunities to increase local technological innovations, adapt foreign technologies, facilitate technology transfers and undertake pertinent R&D projects depend on the macro and microeconomic signals and incentives, but also on the local S&T infrastructure, the labor force profile, and the capacity for international networking with

other firms and research centers. In Brazil, Claudio de Moura Castro and Helio Barros[15] have noted the presence of certain specific elements, such as geographically close R&D centers and a good educational base.

In Central America, two critical obstacles stand in the way for individuals attempting to rise out of situations defined by low capabilities, opportunities and incomes. First, his or her knowledge about good practices, including about technologies and attributes, is fuzzy at best. Information about where opportunities lie, the skills required, and the types and sizes of transaction costs involved in searching and/or operating within the law are insufficient to make successful decisions. Secondly, legal systems are too poorly organized for people to transform endowments (untitled land or commercial values that are difficult to assess) into valuable market assets, thus leveraging the significant investments needed for the move to a higher standard of living.

For many Central American countries, the flexibility that characterizes advanced free market economies is absent, particularly for the significant percentage of people living in poverty. In turn, they are unable to achieve the level of economic power necessary to demand a significant reallocation of resources backing policies that lift barriers to their development. Furthermore, the lack of links (the typical dual character of the economies and segmented markets) between the economies of the poor and the economies of the more advanced sectors within the same country results in ends and means that do not readily adjust to changing constraints and opportunities in the global economy. The serious weaknesses in socioeconomic institutions mean they can do little to correct matters, while many potential actions are doomed simply by the government's inflexibility or excessively slow response in adapting policies for changing conditions or diffusing knowledge that could benefit the poor.

In contrast to the larger, better-endowed developing countries, or the industrialized economies, the movement of resources among alternative uses in smaller countries produces greater friction, is more costly and proceeds much more slowly. Such economies do not permit the frequent changing of factor proportions, technologies and composition of output that would be necessary for a strong "innovation machine" to emerge and boost growth. Instead, what can be observed on the demand side, for instance, is low responsiveness among purchasers to changing relative prices, and great comparative difficulties of substitution in the disposition of income between consumption and saving. These circumstances have serious ramifications for vulnerable groups, since the low response speed and the high costs that must be incurred to achieve a given adjustment discourage the sort of actions needed to lift people out of poverty (more on this discussion under issue two below).

To complicate matters, it seems that the potential for increased international integration faces obstacles in the form of cultural and historical attitudes. Recent trade literature points out that even countries that have entered into far-reaching trade agreements

[15] Claudio de Moura Castro and Helio Barros. "O Ambiente da Inovacao e o Sucesso Pela Tecnologia: Algunos Casos Ilustrativos," IDB Governors Meeting, Fortaleza, Brazil, March 2002.

recognize that trading within national or regional borders still remains a major determinant of higher volumes of economic exchange.[16]

With these issues in mind, one can argue the need for new knowledge-enhanced actions and policies that will encourage greater economic flexibility. These could include some of the following: First, adequate and timely information and data on changes in economic conditions must be accessible for the economy to identify where it needs to change or adapt. The speed of dissemination of information and its characteristics (such as being available to the poor) have to allow timely responses. Second, there must be widespread knowledge of the implications of such new conditions, and of ways to bring about changes. Of particular importance here is the presence of an incentive system to guide agents toward the national goals – both competing where it makes sense and cooperating to create rules and institutions that promote a good national business environment. Access to timely advice and technical assistance is crucial, so that agents and enterprises can understand the costs and benefits of changes in their investment plans and make well-informed decisions. Thirdly, national institutions must be strong and prepared for the eventual emergence of an innovation machine.

At the same time, serious research has to be conducted on the desirability of new and enlightened forms of government intervention in strategic areas, which perhaps should be defined by national consensus. Clearly, the markets in smaller Central American countries are characterized by rigidities that will not be automatically corrected by the market because the vicious cycle they engender prohibits their own removal. Knowing that governments can intervene in ways that add further impediments to markets, we should be able to learn from our mistakes and design better models. It is a touchy topic, but a strategic intervention that does not seriously disrupt the smooth operation of markets, and instead helps identify and diffuse knowledge, for instance, could be quite beneficial. The lessons of the successful Asian countries in strategic interventions need to be further and more deeply debated.

3. Adequate knowledge, timely dissemination, strong national institutions

In his very interesting article "A Reconsideration of Import Substitution,"[17] Henry Bruton reaches an important and pertinent conclusion: He contends that the primary sources of development are learning and knowledge accumulation. Indeed, despite heroic attempts, the restructuring of economies to increase productivity through producing former imports has given rise to monumental, unforeseen problems. And the transfer of technological, administrative and marketing knowledge has proven to be much more complicated than was expected in the early 1950s. Empirical evidence has increasingly shown that "indigenous learning processes generally were not emerging in the import substituting countries. The (implicit) assumption that simply changing the structure of an economy

[16] R. Feenstra, 1998. "Integration of Trade and Disintegration of Production in the Global Economy." *Journal of Economic Perspectives*, 12:4, pp. 31-50. J. Helliwell, 1998. *How Much Do National Borders Matter*. Washington, DC: Brookings Press.

[17] *Journal of Economic Literature*, Vol. XXXVI (June 1998), pp. 903-936.

would also change its capacity to learn and to accumulate knowledge was evidently incorrect. The task was much more complex.[18]

It is close to impossible to get to the heart of the difficulties involved in economic restructuring without devising a workable, country-specific mechanism to facilitate massive and timely dissemination of knowledge about technologies and attributes. Otherwise, macroeconomic policies and micro incentives will continue to hit decreasing returns too early in the game, failing to inspire the widespread changes that can sustain productivity increases and poverty reduction over the long term. When changes in globalized markets occur (e.g., the lifting or imposing of an influential import quota), for example, new investment opportunities may emerge for a given country to transform a potential comparative advantage into a real one. However, given the rigidities that beset small economy markets, and the high transaction costs of acquiring knowledge and timely information, the national response may not be up to the task and the opportunity may be squandered.

An important condition for avoiding this kind of pitfall is having a set of complementary institutions that promote public goods, such as reducing the transaction costs of acquiring knowledge and information, which in turn reduces transformation (production) costs. Yet it is well known that socially efficient institutions do not just erupt like lava from volcanoes. Instead, institutions are typically created to serve the interests of those with the bargaining power to lobby for new rules and practices. They often limit the freedom that poorer communities have to develop. While the question of the need for and type of collective action is very large, at the very least, mechanisms should be set up to allow prompt consultation among stakeholders affected or potentially benefiting from new institutional arrangements. By facilitating or barring access to pertinent information, institutions are key determinants of the real choices available to citizens and economic agents, including in terms of affordability.

Let me quote a relevant passage from Douglas North's *Institutions, Institutional Change and Economic Performance* (recalling that North defines institutions as the rules of the game in a society, or, more formally, the humanly devised constraints that shape human interaction): "Conceptually, what must be clearly differentiated are the rules from the players. The purpose of the rules is to define the way the game is played. But the objective of the team within that set of rules is to win the game – by a combination of skills, strategy, and coordination; by fair means and sometimes foul means."[19] We tend to

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[18] Jeffry Sachs puts the technology transfer problem another way: "If technologies easily crossed the ecological divide (the poor and the rich live in different ecological regions of the world), the implications would be less dramatic than they are. Some technologies, certainly those involving the computer and other ways of managing information, do indeed cross over, and give great hopes of spurring technological capacity in the poorest countries. Others – especially in the life sciences but also in the use of energy, building techniques, new materials and the like – are prone to 'ecological specificity'. The result is a profound imbalance in the global production of knowledge: probably the most powerful engine of divergence in global well-being between the rich and the poor." In "Helping the World's Poorest," http:/www.cid.Harvard.edu/cidinthenews/articles/sf9108.html.

[19] Douglas C. North, 1990. *Institutions, Institutional Chance and Economic Performance.* New York: Cambridge University Press.

confuse the rules and the players when we insist exclusively on competition without properly analyzing and providing for effective enabling conditions.

It is clear that competition alone in many developing countries has not succeeded in weeding out "inferior" organizations. The ethical value system and institutions are indifferent or ambivalent about the presence and, frequently, preponderance of organizations that are, as North writes, "…more efficient at making society even more unproductive and the basic institutional structure even less conducive to productive activity."[20]

It is also often true that without the cooperation of rulers and powerful interests, a country will not be able to establish, for example, the property rights needed for the poor to participate in markets – and, obviously, neither would it establish the judicial courts to enforce such rights. Thus, a system of inefficient property rights ensues that thwarts economic growth. Clusters of small businesses cannot emerge to pool their efforts and investments, seeking higher levels of productivity and quality. Nor can there be an affordable mentoring system that prods less educated or trained individuals to find better opportunities.

National institutions in Central America, to a greater or lesser extent, are ill-prepared for massive diffusion of knowledge and erection of a robust national innovation system. Such systems require a multifaceted and coordinated approach involving many actors (government authorities, engineers, business entrepreneurs, scientists, educators, university professors and administrators, laboratory professionals, etc.). In Central America, the vested agendas of these actors currently are not well coordinated. Frequently, they are antagonistic.

In my S&T missions in the region, I have found consistently, in one way or another, small groups of private, public and academic professionals with great eagerness to use scientific and technological knowledge. They are not large enough in number, however, to create sufficient public awareness or pressure to bring about needed policy changes. Normally, they also cannot articulate a vision that might capture the imagination of decision makers and their constituencies, or stimulate entrepreneurs into major investments – particularly smaller entrepreneurs.

Along with meager institutional support, typical constraints in many countries include poor understanding of how to effectively disseminate knowledge widely, and of what is involved in terms of opportunity costs, investment plans and/or required national capabilities. In addition, the many decades of economic rent seeking – both under import substitution and export promotion regimes that created particular niches – nurtured a private sector averse to innovation.

Perhaps even more important to note are the ample scarcities of proactive attitudinal mindsets among economic agents; exemplary reference groups to imitate or follow; nurturing or technical support institutions; and other firms, either complementary or

[20] Ibid, p. 9.

competitive, that both demand and facilitate decisions on technological changes in successful knowledge-enhanced economies.

What are the telltale signs of low market receptiveness to technological innovations? I speculate that there are at least five: (a) the scarcity of risk capital (i.e., funding akin to venture capital); (b) the absence of complementary technological services, such as appropriately equipped and run laboratories; (c) the disregard and frequent mockery surrounding creative technological ideas that serve a pressing human or organizational need (the kind of creativity associated with successful innovation starts as a rather schizophrenic combination of rationality and insanity that is outside ordinary experience); (d) the tendency, as a result of this disregard, for people to become good at simply extending the logic of existing ideas and technologies, using only the technical experience and the academic knowledge in their heads (most people can never reach truly innovative ideas, because thinking within the box will never allow it);[21] and (e) the lack of entrepreneurial passion for creativity, partly because it is easier to devise innovative ways to pursue economic rent, protection or unfair competition.

As these considerations are more sociological and psychological in nature, they have received insufficient attention from economic theorists. What we know is sketchy and anecdotal. The sociology of entrepreneurial innovation needs to be researched more adequately in every country, and some form of assessment devised. There are some organizational obstacles at institutions like the IDB, however. First, the sort of surveys, focus group approaches and Delphi methods that can be used to measure the effectiveness of interventions are not always deemed objective, in the normal way the Bank uses the term. As such, one would be hard pressed to make a case for the importance of investing in developing these sociological profiles. Yet there is a need for some intermediate scheme that ventures beyond subjectivity without having to be bound by traditional hardcore indicators. Much more research and discussion is needed to make further recommendations.

Despite all the negative aspects that institutions display in Central America, there are sparks of change, due largely to ongoing dialogue with international donor agencies. I contend that sustainable solutions are likely to revolve around knowledge-enhanced niches, in which advanced economies can outsource goods and services, say, from Honduras. Consequently, Honduras would be able to participate more fully in the global economy, and without having to make unaffordable investments in technologies or infrastructure.

4. Panama: A case history

To illustrate what has been presented so far, I turn to Panama, where the Bank has the longest experience with the new generation of S&T projects. The first project in Panama

[21] There is research asserting that most crazy ideas fail to make it in the market. Yet, it is also known that successful innovators submit the crazy thought to rational scrutiny to allow the potential merits, if any, to emerge. If the merits justify further market probing and investment, a successful innovation appears.

was approved in 1998, and implementation started in earnest in late 1999 with the installation of a new government.

The National Secretariat for Science, Technology and Innovation (SENACYT) was upgraded to a near-ministerial level in 1997, when the government pursued external resources to complement the meager national budget appropriations allocated to the secretariat. The Bank was approached about a lending program for S&T in 1996.

As the Panamanian request for a program started with a strong objective to expand research rather than enterprise productivity, it was not easy for the Bank to agree initially on the need to include smaller enterprises or topics generally not associated with hard sciences. The SENACYT board included large and powerful members of the academic and private sectors, who displayed little concern for the technological needs of smaller enterprises or the poor, neither of whom were represented on the board. The agenda for research as a supply item was adequate to the extent that it concentrated on areas with an existing track record, but it bore no clearly stated links to the demand side. The idea seemed to be: Build and they will come!

In pursuing the small and medium enterprises as beneficiaries, the project faced a market failure: Banks in Panama were not known as risk takers in general, but even those oriented toward SMEs shunned technological projects. Venture capital was out of the question in 1997. Neither was there any hope for developing "angel investors." Panama was known as an international service provider that had successfully imported turn-key technology in critical areas (such as the Panama Canal, banking and oil pipelines). Why should Panamanians bother about technological innovations, and particularly why bother about the SMEs?

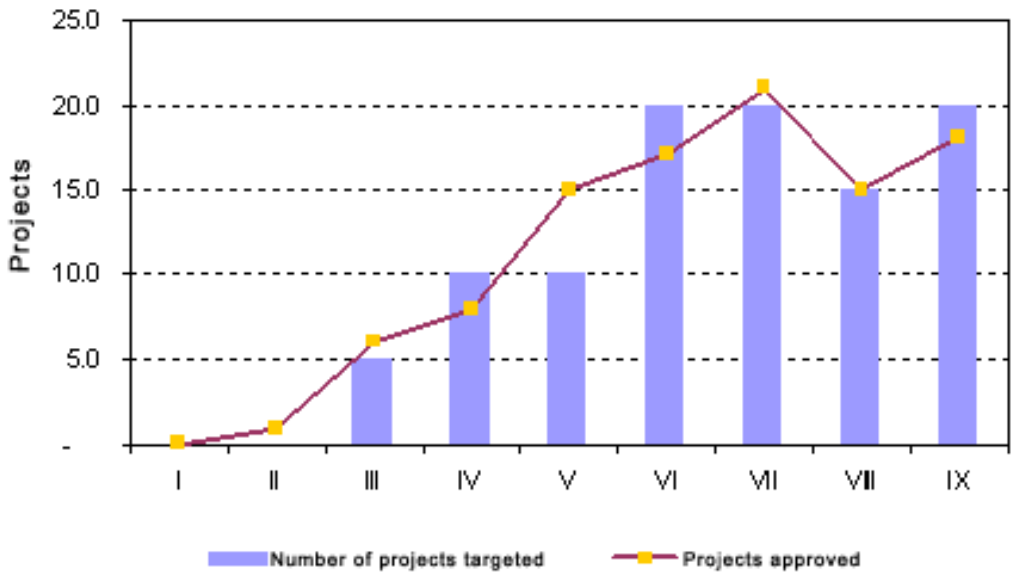
Nonetheless, there were interesting and promising results in production-related research topics such as bio-prospecting, aqua-culture and communications technology. And the persistence of SENACYT aligned with emerging government decisions about opening up the economy. What had been a not-so-fluid dialogue with the Bank – it was not even clear how the research program would enhance higher education, let alone support economic productivity – suddenly took on a new momentum as the Ministry of Planning gave high priority to a proposal that would pair a technological modernization fund with a matching grant scheme to support SMEs needing technological reconversion due to the lowering of import tariffs. Support was to come as funding that could alleviate the scarcity of risk capital.

The Bank agreed to back the Technology Modernization Fund (FOMOTEC), which started operations in 2000. Its management was outsourced to a credible business consulting firm. Some initial problems were encountered. While strict rules for technological innovations were strongly emphasized at first, for example, these had to be relaxed after complaints from the SMEs. The new SENACYT authorities who came into office in 2000 also rejected some originally eligible funding activities such as technological tours – which had been particularly successful for obtaining ideas and technical know-how in other developing countries such as Chile. SENACYT´s argument was that this kind of funding would be misused and yield no benefits. Additionally, a

number of adjustments had to be made in the operational manual to allow the private administrator of the fund to work smoothly.

With these issues sorted out, the Fund has been successful in two important respects. First, it has facilitated and accelerated technology-related investments that would have been postponed for a few years or might never had taken place. Second, it has initiated a new atmosphere and activities whereby engineers, technology experts and entrepreneurs have begun learning about the routines associated with introducing new technology – even if it is not strictly innovative (very few required any concern about patenting or property rights).

Graph 1
Projects and Targets



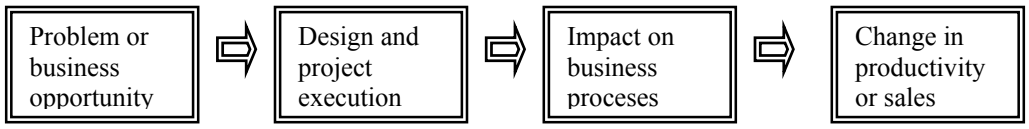
Graph 1 shows that the number of approved projects is close to targets that were previously set (I will refer to effectiveness later).[22] From that standpoint, one can say that market demand and supply gaps have been closing.

Operationally, FOMOTEC takes the following approach to assessing projects: (a) an SME identifies a problem or an opportunity for improvement using new technologies; (b) the SME presents a business plan and requests funding from FOMOTEC; (c) if the project is approved, a contract is signed specifying the activities (technical support, training, minor acquisition of equipment and inputs related to testing the new technology), as well as the expected impact on the business' operation (design, production, quality assurance, organization or administration) and bottom line (sales,

[22] Pablo Angelelli. "Fondo para la Modernización Tecnológica Programa de Apoyo a la Competitividad de los Sectores Productivos," Evaluación Intermedia, October 2001. Inter-American Development Bank.

lower costs, productivity, increased market participation). Figure 1 summarizes the sequence.

Figure 1



Surveys subsequently showed that business people have been highly motivated to reach the results agreed with FOMOTEC. In many cases, the SMEs have contributed more of their own resources than specified under the contract. A routine for technological innovation has developed in Panama to the point of having FOMOTEC move to the City of Knowledge, where a technology park, business incubators, and other technical and academic support come together in one facility.

As expected, distribution by business objective was fairly balanced. Of the 19 projects sampled in the surveys, 14 had an innovative impact on a product, 10 on services and two on organizational effectiveness. It is important to note that about 50% of the product innovations reflected a market innovation, that is, the introduction of an improvement or new product that could be imitated by other firms, with the potential for widening the market and deepening competition.[23]

The case for justifying the Panamanian government's subsidies to the SMEs had been made in terms of it filling a market failure for funding technological innovations, which was due to fear of technological risks among commercial banks. Thus, it came as somewhat of a surprise that the evaluation of the implementation of FOMOTEC found that most projects reflected a low risk: 15 of the 19 projects surveyed presented a low risk in relation to the technology sought, three showed a moderate risk, and only one displayed a high risk.

However, this is a good result for an up-and-coming new fund in a small economy without much experience in technological innovations. An evaluation of Chile's FONTEC (Fondo Nacional de Tecnología) – a much more advanced fund in a much more advanced developing economy – showed that very little of the financing was channeled toward state-of-the-art technologies. Only one or two out of the 35 projects surveyed from Chile's FONTEC could be referred to as major or revolutionary innovations. The bias toward low degrees of technological innovation is understood as part and parcel of learning by doing, in this case by the SMEs. As such, the "routinization" that develops is a greater benefit than higher levels of technologies, especially given development paths

[23] Pable Angelelli and Nicolo Gligo, 2002. "Apoyo a la innovación tecnológica en América Central: La experiencia del Fondo para la Modernización Tecnológica y Empresarial de Panamá. Informe de Trabajo del Banco InterAmericano de Desarrollo." A technical paper for the Inter-American Development Bank.

characterized by lack of or infrequent experiences with national objectives for technological change.[24]

It is interesting to note that straight technology transfer from outside the country was the main instrument used to innovate in four of the 19 cases surveyed in Panama. Many economists consider technology transfers non-innovation items. Strictly speaking they are right. Yet Panama, or any country, is fully justified in considering these transfers a major contribution to capacity building in S&T, to the extent that a technological adaptation was required to bring a new product or service to the market. In other words, a process akin to innovation took place within the walls of the enterprise, since the enterprise learned a new knowledge-based routine to pursue higher productivity. In eight projects from the surveys, the transfer was accomplished through the identification and proper use of international consultants. Only four projects dedicated significant resources to research and development – of which one possessed a high technology risk.

There is another important risk, and that is the one associated with fragile institutions. In Panama, fiscal policy, for instance, has changed frequently, which can have a serious impact on a new product or service. This institutional risk is difficult to assess and is normally mixed into calculations of commercial risk. To the extent that there is a fragile rule of law and no guarantees that property rights will be seriously upheld, and mechanisms for licensing an innovation are primitive and unfamiliar, the end result is that only projects with low commercial risk are undertaken. That is why the evaluation of FOMOTEC showed that most projects funded did not need a pilot phase or a focus group marketing analysis. Most had a clear impact on production and the market, or at any rate one that could be easily or intuitively estimated.[25]

SENACYT has also provided investment to promote research in some key R&D areas, as well as in needed metrology equipment. For that purpose, financing went particularly to bio-prospecting and marine resources, ecotourism, electronic commerce and basic science. The doors of the laboratories are just opening, so it is hard to assess how valuable these items will be for the national innovation system. In addition, SENACYT, in making decisions on such procurements, has become detached from the S&T establishment and some key stakeholders. This has created alienation and weakened the cohesiveness of the system. For their part, private sector associations have neglected to see the many activities that SENACYT is carrying out. There remains a lack of communication on SENACYT's side, along with the private sector´s own reluctance to ask questions and demand answers from the secretariat.

Generally, in contrast to more advanced free market economies, the private sector in Panama is very cautious about new technological opportunities. Perhaps enterprises do not readily see or do not have adequate knowledge of the benefits of research and laboratory services. Recently, for example, some very modern lab equipment installed for

[24] Ibid. p. 19.
[25] Ibid. p. 20.

forensic analysis of DNA that was much wanted by police investigators has failed to make any headlines in the media.

Even in popularly acclaimed projects, such as accelerating the expansion of e-commerce for SMEs, where the private sector associations have shown ample interest, it has taken over two years to coordinate all the key players in the private sector associations and to come up with counterpart funding to secure Bank financing, even with the stimulus of the Bank's grant money. Despite many meetings and proposals from business leaders, Panamanian stakeholders wanted a surefire project, where none could be had. The piloting of e-commerce initiatives and institutional strengthening were at times difficult to sell, and the idea of investing your own money to learn was not easily accepted.

While the conditions necessary to create a free market and the associated innovation machine are not there yet in Panama, the Bank projects have helped considerably. The concern about taking a horse to water, but being unable to force it to drink weighs heavy. Of course, the horse has to be thirsty, and it has to be able to easily understand that the water will quench its thirst. The question that remains is whether the Bank's approach is the most efficient method for introducing the required knowledge.

In terms of the evolution of a national system of innovation as a whole, one can only say that while there is significant progress, the system needs serious support both from the major stakeholders and from the government. The potential for growth has not yet been achieved, and while the piecemeal, isolated advances are not negligible, they stop short of any leapfrogging event. There remains a need to more effectively pursue the goals of reducing transaction costs and improve the efficiencies and synergies that derive from a market-coordinated exchange. As well, macroeconomic policy makers need to be more informed about how knowledge diffusion is taking place so as to provide incentives and encourage the right initiatives and/or corrections.

Yet there is also enough evidence to maintain that the investments and interactions that the Bank-supported interventions have allowed, while small and dispersed, are sufficiently significant to serve as foundations for further development. Let us not forget that technological innovation as a major national system for achieving economic growth is at its earliest infancy.

B. Issue 2:

1. Meager investments made in technologies enhancing communications, and the opportunities and capabilities of poorer communities and individuals.

By and large, we are all in agreement that technologies (communications, health, education, production, etc.) can be used to assist the poor, and some have already proven highly effective – as in the case of some health technologies. The problem is that the exact form of intervention between the technologies and the poor is not obvious in many cases. These complications, more general uncertainties, the distrust of the power of S&T or of local scientists to aid underserved populations, and the small national budgets

assigned to research and problem solving combine to doom any possibility of leapfrogging in poorer areas.

Poverty is normally defined as a situation of low income, and that is certainly a pervasive characteristic of people lacking the means to finance their own development. But, as Amartya Sen[26] has pointed out repeatedly, there are good reasons for seeing poverty in a broader sense as a deprivation of basic capabilities. Social exclusion, for instance, is not ultimately a question of income but of values that lead, as Sen points out, to loss of self-reliance and self-confidence, and poor psychological and physical health.

The question then becomes: How can science and technology increase capabilities, i.e. increase the capacity or power or ability of an individual to reach minimum levels of health, knowledge, skills, employment or enterprising opportunities, etc.? A common problem preventing this process from taking place is the lack of resources targeted to poorer groups. For instance, of the 2000 patents granted in medicine over the past 10 years, only 10 were related to curing tropical diseases. Of these, half were geared toward animal stocks and half toward humans.

In this context, it is interesting to note Jeffrey Sachs' observation: "As it happens, the poor live in different ecological zones, face different health conditions and must overcome agronomic limitations that are very different from those of rich countries. Those differences, indeed, are often a fundamental cause of persisting poverty… Not only life but death differs between temperate zones. Individuals in temperate zones almost everywhere enjoy a life expectancy of 70 years or more. In the tropics, however, life expectancy is generally much shorter. One big reason is that populations are burdened by diseases such as malaria, hookworm, sleeping sickness and schistosomiasis, whose transmission generally depends on a warm climate. (Winter may be the greatest public-health intervention in the world.)"

At the Bank in particular we need to probe the point of one of his conclusions, that "the inequalities of income across the globe are actually exceeded by the inequalities of scientific output and technological innovation." (See box 2 below.)

Specifically, the rigidities and inadequacies related to knowledge about technologies and attributes limit the spread of economic growth to a small privileged group. When large sections of the population are too distant or too rural to have minimally adequate access to the knowledge and basic social services needed to build their own development, the result is that national productivity never rises to the critical mass necessarily for growth that could deal effectively and sustainably with poverty alleviation.

Yet in Central America, which faces all of these issues, the track record in terms of priority funding and interest in S&T remain abysmal. One may criticize or praise the achievements of Ministries of Education in any one of the countries, for instance. Yet, the S&T councils and/or ministries of science and technology would be happy if they could capture a mere 1% of the national interest and resources that education gets.

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[26] See for instance, his *Development and Freedom*. New York: Anchor Books, 2000.

The councils, which go under the generic name of CONCYTs, or *consejos nacionales de ciencia y tecnología*, are perceived as superfluous, useless or a curiosity at best. Allegations to the contrary can be easily debunked by noting the councils' extremely small budgets and actual responsibilities. Their connection with R&D is sometimes bound to pressing and high-priority items, such as financing for combating some epidemiological issue or crisis. Yet problems of how to use, adapt or transfer new technologies or to lift the barriers to higher capabilities are not normally in their agendas.

Box 2: Insufficiency of malaria-related R&D

Malaria kills as many as 2.5 million people per year. The disease is so heavily concentrated in the poorest tropical countries, and overwhelmingly in sub-Saharan Africa, that nobody even bothers to keep an accurate count of clinical cases or deaths. Those who remember that richer places such as Spain, Italy, Greece and the southern United States once harbored the disease may be misled into thinking that the problem is one of social institutions controlling its transmission. In fact, the sporadic transmission of malaria in the subtropical regions of the rich countries was vastly easier to control than is its chronic transmission in the heart of the tropics. Tropical countries are plagued by ecological conditions that produce hundreds of infective bites per year per person. Mosquito control does not work well, if at all, in such circumstances. It is in any event expensive.

Recent advances in biotechnology, including mapping the genome of the malaria parasite, point to a possible malaria vaccine. One would think that this would be high on the agendas of both the international community and private pharmaceutical firms. It is not. A Wellcome Trust study a few years ago found that only around $80 million a year is spent on malaria research, and only a fraction of that on vaccines.

The big vaccine producers, such as Merck, Rhone-Poulenc's Pasteur-MérieuxConnaught and SmithKline Beecham, have much of the in-house science but not the bottom-line motivation. They strongly believe that there is no market for malaria. Even if they spend the hundreds of millions, or perhaps billions, of dollars to do the R&D and come up with an effective vaccine, they believe, with reason, that their product would just be grabbed by international agencies or private sector copycats. The hijackers argue, plausibly, that the poor deserve to have the vaccine at low prices – enough to cover production costs but not the preceding R&D expenditures.

The malaria problem reflects, in microcosm, a vast range of problems facing the HIPCs (highly indebted poor countries) in health, agriculture and environmental management. They are profound, accessible to science and utterly neglected. A hundred IMF missions or World Bank health sector loans cannot produce a malaria vaccine. No individual country borrowing from the Fund or the World Bank will ever have the means or incentive to produce the global public good of a malaria vaccine. The root of the problem is a much more complex market failure: Private investors and scientists doubt that malaria research will be rewarded financially. Creativity is needed to bridge the huge gulfs between human needs, scientific efforts and market returns.

Jeffrey Sachs, "Helping the World's Poorest."

While there seems to be a worldwide consensus on the need for speeding up education coverage and quality in the race toward improving the capability of the poor to develop, the same priority does not attach to scientific and technological knowledge diffusion. It would seem that the two, education and technology, are perceived as disconnected in many a policy maker's approach to economic development. As a result, technology policy is backward and incapable of supporting the necessary kinds and levels of human capital investment. The payoffs to social sector investments, in education and health particularly, will be ever slower in arriving.

This perception prevails in spite of evidence to the contrary. Good health, to illustrate, is clearly a capability-enhancing input to human development of the poor. It therefore would be useful to assess the contributions to health outcomes of income, education and

technical progress (largely health technologies, such as oral rehydration technologies adapted to conditions in developing countries).

In Table 3, extracted from UNDP´s 2001 *Human Development Report*, one can clearly see how much greater the contribution of health technology to mortality reduction has been, compared to gains in education or income.

Table 3

Technology as a source of mortality reduction, 1960–90
(percent)

Improvement in	Contribution of gains in income	Contribution of gains in education level of adult females	Contribution of gains in technical progress
Under-five mortality rate	17	38	45
Female adult mortality rate	20	41	39
Male adult mortality rate	25	27	49
Female life expectancy at birth	19	32	49

Since S&T innovations are acknowledged drivers of growth in the advanced nations, difficulties or lags in absorbing new technologies can take firms in small economies out of the market. Thus, little can in fact be gained by concentrating on traditional education alone without equal support for science and technology diffusion. Table 4, also from the UNDP report, illustrates this point. The bulk of Central America's exports lies in primary products and resource-based manufacturing, sectors growing very slowly, while the region's contributions to the world's fastest growing sector – high-tech manufacturing – are few and rare. Since exports are the most promising source of growth, it would follow that new comparative advantages need to be identified and nurtured to develop niches that fit into the high-tech sector.

Table 4

High-tech products dominate export expansion
(average annual percentage growth in exports, 1985–98)

Area	High-tech manufactures	Medium-tech manufactures	Low-tech manufactures	Resource-based manufactures	Primary products
World	13.1	9.3	9.7	7.0	3.4
Developing countries[a]	21.4	14.3	11.7	6.0	1.3
High-income OECD[b]	11.3	8.5	8.5	7.0	4.4

a. Includes Eastern Europe and the Commonwealth of Independent States.
b. Includes Cyprus, Israel and Malta.

What is the upshot? Insufficient use of technological knowledge is lowering the potential for productivity growth, and therefore the competitiveness of enterprises. This translates into further obstacles for appropriate knowledge to trickle down to the poor. The less knowledge and information that a poor person has, the less he or she is able to improve

his or her capabilities –particularly capabilities to participate even at the low end of the value chain of export expanding sectors. As well, there are greater restrictions on his or her freedom to develop and escape poverty.

Today, including the excluded is harder to do than even 10 years ago, because the human and social capital bases are too weak to fuel the race to catch up. The faster pace of technology-based innovations, which dominate economic competition among international players, raises the hurdles and the stakes. Indeed, achievements and advances in reading literacy pale in comparison to the rapidly widening gap in technology literacy between the advanced industrial and knowledge-based economies and the developing economies. The more you gain just in traditional education, the less it can be used efficiently and/or sustained in a world where knowing how to read, write, add and subtract is increasingly and enigmatically intertwined with technological knowledge.[27]

That this new cognitive skill, which includes technological literacy in a fundamental sense, is bound to become a requirement for success in economic exchange can be easily seen if one acknowledges that price is not the only critical aspect of economic competition anymore (if it ever was). Technological innovation is as much or more of a determinant of economic success in today's globalized interactions. As such, "reading" technological trends will soon become a basic capability for job seekers everywhere. In addition, if countries are to find niches in international networks, the capacity to adjust rapidly to frequent external innovations through adoption and/or adaptation of existing or alternative technologies is crucial. This capacity requires that a country possess a knowledge-enhanced economy where most economic agents, including the poor, are minimally techno-literate.

In somewhat more technical terms, the scarcity of resources (particularly tacit-knowledge[28] resources) associated with the rapid pace of technological advance in some countries means that such resources are inaccessible to many individuals – in fact, to

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[27] The Organization for Economic Cooperation and Development (OECD) conducted a massive study to assess whether students around the world are well prepared to meet the challenges of the future – the OECD Programme for International Student Assessment (PISA). PISA revealed considerable variation among countries and noted a marked influence of the socio-economic background on students' readiness. It is interesting to note, for the purposes of the above discussion, that PISA measured literacy very differently from the traditional ability to read and write. It measured it on a continuum, not as something that an individual either does or does not have. It defined the following domains of analysis: a) the content or structure of knowledge that students need to acquire in each domain (e.g., familiarity with scientific concepts); b) the processes that need to be performed (e.g., retrieving written information from a text); and c) the contexts in which knowledge and skills are applied (e.g., making decisions in relation to one's personal life, or understanding world affairs). Thus, mathematical literacy, for instance, is taken by PISA to indicate the ability to put mathematical knowledge and skill to functional use rather than just mastering them within a school curriculum. That is, for instance, having students take a quantitatively supported point of view or opinion about a government's spending plans. OECD, 2001. *Knowledge and Skills for Life: First Results from PISA*. Paris.

[28] Tacit knowledge is that which arises from protracted intimate interaction and familiarity with a process (perhaps a build-up of pieces of information through years or even generations). It cannot be easily encoded for transfer to another person and thus resides within the recesses of the brains of experts.

most individuals in developing countries. The segmented markets, or dual character of economies are then reinforced. Consequently, the faster advance of the tech sectors retards that of non-tech or low-productivity sectors. One can argue that the "invisible hand" of Adam Smith or the "creative destruction" of Schumpeter will lead to the development of training centers and network arrangements that will balance this effect. Frankly, the historical record does not support this position as it refers to developing countries; furthermore, the required changes to bring about the "invisible hand" of free markets cannot take place over night as was discussed above.

Most agents in a technologically illiterate economy cannot even begin to comprehend what weaknesses in skills they have. The technological "oversight" is so severe that nobody has yet cared to measure technological illiteracy. We have no average assessment similar to education's degree of coverage, for instance, and no way of knowing how bad or in which areas the technological weakness is worst. While education curricula in most countries responsibly contain guidelines for teaching the sciences, this is generally the most neglected area of educational investment in developing countries. Much more is invested in educational materials for teaching history or geography. But even if science education were improved, lopsided social values against rapid and frequent technological change arrests any visionary's valiant, lonely voice shouting for science and technology.

While Bank activity in S&T in the poorer countries of Central America is very recent, I feel it is pertinent and necessary that we ask what have we learned about S&T so far in these nations, and to what extent do we want to support superior, technologically informed solutions to their development quandaries. My feeling is that we are not doing enough to help them rationalize their often implicit agenda for a knowledge-enhanced economy. In this respect, we will need to ask also whether all governments really mean it when they say they desire or want to know how to grow as fast as possible.

One area the Bank is pushing is technologies for poverty alleviation. However, poverty, science and technology are strange bedfellows in these countries. Only recently has the rhetoric improved – with phrases like closing the digital divide. The Bank has answered the demands of countries by facilitating knowledge diffusion electronically to poorer isolated communities through the now common instrument of telecenters. (See box 3 on the Honduran project.)

But if freedoms and opportunities are to increase significantly for the poor, technological knowledge, in particular, needs to play a pivotal role. Technology can also lower the expense of access to needed types of knowledge, particularly knowledge about ways for the poor to move to the next stage of personal or community growth and development.

In other words, there is a need for clearly defined target groups and context-sensitive objectives to build capabilities. The strategies that build capacity for a knowledge economy become a powerful engine for job creation and productivity

Box 3: Honduras – Enhancing the capabilities of the poor with technologies

We are all aware of commonplace, sweeping generalizations, such as the need for closing the digital divide or for boosting developing countries onto the globalization bandwagon. As motivational phrases go, these are as good as any. However, the business of setting in place a national organization to manage technological change in a small, poor country is something else. First, the human resources with the technical profile needed for a major, nationwide initiative are likely not there, even if the Bank were to provide all the financial resources for investment. Second, developing the appropriate content with each of the communities, so that it is relevant and conducive to opening new opportunities, is somewhat slow and costly.

So what can we do? We can try! The Bank is experimenting with new technologies that may enlarge the opportunities and capabilities of the poor. One such experiment is starting in Honduras, where, under a project entitled "Enhancing Capability Through Technology in Poor Communities of Honduras," we are supporting wireless communications in a pilot that offers distance education and micro-enterprise training to isolated communities.

A new development partner that the Bank is engaging in this project is the consortium Digital Nations, led by the MIT Media-Lab. For the first time, the Bank is facilitating funding for the incorporation of a country into Digital Nations.

The consortium unites an expanding set of developing nations with a set of mega-tech enterprises, such as Intel, Nike and Hewlett-Packard, who join because of mutual interest. The countries want to take a leap forward through technology, and the corporations aim to develop new products designed for and affordable to the poor. They reason that the 4 billion people who are not using the Internet comprise a pretty big market.

In developing a new generation of technologies and applications that enable people to design, create and learn in new ways, the consortium is helping them become more active participants in their societies. As they put it, we need to develop a creative core of people in the developing countries who are willing to lead the way with new tools and methods more in tune with the local customs and cultures.

The question of lowering transaction costs and providing better social services is at the bottom of this justification. For instance, one of Digital Nations' activities involves creating learning communities. In India, they have devised new tools and practices enabling people of all ages to take more active roles in the development of their communities – and to gain new ideas about learning. If done right, these activities carry tremendous potential for reducing the obstacles to employment or setting up enterprises. In addition, as community members work together on projects, the community as a whole can develop new knowledge beyond what any individual could on their own.

As the Bank unfolds its pilot in Honduras, it too will learn as an institution. The question of how to mainstream the project and expand it on the national scale will be a critical one. The Bank does not want to mislead countries with very limited resources into making investments with low payoffs.

Key issues: As I noted in the introduction, my central points are these: Given an international marketplace that is increasingly dependent on knowledge-based competition, science and technology policy in poor countries has to emphasize relaxing three constraints: (a) a policy environment that neglects developing or disseminating knowledge tailored for the poor – for example, balancing the emphasis on formal education with increasing massive diffusion of practical know-how; (b) widespread ignorance about how to convert the endowments of the poor into marketable assets[29] – i.e., little effort is given to developing mechanisms and technologies that can accomplish this conversion of the poor's "assets" into marketable assets; and (c) an economy-wide bias against frequent technological innovations and technological transfers.

[29] See Hernando de Soto, 2000. *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else.* New York: Basic Books.

What the Bank can do: In terms of S&T in projects directed at poverty reduction, we can: a) promote active local involvement in R&D activities designed and implemented jointly with valued representatives of the final users (the poor), and which search for effective technologies and policies that enhance capabilities and opportunities for personal and community growth; and (b) encourage experimentation with methods and practices that foster attitudes favorable toward the emergence of knowledge-enhanced economies.

Such an approach recognizes that one important goal of science is, after all, how to use knowledge to find answers to questions that society deems important. In this case, the Bank is acknowledging that science and technology can be of particular value in reducing poverty. The methods and technologies that science employs in this task are key, of course, and facilitating local access to these should characterize Bank support for poorer, smaller countries in Central America.

2. Technology and education – what to invest in?

One big decision in addressing the topic of technology and poverty is how much to invest in traditional education vis-à-vis developing curricula, information, content and pedagogy that is of interest to poor target groups. It simply is not very convincing to use exactly the same curricula and pedagogy in rural, poor communities as in those that are more urban and closer to modern business activity. Also at stake is the appropriate design of two interfaces: between the poor user and the hardware (how to transmit inputs into, take care of, repair and upgrade the hardware), and between the user and the software (how to develop an appropriate language, given the culture-deprived setting).

Finally, despite worldwide agreement among scholars that an important challenge in education is how to apply it in a productive mode, the complementarity between knowledge-based economic activities and education is not generally well understood in the Central American context. What is it that needs to be conveyed? Precisely what is known about such a nexus?

Cross-sectional research has shown that there is a two-way causation between education and technology/productivity. Andrew Foster and Mark Rosenzweig[30] found, for instance, that investing in education alone will not improve the economy unless there are opportunities created by new technologies or capital investment that can utilize better-educated workers.

While controversial with educators, I would use Rosenzweig´s definition of learning within an economic framework, where he takes learning to entail the acquisition of better information on "the most appropriate set of inputs in a production process. If discrepancies between optimum production input levels and actual levels are significant,

[30] Andrew Foster and Mark Rosenzweig. "Technical Change and Human Capital Returns and Investments: Evidence from the Green Revolution," *American Economic Review*, September, 1996, p. 931-953. Also, Mark Rosenzweig. "When Investing in Education Matters and When It Does Not," *Challenge Magazine*, March-April 1996.

then there are incentives to learn and rewards for those who learn the fastest. Information on "best practices" may come from external sources or help lines. "

The Indian Green Revolution showed the utility of a complementary education-technology policy. It had a clear beginning, Rosenzweig says: the import of new hybrid seed varieties of wheat, rice and corn (and later sorghum) in the mid-1960s, which were substantially more productive than indigenous varieties. The source of economic growth was external, and technical change was not itself the direct or indirect product of schooling. However, knowledge about technology was critical, because when combined with basic education in arithmetic, the capabilities of farmers with education made a difference. Indeed, the productivity of the new seed varieties varied across India because of the sensitivity of the new seeds to water and soil nutrients, which could only be assessed and corrected by those farmers with better education. Furthermore, Rosenzweig's estimates indicate that in areas where higher productivity was expected by the communities, school enrollment rates were significantly higher among both farm and non-farm rural households. The suggestion, of course, is that schooling investments yield higher returns the closer and more relevant they are to economic productivity, and therefore the closer to increasing capabilities through higher personal incomes.

These too, are examples of the types of learning that have been bypassed when designing grandiose schemes for import substitution or export orientation, or under the more encompassing Washington Consensus.

In this context, let me touch base with the digital divide issue. In the end, it will not be possible to reduce the digital divide without simultaneously seeking to enhance complementary knowledge or the cognitive skills required for “being digital.” One hears much about interesting discussions on the digital divide and the need to develop an information society. But at bottom, these are cries for connectivity and communications in a globalized world. They really do not address weaknesses in accessibility to appropriate knowledge. What is needed is a well-organized critical mass of scientists, engineers and scientific visionaries, who can effectively look after the needs and constraints that their less capable fellow citizens face in their pursuit of economic gain. There is little that increasing connectivity, by itself, can do for economic growth. The science-like cognitive skills must be there as well.

These skills include an inquiring attitude, with a concern for detecting valid information and data. This will not transmit from one head to another through osmosis, just by having, for example, a local business person sit in front of the Internet looking at how other business people used technology to improve their productivity in Malaysia. Instead, you need a nationwide appropriation of the values and benefits that science can bring to ordinary people in their daily lives. Information technologies will help to the extent that local expertise can guide citizens in finding answers to the crucial questions facing their particular country – not just in addressing the questions facing the R&D agendas of advanced industrial and knowledge-based economies.

IV. CONCLUSIONS

In terms of policy engineering, the task ahead must be to consider researching the following. First, a new incentive system needs to be engineered to facilitate cooperation in devising a pertinent and well-organized set of rules (policies and regulations) that meet with the demands and approval of stakeholders, small and large. Cooperation is also needed to identify and invest in key public goods, such as laboratories and ingenious R&D schemes that may be used by the SMEs and poor communities. This will set the tone and provide more of a level playing field on which to encourage competition. An enabling framework will foster more activities with positive social over private rates of returns, which in turn will prompt certain synergies to emerge.

Secondly, countries need to design policy frameworks that empower the poor through know-how and associated technologies allowing easier entry into formal markets. At the same time, countries need marketing campaigns to offset or soften the prevailing aversion to innovation and promote instead more risk-taking entrepreneurial approaches. Since the amount of information is quite meager about these attitudes, well-targeted, country-specific research needs to be undertaken to boost optimism and dynamism.

Each of these recommendations entails more discussion and research for proper definition before they can confidently promoted. Yet carrying out these two tasks will strengthen the other components of an enabling environment[31] – such as macroeconomic stability, export expansion and environmental sustainability – which the Bank and other international agencies are supporting.

In devising policies to achieve these changes, the issue of whether the political and economic structure will permit them to rapidly emerge becomes important. In particular, while the academic and practitioner literature abounds on these topics, there is still a great deal that nobody knows about identifying and designing appropriate technologies for the poor. One also still needs to be constantly aware of what it takes to make a specific economy grow quickly while including the poor. That is why I argued above that there is a need to research and thoroughly discuss the pros and cons of existing or proposed sets of[32] policies to help small economies develop stronger "innovation machines," and to clearly identify what conditions need to be present to enable an individual to use new knowledge-enhanced tools to complement his or her creative powers and to attain better living standards.

[31] The other complementary conditions are those surrounding an export-lead growth, social safety nets, and proper social and human capital investments.

[32] If we assume that all the countries in Central America, Hispaniola and Mexico want to become successful free market economies.

In the spirit of the innovation machine, creative policies are needed that can unleash the power of the market. Sachs proposes the following for attracting resources for malaria R&D: "Rich countries would make a firm pledge to purchase an effective malaria vaccine for Africa's 25 million newborn children each year if such a vaccine is developed. They would even state, based on appropriate and clear scientific standards, that they would guarantee a minimum purchase price – say, US$10 per dose – for a vaccine that meets minimum conditions of efficacy, and perhaps raise the price for a better one. The recipient countries might also be asked to pledge a part of the cost, depending on their incomes. But nothing need be spent by any government until the vaccine actually exists."

Could we follow that approach of promising a market in other areas of interest for Central America? Can we promise biotech firms a deal for coming in and exploiting the rich biodiversity of the region while training and transferring technologies for locals? While Costa Rica and Panama have taken important initial steps in this direction, much more is needed.

Finally, I will synthesize the policies for consideration in the following table:

Table 5: Elements of a strategy to enhance support of S&T in Central America

Development goal sought	Strengthen markets	Promote innovative entrepreneur-ship	Building the innovation machine	Using S&T to increase chances of the poor
Effective technology policy in support of macroeconomic policies	1.Identify and provide easy access to adequate and timely information on changes in national and world economic conditions. 2. Facilitate and spread widely knowledge to detect the implications of new world conditions. 3. Construct faster mechanisms to disseminate such information in a user-friendly fashion, so as to elicit a timely reaction to economic signals. 4. Support research that leads to enlightened government intervention in strategic areas, which perhaps should be defined by national consensus. 5. Facilitate indigenous learning and dissemination of knowledge in strategic areas by instituting local versions of technology extension professionals (such as those supported by the government of Canada, or through technical support centers like the ones assisted by the United States).	1. Set in motion a method to identify and attract potential entrepreneurs, who can be trained to become better prepared to channel their passion and focus their organizations on frequent innovations. 2.Provide research support to understand the sociology and psychology (and institutional requirements) of innovation in smaller, poorer countries, and design policies for such purposes.	1. Introduce facilitators of technology transfers (technology extension services or technology centers) as the first stage in promoting innovations. This will be geared to marginal but important (due to their relatively low cost) changes in productivity. 2. Design and set in place a parallel technical support system to stimulate and finance more drastic, strategic innovations that can help some economic sectors leapfrog into major exports. 3.Design and support more effective methods to upgrade university-based learning and training media – including university/business coalitions. 4. Identify fruitful and strategic government interventions.	

Development goal sought	Strengthen markets	Promote innovative entrepreneur-ship	Building the innovation machine	Using S&T to increase chances of the poor
Effective technology policy in support of enhancing the capabilities of the poor				1.Give at least equal policy weight to technology and not just to education as the main driver of economic growth for the poorer communities. 2.Promote more strongly a new role for schooling, where learning entails the acquisition of better information on the set of inputs in a production process that is most appropriate and relevant to activities important to communities. 3.Demonstrate past community, individual or collective actions that have used technology to solve similar problems related to productivity, quality improvement, connectivity, networking, international partnering, and other issues in the production of goods and services. 4.Pursue reductions in the digital divide, while simultaneously seeking to enhance complementary knowledge and cognitive skills required for "being digital." Address cultural and attitudinal weaknesses in accessibility to appropriate knowledge and technological media for connectivity (for example, evaluate the cost/benefit of satellite versus terrestrial alternatives).