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THE POTENTIAL ROLE OF SOFTWARE IN ENHANCING THE COMPETITIVENESS OF DEVELOPING COUNTRY FIRMS*

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* The views expressed in this document are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document has not been edited.

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INTRODUCTION

There is a fairly wide and expanding literature on the potential role of developing countries in the global software industry and on the related problems of developing a software industry in these countries.[1] Most of this effort has focused on how developing countries, particularly the Newly Industrialized Economies (NIEs) might be able to participate in the global software industry, which niches they could penetrate, and how they could take advantage of their comparative advantages in this regard.

Also addressed are the practical problems involved in developing local software production capabilities and acquiring the requisite know-how, technology and market intelligence and access.

Strangely, what has received relatively little attention is the potential role of software applications, from whatever source, for improving the productive efficiency of enterprises in developing countries, thus contributing to economic development and to competitiveness in international markets. Even though there are many examples of software applications making significant contributions to productivity in both the public and private sectors in developing countries in various sectors, no systematic study and assessment of these experiences have been made.[2]

In the modern global economy, international competitiveness is a driving concern. The trend towards freeing up domestic economies, liberalizing markets and encouraging private sector development and entrepreneurship has made it vital for firms everywhere to become more competitive on a global basis. For the developing countries, this presents a special challenge. After years of following "import substitution" models of industrial development[3] and a relatively protected domestic market, firms in developing countries are having

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[1] Robert Schware, "Software Industry Development in the Third World: Policy Guidelines, Institutional Options and Constraints", **World Development**, Vol. 15, No. 10/11, pp. 1249-1267, 1987; Carlos Maria Correa, "Software Industry: An Opportunity for Latin America?", **World Development**, Vol. 18, No. 11, pp. 1587-1598, 1990; Ukandi G. Damachi, H. Ray Souder and Nicholas A. Damachi, (eds) **Computers and Computer Applications in Developing Countries**, Macmillan Press, London, 1987; Robert Schware, "The World Software Industry and Software Engineering: Opportunities and Constraints for Newly Industrialized Economies", **World Bank Technical Paper** No. 104, The World Bank, Washington D.C., 1989

[2] For example, the Indian railway system has been totally transformed as a result of computerization, and the software and systems development was carried out by a local firm. Reservations, ticketing and scheduling has vastly improved now for rail travel in India.

[3] Furthermore, these "import substitution" approaches have been criticized as actually being "import reproduction" strategies, and thereby not contributing to domestic industrial development of a balanced and long term nature. See Lynn Mytelka, "The Unfulfilled Promise of African Industrialization", **African Studies Review**, Vol. 32, No. 3, pp. 77-137, 1989, for a critique of the traditional import substitution models.

to face the realities of hard competition both foreign and domestic. A major hindrance in this regard is the low level of efficiency of industry in the Third World.

In a general sense, there is a vast gap in productivity levels between industrialized and developing countries as measured in terms of gross output per worker or value added per worker,[4] partly as a result of technology gaps. However, given a certain level of technology, it is also true that productivity is lowered by the inefficient utilization of technology and by inefficiencies in the management and organization of production itself.

Attempts have been made to capture these aspects of inefficiency, at least at the macro-level, through such measures as domestic resource cost (DRC), effective rates of protection (ERP) and total factor productivity (TFP). These measures, however, do not offer any useful insights into the likely causes of these inefficiencies. Pack[5], for example, argues that these measures do not tell you whether any possibilities exist for improving productivity, through, for example, skill transfer. The sources of inefficiency are not clarified in any manner.

On the other hand, recent developments in the management literature have highlighted the important role of "softer" procedural and organizational improvements for enhancing overall productivity. Distortions and "disconnects" in the manufacturing process, communications, inter-departmental linkages and information flows are identified as some of the root causes of inefficiencies in the system as a whole. The "new" management techniques, such as Just in Time, Zero Defects and Total Quality Management stress this focus on the processes that are associated with manufacturing and its relevance to improving the productivity and competitiveness of the firm. Most of this literature has focused on the industrialized world, though some efforts have been made to examine the implications of the new management practices for developing countries.[6] In recent times, this approach has taken an explicit

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[4] See UNIDO, **Industry and Development: Global Report 1989/1990**, Vienna, Austria, 1990, for detailed data on productivity levels in individual countries and sectors.

[5] Howard Pack, "Productivity and Industrial Development in Sub-Saharan Africa", Working Paper No. 3, Technology Assessment Policy Analysis Project, USAID, Washington D.C., 1990.

[6] For example, Atul Wad, "Technological Capabilities and Organizational Capabilities in Developing Countries", Working Paper, The Technology Assessment Policy Analysis Project, USAID, Washington D.C. 1990; Kurt Hoffman, "Technological Advance and Organizational Innovation in the Engineering Industry", **World Bank Industry Series Paper**, No. 4, March 1989, and Carlota Perez, "Microelectronics, Long Waves and World Structural Change: New Perspectives for Developing Countries", **The World Bank, Strategic Planning Review**, Discussion paper No. 4, December 1989.

focus on the technological processes of the firm and how these could be improved upon.[7]

Thus, there have been recent developments that have begun to address the issue of productivity and competitiveness in developing countries. A wide range of firm level and policy measures need to be considered in order to effect productivity improvements. Software can play an important role in this regard.

The purpose of this paper is to examine the practical issues involved in developing and applying software for the improvement of the competitive position of firms from developing countries, with a specific focus on small and mid-sized firms. Furthermore, the paper is primarily concerned with the applications of software to the industrial sector in developing countries.

The paper will first discuss the broad changes in the global economy and how they are changing the concept and determinants of competitiveness in the modern world. It will then examine the potential role of software applications in improving the efficiency of domestic enterprises, and the different areas where software can have an impact. Following this is a discussion of the issues involved in developing or acquiring the needed types of software and the issues involved in the delivery of software to the users. The paper concludes with an analysis of the policy implications for developing countries.

THE CHANGING GLOBAL CONTEXT

Several dramatic changes in the global context for development make it more important for developing countries to become active participants in the world economy. The new global context presents a different set of challenges for these countries:

- A heightened pace of global competition and new bases for competition;
- The rise of the NICs and the gradual entrance of Eastern Europe into the global economy;
- An accelerating rate of technical innovation and change, particularly in the advanced technologies (e.g. informatics, biotechnology);
- The emergence of science-based knowledge-intensive technology, and its spread throughout the industrial world;
- The internationalization of capital and production and the globalization of manufacturing. The development of niche markets and product and market differentiation on an unprecedented scale, at least in the industrialized nations;

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[7] See, for example, Steven Hunt, Atul Wad and Timothy Lavengood, "Technology Assets Management: Optimizing the Returns from Technological Assets", Joint Working Paper of Arthur Andersen & Co. and the Center for the Interdisciplinary Study of Science and Technology (CISST), Northwestern University, 1991.

- Changes in the concepts of efficiency and productivity (from economies of scale to economies of scope), which places greater emphasis on flexibility and innovativeness.

These changes have had important implications for what constitutes competitiveness in today's world. With the shift to a new techno-economic paradigm, the traditional bases of competitiveness are being eroded and replaced by a new set of concepts based on quality, responsiveness, speed to market, flexibility and efficiency in service. In this new playing field, the traditional strength of the third world, cheap labor, may not retain the value it once had. On the other hand, the changing situation could open up new areas of opportunity for the developing countries.

The Challenge for Developing Countries

For developing countries, the implications of these changes are complex and serious. To compete, they must undertake a series of steps. They will have to:

- Improve the process of technological development and capability building in their industries so as to make them more productive and competitive. This is particularly true for countries that have undertaken policies to liberalize their economies and privatize public sector corporations. In order to survive and succeed in the more open and hence more competitive environment being created, local firms need to upgrade their technological capabilities through internal technology development, sourcing of foreign technologies, adaptation, joint-ventures, and other means;

- Developing countries must develop their international business strategies and increase their participation in global markets on the basis of their competitive advantages. This requires more systematic and sophisticated marketing, market "intelligence" and market access. Their firms need to be able to define "niches" and windows of opportunity, enter into cooperative arrangements with firms in other countries, and deliver quality goods or services on time and at the right price;

- Firms in developing countries must improve the quality of their manufacturing processes and their products, to be competitive. Inefficient modes of operation that were affordable under more protective environments need to be rectified. New management techniques and other measures are needed to improve productivity;

- Developing country governments must adopt innovative policies and institutional mechanisms to create conditions which foster productivity and make firms more competitive.

Clearly, these are not easy tasks. Even though there is a proliferation of new product and process technologies, it is difficult to keep abreast of relevant developments and sources. As technology becomes more complex, it is difficult to assess the relative merits of each without some basic resident expertise. Gaining access to sources, and to the resources needed to adapt and modify these technologies to local conditions is also a problem. Furthermore, negotiating technology licenses is a complex process requiring

legal, marketing and technical expertise often not easily available to firms in developing countries.

Similarly, developing a more sophisticated approach to marketing requires networks, contacts, various forms of expertise and resources that such firms typically do not have or cannot afford. It is costly to conduct market studies, to make frequent marketing trips overseas, and to find foreign distributors and collaborators.

Furthermore, local technological capabilities and resources are often inadequate to meet industry needs. Even where large local R&D systems have been established, these are typically not in tune with the needs of industry and lack a "demand driven" approach. The value of these R&D capabilities to local firms is questionable.

In other areas, such as marketing, quality control and management, local capabilities are generally weak, if not altogether absent. The culture and infrastructure of support service organizations and consulting firms in these "soft" areas, which are taken for granted in the U.S., rarely exist in developing countries. Where they do exist, they are generally priced out of the range of most small and mid-sized firms. This situation is compounded by a general lack of experience with, and subsequent distrust of, consultants.

Clearly, there is a gap between the needs of firms in developing countries with respect to their technological capabilities and business development efforts, and the institutional and infrastructural context in which they exist. Their institutions often were set up to meet other priorities, or are based on a different view of the role of science and technology in economic development. They tend to be bureaucratic, non-market-driven and not responsive to industry because they are normally subsidized by the state. The protectionist policies that many countries pursued in the past have insulated local firms from the competitive pressures that would have generated technological innovation, increased productivity, more sophisticated marketing, and more aggressive movement into international business.

Carlota Perez* has summarized the main points of difference between the old and new paradigms and what they imply for the firm. These are shown in Figure 1.

A New Perspective on Technology

At the core of the issue here is technology. For decades, the international community has focused on how science and technology can contribute to the economic development of the third world. What has happened

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* Perez, op. cit.

Figure 1: The New vs. the Traditional Paradigm:
Contrast Between two "Ideal Types" in Managerial Common Sense

	CONVENTIONAL COMMON SENSE	NEW EFFICIENCY PRINCIPLES & PRACTICES
COMMAND AND CONTROL	Centralized command Vertical control Cascade of supervisory levels "Management Knows best"	Central goalsetting and coordination Local autonomy/Horizontal self-control Self-assessing/self-improving units Participatory decision-making
STRUCTURE AND GROWTH	Stable pyramid growing in height and complexity as it expands	Flat flexible network of very agile units/Remains flat as it expands
PARTS AND LINKS	Clear vertical links/Separate specialized functional departments	Interactive, cooperative links between functions along each product line
STYLE OF OPERATION	Optimized smooth running organizations Standard routines and procedures "There is one best way" Definition of individual tasks Single function specialization Single top-down line of command Single bottom-up information flow	Continuous learning and improvement Flexible systems/Adaptable procedures "A better way can always be found" Definition of group tasks Multi-skilled personnel/Ad hoc teams Widespread delegation of decision making Multiple horizontal and vertical flows
HIRING AND TRAINING	Labor as variable cost Market provides most trained personnel People to fit the fixed posts Discipline as main quality	Labor as human capital Much in-house training and retraining Variable posts/Adaptable people Initiative/collaboration/motivation
EQUIPMENT AND INVESTMENT	Dedicated equipment One optimum plant size for each product Each plant anticipates demand growth Strive for economies of scale for mass production	Adaptable/programmable/flexible equip. Many efficient sizes/Optimum relative Organic growth closely following demand Choice/combination of econ. of scale, economies of scope or specialization
PRODUCTION PROGRAMMING	Keep production rhythm; use Inventory to accommodate variations in demand Produce for stock; shed labor in slack	Adapt rhythm to variation in demand Minimize response time (As in "just-in-time") Use slack for maintenance and training
PRODUCTIVITY MEASUREMENT	A specific measure for each department (purchasing, production, marketing, etc.) Tolerance on quality and rejects	Total productivity measured along the chain for each product line Strive for zero defects and zero rejects
SUPPLIERS, CLIENTS, AND COMPETITORS	Separation from the outside world: Foster price competition among suppliers; make standard products for mass customers; arms length oligopoly with competitors The firm as a closed system	Strong interaction with outside world: Collaborative links with suppliers, with customers and, in some cases, with competitors (Basic R&D for instance) The firm as an open system

Source: Perez, op. cit.

as a result of the change in the entire basis of manufacturing and the dynamics of the market, is a fundamental re-thinking of the concept of technology itself. While it is not the purpose of this paper to delve too deeply into this matter, it is useful to mention some of the main ways in which our notion of technology appears to be changing.

- Technology is not just the hardware but includes a soft dimension as well (i.e. technical know-how, skills and knowledge related to technical knowledge and the commercialization process, management, marketing, etc.). These "soft assets" can be crucial to the proper utilization of the hardware, and an entire specialty area is evolving in the field of management that deals with this aspect of technology;*

- Technology should be viewed as a whole system rather than discrete elements, incorporating R&D, design, process and production engineering, maintenance, management, and marketing. Thus technology is a complete package of processes and equipment that are all needed to ensure a technological capability;

- Technology is becoming increasingly knowledge-intensive, with a rapid increase in the knowledge intensity of production and a growing research intensity in the development of new technologies. In some cases, the initial investment costs simply to enter into a high-tech sector such as semiconductors, is prohibitive even by industrialized country standards. For developing countries, this suggests serious barriers to entry into certain areas of technology and the more relevant question is where they can find a place with respect to the industry based on this technology;

- Technology can no longer be regarded as a cost of modernization but as an investment towards long-term growth and competitiveness. The "supply" push approach to technology with its assumption that the key to growth is the injection of more technology and more science needs to be revised. Innovation is the key concept today, and is much more a demand driven notion. Technology is still an essential input, but the type of technology, how it is used, and how it is developed need to be addressed on the basis of what is the demand for the final results of that technology, demands set in the marketplace and derived from the needs of society;

- Technology is not simply a static input to a productive system but rather a variable that can be manipulated. Thus, the same piece of equipment can be used badly or well - as a result of non-technical factors. Simply having the technology is not enough, it must be used well, and this requires an understanding of and capability in the management of technology at the enterprise level, and the development of sensible and realistic technology policies and plans at the national level;

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* See, for example, Steven Hunt, Atul Wad and Tim Lavengood, "Optimizing the Returns from Technological Assets", joint working paper for Arthur Andersen & Co. and Northwestern University International Business Development. The strategic management literature also contains an increasing number of articles that deal with this issue. For example by David Teece, R. Jaikumar, C.K. Prahalad.

- Technology encompasses not only what is commonly included under the term - i.e. western technology - but traditional bodies of knowledge as well. Increasingly in use as an alternative to "technology" is the concept of "knowledge systems", which may range from complex computer systems to techniques based on accumulated knowledge in traditional societies. For example, traditional medicinal remedies based on local herbs and roots, food preservation techniques etc. The scope of what constitutes knowledge has thus expanded, and thereby also become more complex.

In short, the entire notion of technology needs to be revised and reconceptualized in order to take into account the changing realities of the present time. The improvement of productivity of manufacturing therefore needs to be centrally based on an appreciation of the benefits that can be gained by using technology well.

THE ROLE OF SOFTWARE

The Current Situation for Developing Countries

While there has been a great deal of concern over the implications of the computer revolution for developing countries and the debate continues, much of this debate has centered on the hardware aspects of the technology. In the past, there was concern over the options available to developing countries to build local capabilities in this technology, an option that is fast dwindling as the costs of initial investment continues to rise and the barriers to entry, at least in the core areas, become even tighter. (On the other hand, the costs of computer systems continues to drop, making the acquisition of these systems more feasible in developing countries.)

Several countries have, however, made in-roads in the ancillary industries, such as printers, disk drives, monitors, etc. For example, the total production of the largest hardware manufacturers in the third world, mainly the NIEs, exceeded $12 billion in 1988. For the manufacture of peripherals, the comparative advantage of cheap labor will probably continue to shape the pattern of movement of the industry through the third world.

On the other hand, in the software industry, the participation of the third world has been much smaller. The U.S. continues to dominate the global industry, which is estimated to expand to $340 billion by 1996, by growing at an annual rate of 20-30%. But in this business, the third world barely accounts for a few percentage points, although there is evidence that the size of the software markets in some countries is increasing rapidly (Figure 2) and governments in some countries, such as India, are taking proactive supportive measures for the development of this industry.

At the same time, the industry itself is going through major changes:[10]

- A shortage of trained personnel, resulting in a situation where software costs now account for the major share of total system costs;

- A global struggle over operating system standards;

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[10] Drawn from Schware, 1990, op. cit.

FIGURE 2: SOFTWARE AND COMPUTER SERVICES MARKET
IN SELECTED ECONOMIES
(Current 1984 $ Million)

COUNTRY	1984 SOFTWARE	1984 SERVICES	1984 TOTAL	1987 SOFTWARE	1987 SERVICES	1987 TOTAL
Brazil	363.5	337.7	701.2	2,186.2	2,031.4	4,217.6
Hong Kong	25	n.a.	n.a.	61	n.a.	n.a.
India	18.3	92.8	111.1	37.7	298.9	336.6
Korea, Rep.of	40	20	50	107	40	147
Malaysia	20	n.a.	n.a.	67	n.a.	n.a.
Mexico	59	6	65	117	13	130
P.R. of China	175	n.a.	n.a.	968	n.a.	n.a
Saudi Arabia	25	n.a.	n.a.	49	n.a.	n.a.
Singapore	27	21	48	71	59	129
Taiwan	26	29	55	57	51	108

Source: Schware, 1989, p.32

- A trend towards customized, integrated multi-vendor hardware and software solutions;

- A growing emphasis by hardware vendors on software production and sales, leading to a concentration of firms within the industry;

- A simultaneous expansion and fragmentation of the industry resulting in a growing number of software vendors.

These changes could have serious implications for developing countries in terms of their role in the global software industry. It may open up new opportunities in niche areas, but it may also close existing options. In the case of "body-shopping", for example, which is practiced by companies from India, who sell cheap labor for software development through marketing arms in the industrialized countries, a common problem faced is that potential clients are uncomfortable with the arms-length transaction involved and prefer to deal with software developers who have their staff and production close at hand. This despite all the arguments of cheaper labor, ease of transmission of data etc. There is concern over quality control, after sales service, protection of proprietary knowledge and delivery schedules. Nevertheless, several firms from developing countries have been successful in selling software services to clients in the North.

Software for Domestic Applications

The focus of this paper is on how software can contribute to the improvement of productivity of industry in developing countries. Issues related to the participation of developing countries in global software markets are closely related but distinct in this regard.

At a first glance, there seems to be a strong argument in favor of the potential for software for solving problems in the third world. Most developing nations are characterized by:[11]

- Low productivity;

- Labor intensive manufacturing operations;

- Underemployment;

- Poor work habits;

- Inadequate maintenance;

- Low skill and education levels;

- Material shortages;

- Improper supervision;

- Resistance to change.

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[11] Nicholas Damachi and H. Ray Souder, "Computers and Developing Nations", in Damachi et. al. (eds) op. cit.

Damachi and Souder argue that it is precisely these types of problems that lend themselves to solution through the applications of computers, which are characterized by:

- Low equipment costs and declining trends in costs;
- Cost effective operations;
- Remove or reduce repetitive tasks;
- Enable productivity control;
- Assist in quality control;
- Can be made user friendly;
- Improve the quality of data storage, retrieval and analysis;
- Enable decentralized decision making;
- Most systems are standardized.

Thus, there is a strong and logical set of arguments as to why software can be used to enhance productivity in developing countries. On the other hand, the diffusion of software applications has generally been slow. Partly, this is a function of the slow adoption rate of computer technology in general. In most developing countries, the large corporate sector and public sector undertakings have been the driving force in generating a demand for computer technology, but small and medium sized enterprises have not been as active. Yet, it is in the small and medium sized sector that some of the most valuable benefits could be reaped.

Barriers to Software Development

There are several reasons for this situation, some related to the characteristics of developing countries themselves, and some to the nature of software applications.

The barriers to the adoption of computer technology in developing countries include:

- Poor infrastructure and communications systems, which impedes the proper utilization of the technology;
- Lack of appreciation by end users of the benefits to be gained;
- Perceived high costs associated with computers, even though this is increasingly not the case;
- Lack of financial resources and foreign exchange to purchase the required technology;
- Concerns over the security of computers, especially for small businesses which often use innovative accounting techniques;
- Shortage of trained personnel to operate the equipment;

- Antiquated management philosophies and systems which do not lend themselves to the adoption of computers. Many managers in developing countries feel threatened by computers, because they fear loss of control and a reduction in their own status in the organization;

- Lack of information about the types of applications possible with today's computer technology;

- Only a few local companies with the resources and capabilities to deliver software applications effectively. Many are simply vendors of imported software and do not have the capacity to provide on-site assistance in installation, trouble-shooting and problem-solving. There is no "hot-line" for software users;

- High costs of the software itself, because of licensing fees, royalties, duties and high profit margins;

- In some countries, a situation where hardware has been oversold, and has been under-utilized, leading to a general mistrust of the technology, and a hesitance to invest further in software that would in fact make the hardware more productive. There is little appreciation of what Schneider[13] refers to as "hardware+software" thinking;

- Standard software packages do not fulfill user requirements totally;

- Inflexibility on the part of the vendors, who expect the organization to adapt to the software rather than vice-versa, which relates to the lack of local capability to adapt and modify software systems for local uses;

- The "body-shopping" syndrome, which results in the best talent being drawn to work on projects for foreign clients. The salaries tend to be higher, and there are other perks such as foreign travel;

- Improper government policies, which tend to favor exports of software services rather than provide incentives to local companies to develop a domestic client base. Also, in many countries, the policies tend to emphasize the "supply" side rather than attempt to foster a real local demand. Thus, in India, the government encourages the training of software engineers and rewards companies that are able to sell services overseas;

- Lack of experience in the marketing of software in developing countries. Firms tend to under-invest in the marketing effort, even though even a cursory analysis of the industry indicates how important it is to success.

Furthermore, there is the larger problem associated with what is

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[13] Hans-Jochen Schneider, "Software Production: Organization and Modalities", UNIDO, Vienna, IPCT.63, 17 May 1988.

referred to by Schneider as "polluted software", the fact that nearly all software systems in developed countries are badly structured and difficult to maintain. He even goes so far as to state:

> "The state of the art in data processing in industrialized countries is not worth imitating. Through rationalization of hardware production, the hardware/software cost ratio is now 20:80 and is predicted to be 10:90 in 1988. Programming staff in industry and in public administration devote 80-90% of their total manpower to software maintenance. The value of installed software worldwide is about $150 billion to $200 billion. Nearly all these software systems are badly structured and difficult to maintain. This is called "polluted software".[13]

Thus we have a range of problems associated with the diffusion and adoption of software applications in the third world, both as a result of constraints specific to the developing countries, and as a result of the nature of the software industry itself. Yet, in a fundamental sense, software can make enormous contributions to productivity improvements in industry, banking, transportation, services, public administration and communications.

Schware, for example, cites several examples of successful software applications in developing countries:

- A hospital information system in Thailand;
- A municipal management model that projects cash flow requirements in Brazil;
- An accounting system for businesses operating in hyper-inflationary environments in Argentina;
- A system for monitoring foreign exchange transactions jointly developed by an Indian and British collaboration;
- A design and drafting package that incorporates CAD and CAM in Singapore;
- Adaptation of standard software packages for Arabic countries developed in Tunisia;
- Several examples of text processing software in different languages - Korean, Thai, Chinese, etc.

The possibilities do exist. The question is how to overcome the barriers in order to speed the proper development and utilization of software in developing countries.

A BALANCED PATH FOR SOFTWARE DEVELOPMENT

The problem in the past with the manner in which the development of a software industry has been approached in developing countries is that it has been skewed towards:

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[13] Schneider, op. cit. p. 23.

- An emphasis on exports of software services;

- A bias towards the newly industrialized countries;[14]

- A lack of a balanced approach.

The four broad categories of application of software in developing countries are:[15]

- Applications for basic needs and the agricultural sector;

- Applications in the government sector;

- Applications for productivity improvement in industry and service sectors;

- Development of trade and export of software packages and services.

In order to develop a suitable software industry, a balanced approach that takes into account all four of the above areas of application and their inter-relationships is required. This entails understanding how export trade is linked with domestic demand and how the different elements of domestic demand relate to each other.

In addition, a balanced approach must take into account the types of priorities and constraints relevant to the development of these countries. While there are wide variations between developing countries, some generalizations can be made:

- A need to expand exports in order to earn foreign exchange for the acquisition of technology and other inputs to the economy. This is a pressing need for most developing countries, but with the exception of the NIEs, the export performance of most of the South has not been very encouraging in recent years, partly due to declines in commodity prices and partly due to increased competitive pressures. For some countries, there is the added burden of heavy external debt that further encourages a strong need to export. As far as exports of software services are concerned, this possibility only exists for a handful of developing countries, those with large pools of trained human resources. For the most part, developing countries face shortages of trained personnel in the software sectors. However, they may have export opportunities in other sectors which could be expanded by improving the competitiveness of these sectors or sub-sectors through the proper application of productivity improving techniques, including software;

- A need to address pressing social and economic problems - health, employment generation, income generation, nutrition, education and the over-arching problem of environmental protection. Again, software can

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[14] See, for example, Schware, op. cit. 1989, which deals explicitly with the implications for the NIEs.

[15] R. Narasimhan, "Guidelines for Software Development", UNIDO, Vienna, Working Paper, UNIDO/IS.439, 10 February 1984.

play a productive part in this context by enabling the improvement of the quality of social services, administration of health care, education and skill upgrading, etc. For the group of countries categorized as "least developed" by the United Nations, these problems are perhaps the most pressing;

- A very large role played by the state machinery in all sectors of the economy. This has two implications: first, the government is often the largest market for goods and services in the country and as such causes its own huge purchasing power to influence industrial development in desired directions. In many countries, especially India, China and Brazil, the computer industry has received a strong impetus from the public sector, accounting for over 50% of total output of the industry in India for example. Secondly, the government bureaucracy is itself a source of administrative inefficiency that has an adverse impact on the rest of the economy. Proper applications of software in large government bureaucracies could improve their own efficiency and thereby improve the environment within which industry functions. In many developing countries, it is the government bureaucracy that is often cited as the main obstacle to industrial growth - the minor problems and delays associated with getting permits and approvals, the enormous paperwork involved in importing equipment or obtaining foreign exchange, the complexities of the regulatory system, etc. all militate against the efficient working of industry in these countries. While software will not be able to solve all of the inherent problems in third world bureaucracies, it would certainly help;

- A trend towards liberalization of the economy. Spurred by the initiatives of the World Bank and the International Monetary Fund in the 1980s, many countries have enacted structural adjustment programs aimed at developing market based economic systems and opening up their domestic sectors to international competition. The results of these efforts have been mixed, with the least developed countries perhaps faring the worst as a result of poorly designed and implemented programs. Inertial tendencies from the times of protected domestic markets, along with a general lack of capability to compete effectively in international markets have had adverse impacts on some countries. Others, however, have continued to aggressively privatize their public sector corporations with some success, for example, Mexico. In all cases, however, there is now increased pressure to become more competitive and efficient simply in order to survive the new economic climate. There have been positive developments on the "input" side as a result of liberalization, as countries have gradually relaxed barriers to imports of technology and products in a variety of industrial sectors, including the computer industry. On the other hand, the private sector continues to be relatively weak in most countries, whereas it could be the most dynamic and innovative;

- Finally, there is the common concern in all developing countries with the development of endogenous capabilities, however defined, so as to be able to pursue self reliant and sustainable paths of development. More specifically, the concern is focused on developing technological capabilities so as to be better able to develop, acquire, adapt and use technology for development. This need applies as much to software technology as it does to other areas, and the development of long term capabilities in software technology and know-how needs to be a central

consideration in any policy making exercise. We shall return to this issue in the next section.

Developing a balanced approach to software in developing countries therefore needs to be based on a number of considerations:

- The generation of both a demand for software services, and the enhancement of the supply of inputs, such as trained personnel, for the growth of the industry. Demand generation is a role that the state can and should play through its purchasing policies and various incentive schemes. Training programs and relaxed import regulations can support the supply side;

- A balance must be achieved between the concern over exports and the generation of a domestic demand and capability to meet this demand. In the long run, an export capability cannot sustain itself without a strong domestic base - this is a lesson learned in many industrial sectors and is indeed a key element in determining the competitive advantage of a country in a particular industry. An overemphasis on exports can in fact lead to an "enclave" situation, where the export oriented industry has very few linkages within the domestic economy. In the extreme, this industry could price itself out of range of domestic firms and this may already be happening. For example, even though Indian software engineers are inexpensive by world standards, they are very highly paid by Indian standards. A software engineer in India with 3-4 years experience earns as much as someone with 15 years of experience in other fields. This reflects itself in the cost of software services to Indian industry, and makes software affordable mainly to the large corporate sector or the government. Small businesses are unable to afford these services;

- The development of local capabilities for the long term in the appropriate areas of software engineering. Since the global industry is itself undergoing a major change, it is not clear exactly where efforts should be focused. Imitative strategies will not work for a number of reasons, not least of which is that the path that the software industry in the North has followed is itself being questioned. Some of the problems that software will be called upon to resolve include:[16]

  - Problems that are not amenable to algorithmic solutions;

  - Problems that involve judgmental decisions;

  - Problems that require very context specific knowledge that must be consulted dynamically, for example, medical diagnostics;

  - Problems where the solutions cannot be specified beforehand, but must evolve in an open-ended fashion;

  - Problems that involve the integration of a mixture of system components and are based on inadequate or poor quality data.

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[16] Schware, 1989, op.cit.

Furthermore, the economics of software production are changing, with an increasing emphasis on software quality, productive efficiency, economies of scale and market intensity, increasing intensity of R&D (which is itself a barrier to entry), and the lack of availability of financing and venture capital for new start-up firms.

As the technology of software develops, new possibilities are opening up, and new demands are being placed upon the technology. For example, there is increasing interest in the potential of process control and monitoring software, based on expert systems, to address environmental pollution concerns in small firms in the U.S. In fact, the increasing concern over the environment is raising a new set of challenges for the industry world-wide. On the hardware side, many of the manufacturing processes associated with computers are now being questioned for their environmental soundness. On the software side, the potential for solving pollution problems at all levels, in industrialized and developing countries, is being explored. Software packages have already been developed to anticipate toxic spills from factories and avoid the chances of reoccurrence of a Bhopal type incident.[17]

An important recent development is "knowledge-based engineering" which is a software technology that, "provides a means of storing a product or process attributes, rules and requirements. The rules and requirements can generate designs, tooling or process plans automatically".[18]

Unlike traditional CAD software, knowledge-based engineering systems capture the intention behind product design and provide a richer and more flexible design tool. Companies such as Eastman-Kodak and General Electric have been able to cut down design times by orders of magnitude with this software. In an age when "time to market" and "design lead times" are crucial to achieving a competitive edge in the marketplace, the value of knowledge based engineering cannot be underestimated. For the third world, where design times are typically much longer, the application of an appropriate form of this software could yield significant competitive benefits in three respects:

- Reduction in time to market;
- Leveraging of existing engineering knowledge;
- Improved capacity for concurrent engineering.

At present, knowledge based engineering systems require fairly large and powerful systems, but with advances in hardware technology it is not unlikely that they will be able to reside on smaller work-stations or even PCs in the near future.

All of this needs to be seen within the context of the emerging new paradigm of manufacturing itself, discussed earlier. In fact, the issues

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[17] See the HASTE system, developed by ERT in Concord, Massachussets, which is a computer based system for predicting and mitigating potential impacts of a toxic chemical release. The system has already been installed in a number of chemical plants around the United States.

[18] Lawrence W. Rosenfield, "Using Knowledge-Based Engineering", Production, November 1989, pp. 74-76.

related to the potential and role of software in developing countries reflects the problems and issues facing the developing world in general as it addresses the challenge of how to develop in a new global context where competition and productivity have become critical requirements. Software technology can make a significant contribution to manufacturing efficiency in developing countries.

TECHNICAL CHANGE AND TECHNOLOGICAL CAPABILITIES: THE EMERGING PERSPECTIVE

The question of developing domestic technological capabilities in software has been discussed earlier. Much has been written about the general problems of technological capability development in the third world. Recent developments in research on technical change have however shed a different light on what constitutes technological capability. Before turning to the specific question of what technological capability in software involves, therefore, it is useful to briefly review the changing concepts of technical change and in particular technology choice.

Technology choice is no longer as simple as the neo-classical view would suggest. Other factors must be considered in the process, including the current economic conditions in the South, the structure and efficiency of the market, issues of uncertainty and incompleteness of information, the role of management and other "soft" assets, and the evolutionary nature of the technical change process itself. Research by a number of economists, including Richard Nelson and Sydney Winter, Giovanni Dosi, and, for the developing countries, Jorge Katz and Sanjaya Lall, have developed this perspective and provided a new conceptual tool kit for the analysis of technical change.[19] This growing body of literature suggests that technological change does not occur in the steady, linear and incremental way presented in traditional economic models. These models assume that technological change occurs as a spontaneous and linear response to signals from the marketplace; that the market functions perfectly and spontaneously, such that these signals precisely reflect a demand for technological innovation that will always provide a competitive edge to any company that can meet the demand; and that all market actors will read the commercial environment, and react to it, in the same way.

These assumptions of perfect response to market signals, perfect market functioning, and homogeneity of all market actors are gradually being replaced by a new model of technological change which is less linear and leaves more room for interpretation, but which fits better with the process of technological change as it actually happens. This model stresses factors that control the diffusion of technological innovation, such as the tacitness of technical know-how (i.e. the difficulty in codifying such knowledge completely), the appropriability of the returns from innovation and the

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[19] See for example: Richard Nelson and Sydney Winter, An Evolutionary Theory of Economic Change, The Belknap Press of Harvard University Press, 1982; Giovanni Dosi, ed., Technological Change and Economic Theory, Pinter Publishing, 1988; Jorge Katz, "Late Industrialization, Innovation Processes and the Theory of Technological Change: Notes Emerging from the Latin American Experience", mimeo, 1990 (notes for a contribution to Science, Technology and Development: A Sourcebook, Francisco Sagasti and Jean-Jacques Salomon, eds., to be published in 1991; and Sanjaya Lall, Building Industrial Competitiveness in Developing Countries, OECD, Paris, 1990.

important role of learning. It more accurately accounts for the complex interaction between all stages of the innovation process, from basic research to commercialization, and better explains the wide variations in patterns of technological change in different industry sectors. Given these differences to traditional economic models, this new model is more demand-driven and stochastic. With reference to the search process, it emphasizes how firms are likely to search first at the boundaries of their own knowledge before moving too much further, how the uncertainty and lack of information associated with new technology may steer them in directions that are "safer" rather than more innovative, and how over time, firms move in directions that allow them to accumulate learning and know-how in an evolutionary fashion.

This perspective also puts a needed stress on the "soft" side of technology, pointing up the fact that technological change is not simply a matter of installing new hardware. New hardware brings with it a host of demands for new learning and ancillary technologies needed to maximize the value of the new equipment. This perspective is especially important in the area of computer technologies, which tend to be whole systems involving software, hardware and service.[20] It is also important in the sense that it is precisely in optimizing this "soft" side of the manufacturing process that software can play a vital role

The "soft" side of technology is receiving increasing attention in the literature. In a recent review of the literature on flexible specialization and third world industrialization, James and Bhalla note the increasing emphasis being given to organizational innovation. The empirical base for this trend in the developing countries, however, remains small. However, they cite a recent study of the garment industry in Cyprus, which showed that three changes - reorganization of the production line, introduction of a computerized information processing system and the closer integration of marketing and production - contributed to a substantial improvement in the competitive position of the firm.[21]

There are other reasons why the "soft" side of technology may be particularly suitable for developing countries to try to improve. Pressures to lower cost and reduce waste, to manage inventories, reduce design lead times, and satisfy a more differentiated market can encourage the adoption of organizational innovations. The relatively lower costs of introducing such innovations, over hardware, is also to be considered.

This admittedly more complex model is nonetheless more accurate for understanding technology choice and innovation in the context of the weak and distorted markets, institutional weaknesses, and the lack of access to information that characterize many developing countries.

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[20] "Transfer and Development of Technology in the Least Developed Countries: An Assessment of Major Policy Issues", United Nations Conference on Trade and Development (UNCTAD), Geneva, 17 August 1990.

[21] Jeffrey James and Ajit Bhalla, "Micro-electronics, Flexible Specialization and Small Scale Industrialization in the Third World", Working Paper No. WEP 2-22/WP.220, International Labor Office, Geneva, August 1991. The study they cite is by Raphael Kaplinsky, "A Case Study of Industrial Restructuring: From Mass Production to Flexible Specialization", IDS, Sussex, 1990.

Developing country firms generally have weak domestic technology generation capabilities. This is particularly true in the software business. Therefore, the search for technology is likely to be primarily an external one that is limited and conditioned by what they know to be available. Hence the quality of the search process becomes an important determinant of the quality of technology choice. This capability is often referred to as "technology intelligence", or as "technology sourcing and intelligence"[22] and is a crucial component of overall technological capability in software.

The concept of "technological intelligence" is important for our purposes because it encompasses a wide range of capabilities with respect to the ability to effectively identify, acquire and use technology. It includes capabilities with respect to:

- The identification of technological needs at the firm, sectoral and national levels;
- The assessment of available technology;
- Technology sourcing capabilities, along with the ability to monitor technological developments on a global basis;
- The management of technology;
- Technology forecasting and impact evaluation.

Developing such capabilities requires a detailed understanding of the entire technical change process as well as a range of practical initiatives directed at institutional development, skills, and policies. Furthermore, it must be based on a deep understanding of the constraints under which firms in developing countries operate, for example:

- Poor information about technological alternatives;
- Shortage of skills in technology acquisition and adaptation;
- Financial constraints;
- Small domestic markets;
- Poor quality control;
- Bureaucratic constraints imposed by governmental policies and structures.

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[22] See, for example, Michael Radnor and Timothy Lavengood, "Technology Intelligence and Sourcing: Issues and Opportunities for Developing Nations", Working paper, Center for the Interdisciplinary Study of Science and Technology (CISST), Northwestern University, 1990 and "The Technology Gateway Organization: A Mechanism for the Promotion of Technological Development and Industrial Competitiveness for Developing Countries", Atul Wad, Working paper No. 8, Technology Assessment Policy Analysis Project, USAID, December 1990.

TECHNOLOGICAL CAPABILITIES FOR SOFTWARE

Drawing from this broad overview of the dimensions of technological capability in developing countries, it is possible to narrow down to the specific elements that appear to be most crucial to the development of such capabilities in the software industry. Three broad categories of capability can be identified as important for the software industry:

- Capabilities in monitoring and sourcing of software techniques and know-how on a global basis - technology sourcing;
- The ability to adapt and digest technology obtained from external sources for local purposes and to develop technologies locally - technology adaptation;
- The capacity to deliver the technologies to the end users effectively - technology delivery.

Of these, the most important with respect to software is the capability to source effectively. In the case of adaptation and delivery, the issues involved are more or less the same as with other areas of technology.

Technology Sourcing

The effective sourcing of technologies by firms in developing countries is increasingly being recognized as vital to the long term development of technological capabilities. In the industrialized countries, corporations both large and small are appreciating the value of external sourcing of technology, and its importance to their competitive position. For developing countries, this is particularly important in fast moving areas of technology, such as software, which are also typically the areas where they have the weakest endogenous technology generation capabilities.

Technology sourcing is more of an art than a science. Practitioners in the U.S. each have their own particular approach and style. However, certain general principles can be identified that have proved useful in the sourcing process:

- A horizontal perspective on technology; applications in one area may have value in another;
- A global perspective; even though the U.S. dominates the software business, important applications may be available elsewhere;
- Sourcing is a cumulative process, not a one shot event; it must be an on-going effort on the part of the firm, even to the point of designating a person or persons with the sole responsibility for this activity;
- Personal visits and contacts are always more effective than arms length transactions. This is repeated by almost every professional involved in this business. The quality of information and the interest that is stimulated is much greater when personal contact has been made;

- The search must be based on a careful assessment of software needs of the domestic industry; it must be based on a market "intelligence" and technology needs assessment. Prior to starting a search for technology, a demand survey is desirable. The types of questions that need to be answered are illustrated in Figure 3.

FIGURE 3
QUESTIONNAIRE FOR TECHNOLOGY NEEDS ASSESSMENT

1. What are your major software needs at present?
   - Management applications (accounting, finance etc.);
   - Spare parts and inventory control;
   - Production (e.g. MRP);
   - Quality control;
   - Service and maintenance;
   - Other.

2. What business goals will this technology satisfy?
   - New products;
   - Improved quality;
   - Exports;
   - Reduced costs;
   - Larger volumes;
   - Customer relations;
   - New markets.

3. How do you normally identify the sources for software?
   - Personal contacts;
   - Literature;
   - Trade shows;
   - Research institutes;
   - Universities;
   - Consultants;
   - Sales calls by equipment manufacturer.

4. What factors do you consider in selecting a specific software package?
   - Cost;
   - After sales service;
   - Reputation of supplier;
   - Quality;
   - Compatibility with existing software;
   - Ease of use;
   - Level of training needed;
   - Cost of maintenance and trouble-shooting.

In addition, software firms may find it useful to collect background data on the firms they see as potential clients and use this to do their own analysis of the types of needs of these firms that could be satisfied by appropriate software. A typical listing of the type of information that would be needed to identify the specific software needs of a firm is shown in Figure 4.

FIGURE 4
DIAGNOSTIC SURVEY FOR ASSESSING SOFTWARE REQUIREMENTS

1. CORPORATE PROFILE
   - Ownership
   - Employees
   - Sales (Annual)
   - Products (Range of Products)

2. MARKET POSITION
   - Market share
   - Major competitors
   - Distribution networks/channels
   - % of sales for exports

3. TECHNOLOGY
   - Type of equipment
   - Age of equipment
   - Source of equipment

4. PRODUCTION
   - Throughput (volume per hour or day of product)
   - Number of shifts
   - Raw materials
   - Percentage waste/scrap
   - Down time of equipment

5. QUALITY
   - Product image among consumers
   - Number of defective parts produced
   - Average inventory
   - Equipment failure frequency
   - Quality of raw materials and other inputs
   - Number of customer returns

6. HUMAN RESOURCES
   - Management/employee ratio
   - Skills profile and areas of weakness.

The purpose of this information is primarily to be able to assess where there may be room for improvement in the performance of the firm and how this could be accomplished through software introduction. For example, the quality related questions may reveal that the company has a poor image because of a high level of returns, which is in turn a function of poor internal quality control, which could be improved by introducing a total quality management package to the company.

The above discussion reflects to some extent the real experiences of some software companies in developing countries.

Lessons from an Indian Software Company

One of the largest Indian software companies has stressed the sourcing of new products and technologies for years, with considerable success. Based

on interviews with a senior executive from this company, the following general lessons about sourcing were drawn:[23]

- Sourcing as such is not a difficult task, but is labor and time intensive;

- Fairs and expos around the world tend to be an important source of information, and travel to these shows on a regular basis is essential;

- Of the three main regions for sourcing, Southeast Asia, Europe and the U.S., Southeast Asia is good for low end hardware needs, Europe for medium level hardware needs, and the U.S. for software. Europe is a good source for customized software and Southeast Asia has little to offer in software;

- The demand for software exists in the domestic market. The needs have to be understood, though. This can be assessed through surveys or other channels - trade journals, manufacturers' associations, feedback from the sales force, and from government sources;

- Generally, large customers know what they need, whereas the smaller companies are less clear and have to be persuaded;

- It is good to have a long shopping list when starting the search and sourcing effort since not all needs will be met;

- Keeping abreast of the technical literature is extremely important, especially when entering the final stages of negotiations for technology purchase;

- Part of the sourcing effort is to determine what products and technologies are working well in the North, since this enhances your confidence level;

- Having a clear-cut procurement policy and machinery is important to expedite the acquisition of the technology once it has been selected;

- The sourcing effort, as well as the adaptation process should be properly costed out and this cost should be reflected in the price charged to the customer. Firms tend to ignore these costs and often underprice a new product.

Finally, in the acquisition of technology, there is the entire issue related to negotiating. In the case of software, negotiating becomes particularly difficult because of intellectual property rights issues and the problems of valuating the worth of what is essentially a product of "brain-power". The acquirer of technology needs to be able to negotiate with a full knowledge of the legalities, accounting issues and proprietary issues involved in order to get the best deal. Strengthening negotiation capabilities for

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[23] Interview with Arun Tolani, President, ICIM, U.S.A., and formerly Vice-President, ICIM India.

software acquisition is an important component of the technology sourcing capability of a firm.[24]

Technology Adaptation and Technology Delivery

Acquiring the right type of technology is the first step, and must be followed by an efficient process of "digestion" and delivery of the technology. Firms in developing countries often spend long periods adapting and absorbing new software technology. Yet, this is a real cost to the firm and needs to be minimized. There are few studies that examine the processes that follow the acquisition of technology by a developing country firm, and as such our understanding of how this could be improved is limited. On the delivery side, the same issue arises. Adapting the software to the specific needs of the customer, training the user and providing efficient follow-up assistance and trouble shooting is essential to the successful utilization of the technology. Few firms in developing countries pay attention to this aspect, and often leave the customer stranded with a software package that he cannot use.

THE SOFTWARE INDUSTRY IN JAMAICA: AN ILLUSTRATIVE ANALYSIS

It is useful to examine the specific situation of the software industry in a particular country and a recent study by Gillian Marcelle of the Jamaican computer services industry is useful in this regard.[25] The study is one of the few thorough analyses of a domestic computer industry in a developing country and provides an excellent micro-level assessment of the problems and issues faced by the industry. This section draws heavily on the Marcelle report.

Sourcing of technology by Jamaican firms tends to be heavily oriented towards the United States for both hardware and software. In the case of hardware, the larger corporations, such as IBM, ICE and Apple tend to dominate. In the software area, the sources tend to be: hardware manufacturers of operating systems, software specialist houses, and specialized applications suppliers. Jamaican firms also source software through large distribution houses in the U.S. Throughout, the U.S. dominates, though some sourcing does take place from other countries, such as Taiwan, Canada, U.K., Sweden and Belgium. About 20% of Jamaican firms source locally as well.

On average, the costs of sourcing were estimated as between 0.3% and 24% of revenues for the firms studied. This included expenditures on:

- Technical support fees, training and trouble shooting;

- Purchases of related information, manuals, training course etc;

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[24] See, for example, S. Soltysinski, "Strengthening Negotiating Capabilities in the Acquisition of Hardware and Software in Latin America", UNIDO, IPCT.15, February 1987, Vienna.

[25] Gillian Marcelle, "Industry Profile of the Jamaican Computer Services Industry", Consortium Graduate School of Social Sciences and Institute of Social and Economic Research, University of the West Indies, Kingston, Jamaica, 1991.

- Acquiring general technical knowledge in the information services field and keeping abreast of technological trends. Expenditures on conferences, trade shows, industry reports etc. would be included here;

- Subscriptions and fees for access to electronic databases;

- Fees for training courses and seminars.

The average level of expenditure on technology acquisition is high compared to other sectors in Jamaica, indicating the relative importance of this function to the computer industry.

The report also examined the sources of technological know-how used by Jamaican firms to augment what they obtained from the suppliers of technology. Trade shows, conferences, technical journals and training programs were important for this "general capability development" purpose.

In assessing the overall industry, Marcelle concludes that in Jamaica, "All of the technology acquisition activity and in-house technology development is aimed at the product development stage. Training courses, purchase of journals, trade literature and newsletters as well as attending conferences and trade shows all provide detailed product knowledge and equip the Jamaican technologists with a working knowledge of information technologies. Armed with these two inputs, they adapt and modify received information and products to create versions of existing applications or to enhance products but not to fundamentally alter their characteristics of capabilities (emphases added)." [26]

As such, even though the Jamaican industry has become very adept at identifying and adapting technology from overseas and staying current with the state of the art, domestic technology generation capabilities remain weak. To be able to contribute substantially to the competitiveness of Jamaican manufacturing firms and the efficiency of the services sector, this capability is essential.

CONCLUSION: THE IMPORTANCE OF THE "SOFT" DIMENSION OF TECHNOLOGY

This paper has attempted to provide some insights into the importance of software for upgrading productivity in developing countries. It is at best a cursory analysis, since the empirical base for the application of software to domestic industry in developing countries is weak, and is very scant when this question is addressed within the context of the new techno-economic paradigm.

Nevertheless, the writing is on the wall - to improve productivity, firms all over the world are having to look at the "soft" dimension of technology - the intangible processes and linkages that are as important to efficiency as the equipment itself. In Japan, the appreciation of these "soft" assets has reached a very high level In the U.S., the larger firms are beginning to appreciate it. But in the third world, there is still a long road to travel.

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[26] Marcelle, op. cit. p. 24.

For the software industry the challenge is simple to describe and difficult to accomplish: identify where domestic firms can gain the most from software applications; find the relevant software technology wherever it is, adapt it to the local needs and deliver it speedily and effectively to the users.

For policy makers, the need is to develop a more balanced long term approach to the promotion of the software industry, taking into account the complexities of the modern global economy. Most importantly, there must be a balance between export emphasis and the generation of domestic demand. Making it easier for local firms to access and acquire software technology and develop domestic capabilities are two areas where the state can play a very positive role, by relaxing restrictions on imports of technology and using its own sizeable purchasing power to shape demand. Policy makers also need to look at innovative organizational mechanisms that could be established to improve technology acquisition and commercialization - technology incubators, technology sourcing mechanisms, technology banks and clearinghouses, etc.

On the policy research side, much more empirical work is needed on the micro-level. How firms acquire technology, what determines their competitiveness, and how technology is digested and adapted are all processes that need to be better understood in order to more clearly articulate the proper role of software.