PN-ABH-130

THE ECONOMICS OF TECHNOLOGY
WORKING PAPER NUMBER 2

TECHNOLOGICAL CAPABILITIES AND ORGANIZATIONAL PERFORMANCE IN DEVELOPING COUNTRIES

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December 1990

Bureau for Program and Policy Coordination
U.S. Agency for International Development

Technology Assessment Policy Analysis Project
A.I.D. Contract No. PDC-0091-C-00-9092-00
SRI International

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I. INTRODUCTION

The focus of this paper is on the determinants of success for firms in developing countries. Recently, there has been a growing emphasis in the literature on the relationship of technological capability to successful industrialization in LDCs.[1] This paper explores the concept of technological capabilities with a view to identifying its constituent elements and their relationship to organizational performance.

There are a variety of viewpoints about the appropriate route to industrialization for developing countries. The success of the East Asian NICs (Newly Industrialized Countries) has prompted various attempts to understand the reasons and their relevance to the rest of the developing world (e.g. Amsden 1989, Mody 1989, Ernst and O'Connor 1989). The concern is to identify the proper mix of policy measures that will provide the right incentives for industrialization. Opinions vary from an emphasis on heavy state intervention to those that favor a more "neutral" or "laissez-faire" role, with the latter becoming more prevalent lately.

It is not the purpose of this paper to focus on these continuing debates and discussions. Rather, the focus is on what Lall refers to as the "basic building block of industrial success" (Lall 1989), the firm. It is within the firm that

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[1] See, for example, the recent work of Lall (1987), Westphal et.al (1990) and Dahlman and Brimble (1990).

technological capability is articulated and manifested. The specific components of this capability and their relationship to organizational performance are the concern here.

Three broad perspectives guide the discussion in this paper. First, the dramatic technological and economic changes occurring in the global economy, and the emergence of what Perez (1989) refers to as the new "techno-economic paradigm"[2] have created a radically new environment for developing countries and their firms. This new environment is characterized by rapid advances in information based technologies (the "informatics revolution"); new sources and forms of competition, in particular from the NICs and the second tier NICs (Thailand, Indonesia etc), changes in market demand patterns which emphasize customized products and services; the globalization of manufacturing and the emergence of new systems of manufacturing based on flexible production processes; a new definition of efficiency principles based on flexibility and responsiveness; and the emergence of regional groupings. This new environment presents both threats and opportunities to developing countries -- the prospects of falling further behind technologically, but also the potential of exploiting new "windows" of opportunity in the global marketplace (Perez and Soete 1988).

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[2] For detailed discussions about the new "techno-economic paradigm" see Freeman and Perez (1988), Perez (1989) and Kaplinsky (1989) and Piore and Sabel (1984). See also Jaikumar's (1986) discussion of "post-industrial" manufacturing.

Second, the view of the Third World as a homogeneous entity of similar nations is obsolete. There are wide variations in terms of industrial development, natural resources and endowments, technological capabilities, etc., which make generalizations at one level impossible and pointless. A theoretical framework based on a more focused view of the specific characteristics and competitive advantages of each nation, would be far more fruitful and realistic. Such a framework would need to address the difficult question of identifying variables and categories that can indeed allow for generalizations across countries and firms and simultaneously preserve the specificity of the different contexts. In this regard, Porter's (1990) recent analysis of the competitive advantage of nations offers a powerful contemporary framework.

Finally, the firm is viewed here as a unique and proactive entity with specific characteristics, strengths and weaknesses. This is in sharp contrast to the neo-classical view of firms as basically homogeneous (generally small), with equal access to information, technology and resources, that react passively (but instantaneously) to signals from the environment. This admittedly more elegant and "clean" view of the firm is rejected in favor of the "muddier" but more realistic and tangible concept of the firm that is implicit in the models of firm behavior and innovation developed by, among others, Nelson and Winter (1982), Katz (1987), Dosi (1986) and Teece (1986), and also in the mainstream organizational behavior literature (e.g. March and Simon 1958).

A central argument to this discussion is that the circumstances faced by a typical LDC firm[3] are qualitatively different from those faced by firms in industrialized countries. There are fundamental differences in the firm's structure; its relation to technical change and its approach to innovation; the infrastructure and the regulatory and institutional environments; the opportunities and threats that it faces, the predominant types of production processes in use, its relations with suppliers and finally, the factors that determine the firm's success in its operating environment. These differences taken together have strong implications for the analyses of the determinants of technological capability and organizational performance of an LDC firm. Theories of innovation in the industrialized countries must be reassessed for their relevance to LDC firms, and certain key concepts such as innovation, technological capability, and performance need to be modified.

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[3] We use a somewhat limited concept of an LDC firm here for the sake of argument, as one which is wholly locally owned, is involved in some form of manufacturing activity, is mid-sized (by developing country standards) and does not have any strong political ties. There are in reality, however, a range of types: wholly owned subsidiaries of MNCs, joint ventures, publicly-owned companies; those which are largely export oriented, or largely domestic market oriented, firms located in free trade zones, and firms of varying sizes. These issues become important in terms of which types of firms are likely to be more efficient at introducing new technologies and new organizational processes and at exploiting market opportunities. Katz (1984) discusses how different types of production firms develop technological capabilities and Hoffman (1989) discusses how different types of firms may be better or worse at introducing new management techniques.

The objective of this paper is to define the specific qualitative issues that affect an LDC firm's innovativeness and its participation in the global economy and to suggest a framework for the analysis of LDC firm's in terms of technological capabilities[4].

A key concept in this paper is that of "technological assets", the resources of an organization that influence its ability to be a successful player in the global technological and business environment. These "assets" may be either "hard" (e.g., patents, R&D resource, equipment) or "soft" (marketing and distribution, efficient management and human resources). It is argued that "assets" is a more useful concept for understanding the complex question of firm level performance in developing countries than the more conventional focus on technological innovativeness. The extent to which these "assets" are used

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[4] A distinction, now commonly in use in international management consultancy, is made between "international" taken to refer to transactions between firms across national boundaries, and "global" to refer to transactions between firms on a global basis, which <u>includes</u> international transactions. Thus, the scenario faced by a LDC firm seeking to export into world markets is seen as similar to that of a LDC firm competing with foreign companies in its own markets. Clearly, differences will persist so long as there are nation-specific barriers to free trade, but with the current opening of markets in certain countries, there is a relatively lesser distinction between these types of transactions than under prior more "dirigiste" and protectionist environments. In an idealized world of totally open and free markets, the distinction would almost vanish and the remaining differential would derive essentially from the location specific competitive advantages of firms (i.e., access to customers, resources, raw materials) and locally specific contextual conditions (e.g., existence of industry clusters, size of local market, technology infrastructure, etc.).

optimally by the firm is in part determined by its "technology process effectiveness," which includes the internal organizational dynamics whereby a firm receives, processes and responds to market, technology and policy signals from its environment and from within.

Why are these concepts useful? To answer this question it is necessary to examine some of the qualitative differences in the circumstances and character of LDC firms as they relate to questions of performance and competitiveness.

The next section therefore explores in some depth the nature of these differences. This is followed by a more detailed description of technological assets in relation to the concept of technological capabilities. An analytical distinction is made between technological assets and technology process effectiveness as two components of technological capabilities.

The following section explores in more detail the concept of technological assets, their dimensions, the factors that influence their value and thus lead to variations in assets, and the broad categories of assets.

This is followed by a description of what is meant by technology process effectiveness, which includes a discussion of the factors that impinge on organizational performance in LDCs, the implications of the new "technoeconomic paradigm" for notions of efficiency, and the dimensions of technology process effectiveness. The concluding section offers some preliminary

insights into the implications for firms and policy makers in developing countries.

II. TECHNICAL CHANGE AND THE DEVELOPING COUNTRY FIRM

Implicit in the usual treatment of technical change, competitiveness and organizational performance is the presumption of a qualitative equivalence between the circumstances and characteristics of a LDC firm and those of a firm in the industrialized world. At a general theoretical level this may be true -- all firms are involved in the process of production and delivery of goods and services ostensibly for a profit or similar organization goal.

However, it is important to understand that the LDC firm is different in at least two important respects from a developed country firm.

The first difference is with respect to the context in which it operates. In developed countries, firms are organic and natural components of a broader social and economic process of industrialization. The firm exists in an environment where institutions, services and infrastructure have evolved as complementary. In a sense, the firm exists in a relatively "friendly" environment--one where the supply of skills (e.g., from universities), resources (e.g., venture and risk capital), infrastructure (transport), institutions (banks, regulatory agencies) and values complement its own.

This is not necessarily so for the LDC firm. Its environment is typically "unfriendly." It must deal with a

hostile bureaucracy, suffocating laws and regulations[5], a lack of services such as phones and transportation taken for granted elsewhere, and with a currency that is often of little value outside the country. It is, in a sense, disjointed from its context. The challenge of participating in the global economy competitively is therefore compounded for a DC firm.[6]

LDC firms also differ in how they relate to or confront technology. This is a complex issue because there is still little consensus on the nature of technology and technical change, the character of innovation in developing countries and the implications and impact of technology transfer (TT) from industrialized nations.[7]

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[5] For instance, Lall (1987) describes the tremendous stranglehold of the Indian bureaucracy and policy environment on the private sector in India. The development of technological capabilities and learning in the firms he studied occurred in this unsupportive and generally stifling environment. Certain countries, such as India, have historically been more restrictive with respect to the private sector than others and this difference is reflected in the differences in the competitiveness of firms from India in contrast to, say, Taiwan or Korea. Also see Rosenberg (1990) for a critique of the Indian CSIR.

[6] Teitel (1987) describes, in this regard, the "distortions" and constraints faced by LDC firms - credit rationing, raw material quota, import restrictions etc. and their implications for technical change. For Teitel, the state in LDCs takes over much of the entrepreneurial responsibilities and functions from the firm through its heavy involvement in industrial activity.

[7] There is, no doubt, a vast literature on technology and innovation in developing countries. Useful reviews are by Fransman (1986) and Evenson and Ranis (1990). Recent papers that focus on important current issues in technology and development include Katz (1990), Perez (1990), Ernst and O'Connor (1989), Cimoli & Dosi (1988), Stoneman (1987), Cooper and Kaplinsky (1989), Hoffman 1989 and UNESCO (1990). Mention should also be made of a source book on science, technology and development, edited by Francisco Sagasti

A. An Emerging Perspective on Innovation in LDC Firms

A useful approach can be based upon the arguments made by Katz (1990) with respect to the relevance of recent research on innovation and competitiveness to the developing world (in his case, particularly to Latin America).

Katz argues that the neo-classical approach to technical change has serious shortcomings in enabling us to explain the complexities of firm behavior and innovation in developing countries.

> "...even if the neo-classical model could be specified as including an indigenous theory of technical change it is clear that in its conventional presentation the model a priori eliminates major questions related to: (a) the nature of the firm, (b) differences in company behavior due to imperfect information, (c) the role institutional variables play as determinants of individual firm activities, etc. Equilibrium, perfect information, profit maximization, the price system as the only institution transferring information and shaping the behavior of individual agents etc. appear as central features of the neoclassical growth story."
>
> (Katz 1990, p. 4)

The neoclassical vision and policies based upon it do serious injustice to the vital role of firm-specific characteristics, inter-firm differences and the "non-market" particularities of the environment faced by such firms. Indeed,

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and Jean-Jacques Salomon and due for publication in 1991.

However, by and large, a satisfactory framework for the analysis of innovation in developing countries is still lacking. The literature is characterized by different "streams" which reflect the disciplinary and ideological biases of different schools of thought. See Cimoli and Dosi (1988) for an overview of these "streams."

the firm is seen as a passive entity that responds in specific and predictable ways to market forces, and all firms are seen as essentially the same.

Admittedly, there is a growing concern with firm level issues and the implications of new technologies and organizational innovations for productivity and competitiveness (e.g., Hoffman 1989, Perez 1990). There is a growing body of firm level and sectoral case studies as well (e.g., Katz 1984 and 1987).

By and large, however, while there is an analytical focus on the firm, the questions asked and the conclusions drawn still are predominantly at the policy level, i.e., what policies should be implemented in order to promote technological development, productivity and competitiveness? Little if any attention is given to the other side of the equation -- what makes a specific firm succeed?

The relatively recent literature that draws its intellectual roots from Schumpeter's Capitalism, Socialism, and Democracy (1950) offers much more tangible insights into the problem. The work of Nelson and Winter (1982), Freeman (1982), Dosi et al. (1988), Rosenberg (1982) and Pavitt (1984) offer a view of innovation as a powerful and dynamic force in economic growth that is associated with continual change, economic restructuring, the emergence of new forms of manufacturing (and the destruction" of old forms), and new forms of social organization.

"...the professional tool box of the economist is simultaneously enriched and made much more complex.

> imperfect information, uncertainty and disequilibrium allow for behavioral differences among firms, innovative lags and leads, quasi-rents and indigenous changes in market structure. Technological learning can be different from company to company as a function of how much a firm spends in learning, luck, etc. It now becomes possible to postulate models of 'adaptive' behavior in which we do not have to assume that ex ante the firm has entire knowledge of its future technological possibilities. It is also possible to postulate that the objective function of the firm includes more options that the profit maximization one, and this provides room for organizational and behavioral models of firm behavior of the sort proposed in recent years by Simon, March and Cyert, etc." (emphasis added)
>
> (Katz 1990, p. 5)

Powerful as these new tools and approaches may be, they do rest upon certain implicit assumptions about the nature of the firm, the centrality of innovation to competitiveness and the existence of an institutional context that though in a process of change in industrialized nations, is still relatively predictable and designed to support industrial activity. In other words, there is an assumption of interconnectedness and regularity in the midst of change with regard to firms, technology, performance, the role of the state and market dynamics that simply do not directly relate to the LDC firm.

> "It is by no means obvious, however, that the analytical progress currently attained along this line of theoretical work could be straight-forwardly transferred to the (developing countries).
>
> (Katz (1990) p. 6)

There are two reasons for the discontinuity. LDC firms relate to technological change differently than DC firms, and the "restructuring" process in developing countries is also

different, as are the implications of changes in the global technological and economic environment.[8]

B. Meaning of Innovation to LDC Firms

The "neo-Schumpeterian" school emphasizes the centrality of technical change and innovativeness to competitiveness, and this is inarguably true for most firms in industrialized nations, and perhaps for a few in the developing countries. But, for the most part, innovativeness, as understood in terms of proximity to "world technological frontiers" and the successful development and commercialization of new product and process technologies, is not a relevant reality to most LDC firms. As Katz notes, these countries operate "anywhere between one and three decades behind such a frontier." The option of participating in the leading

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[8] The implications of the changes in the global economy for developing countries have been addressed by several researchers, recently, notably Perez (1985), Ernst and O'Connor (1989, 1990) and Cooper and Kaplinsky (1989). Many people have recognized the problem and its consistent ingredients, i.e., the changing character of technology and the implications of the informatics "revolution," the "opening" of previously relatively closed economies, changes in the patterns of work, organization and social processes, the issues facing "latecomer" countries seeking to industrialize, the emergence of new markets and market opportunities and new institutional mechanisms, etc. However, it is still too early to say whether an adequate interpretation and framework for analysis has been developed. There are important missing ingredients, particularly those that deal at the firm level and on behalf of the firm, basically a management strategy for DC firms in the modern context. This may be due to a preponderance in the literature on trying to identify "policy options," almost as a duty in its own right. The presumption is that with the right policy environment, good things will happen. But his only addresses half the equation, the other half, dealing with the firm level of action, remains largely ignored.

edge of technological progress in any particular area simply does not exist. This is not to suggest that the concept of "innovativeness" is not relevant, but rather to indicate that what falls under the rubric of "innovativeness" should be reconsidered in two important respects.

The first has to do with what is included in the notion of technology. One finds a rather peculiar preoccupation in some of the literature on demonstrating the author's understanding of the hardware aspects of technology, as though showing such "hands on" knowledge validates in some fashion the economic analysis that follows.[9] While there is some merit in taking this "hands on" approach, it does reveal both a fascination with the technical details of technology and an implicit assumption about the nature of technology as essentially constituted by hardware.

However, the "soft" aspects of technology are increasingly important, including organizational structure, the "complementary assets" of Teece (1984), the new management techniques (Ito, 1985; Hoffman 1989) and the entrepreneurial quality and values of management.

Organizational success is determined by both "hard" and "soft" aspects of technology, with no prior determination of their relative importance. For LDC firms, given their general inability to participate in the leading edge on the hard side, perhaps the "soft" aspects are more important. Therefore, a firm

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[9] See for example the study by Kaplinsky (1984), which devotes substantial portions to "describing" the technology.

needs to assess itself in terms of both its "hard" and "soft" technological "assets" to ascertain its unique competitive position. For example, Ernst and O'Connor (1989), discuss the possibilities of LDC firms using their access to large domestic markets as a bargaining point in the negotiation for joint-ventures with DC firms.

A second dimension of technology to be reconsidered is the implicit preoccupation with "state of the art" or most advanced technology. A meaningful technology for a LDC firm may be far removed from world frontiers but may still keep the firm profitable and successful in the particular niche in which it operates. This could occur for a variety of reasons: a protective environment which allows the firm to keep its market intact, the existence of a market which because of size or accessibility, is not of interest to other more technologically advanced firms, or simply as a result of the idiosyncrasies of trade and history.

Innovativeness can include product and process development which is nowhere near the world technological frontier. For instance, a firm in Tunisia had based its success on the development of a new packaging machine which was cheaper than the imported alternative. It did not possess all the computerized equipment of imported French and German machines but met the requirements of local packaging firms. This was clearly a case of innovation in a locally defined context. There are innumerable other examples of innovations which derive their

innovativeness by either offering an alternative to imported equipment, making better use of local resources and factor endowments, or adapting imported technology to local conditions, and much of this is captured in the literature on appropriate technology and technology adaptation. These are valid forms of innovation, regardless of their distance from world technological frontiers.[10]

Thus, for a LDC firm, technology must be seen as including both "hard" and "soft" dimensions and encompassing a range of technological areas and levels of technology, and hence a range of potential forms of innovation.

C. The Relevance of the "Stylized Facts" of Innovation

Let us go one step further in this discussion of the relationship of an LDC firm to technological change. For this purpose, it is useful to draw upon some of the "stylized facts" of innovation that Dosi (1988) describes, building on the work of Nelson and Winter (1982), Freeman (1982) and others, and the "barriers to entry" faced by latecomer nations described by Ernst and O'Connor (1989).

In the first instance, Dosi describes innovation as characterized by uncertainty, which entails a lack of complete

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[10] There is nothing new in this point, since the value of indigenous innovation has been long recognized. However, as we shall see later, its inclusion in the overall concept of innovation is important to our understanding of what the "technological assets" of a firm are constituted by.

knowledge about the solutions to existing techno-economic problems and the "impossibility of precisely tracing consequences to actions" (p. 222).

For the LDC firm, this uncertainty also exists but, it can be argued that because it is not as centrally involved in the search for new solutions to frontier problems in technology, there is a lesser degree of technical uncertainty, or rather, that the relevance of technical uncertainty is less for a LDC firm. On the other hand, since it exists in a relatively less sophisticated environment, with poorer sources of information, weaker and more fragmented institutional support mechanisms, and stronger regulatory and resource constraints, it can also be argued that the LDC firm experiences a greater uncertainty with respect to the market. It does not have the same degree of confidence that, if it has a novel product to offer, it could successfully commercially exploit it; it may not know enough about the proper markets, or the proper avenues to pursue for commercialization, or it may not have the required resources and institutional support. There is therefore both a contraction and expansion of the uncertainty associated with innovation for a LDC firm.

Secondly, Dosi describes the increasing scientific content of technological advance, the increasing reliance of major new technological opportunities on advances in scientific knowledge. In industrialized countries, this reliance has provoked a move on the part of firms to strengthen their ties and linkages to the

sources of this scientific knowledge, i.e., the integration of R&D with production.[11] DC firms also pay more attention to developments in basic scientific research on a routine basis and are strengthening their ties to universities and the research community[12].

For LDC firms, this trend has mainly negative implications. Already distanced from world technology frontiers, they find it even more difficult to close the gap.

Furthermore, as the strategic value of science becomes better recognized, "...equality of access to basic research, which was once taken for granted, is no longer guaranteed. Attempts to restrict access of 'foreign' researchers to supposedly strategic areas of basic research, such as super-conductivity, are indicative of this trend," (Ernst and O'Connor 1989, p. 23).

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[11] See Teece (1988) for an analysis of the changing patterns of relationship between the manufacturing firm and the R&D function, and the rationale for stronger integration of R&D within the firm. His arguments against the importance of out-sourcing of R&D are not entirely convincing, partly because he sees in-house R&D and out-sourcing as naturally exclusive. In fact, one requires the other, and several large corporations with strong in-house R&D also give considerable emphasis to external technology sourcing. See also Kay (1988) and Chesnais (1988) for more on this matter.

[12] Japanese corporations, for example, regularly invite scientists from around the world to visit and spend short periods with their own R&D departments. The business value of monitoring scientific progress is also evidenced by the increasing attention being given by corporations to bibliometric analysis of scientific research to identify potential new emerging areas and opportunities.

However, certain developing countries have two points in their favor with regard to scientific research.

Firstly, many of them have made heavy investments in their S&T systems over the past two to three decades, for example, India, Brazil, Argentina and Mexico. Admittedly, these investments, based on a misplaced "supply push" view of the contribution of science to economic growth, have not yielded the expected results. For example, in India, the massive CSIR (Council of Scientific and Industrial Research) system with its scores of laboratories and research institutes has been dismally unsuccessful in feeding industry with useful scientific output. If anything, it has become a barrier to technological development by acquiring the role of "policeman" over incoming technology.[13]

Other problems with scientific research in developing countries have included the "marginalization" of science (Cooper 1973), the lack of a market driven approach to R&D and production and the "brain drain" phenomenon that is partly caused by the education of a cadre of scientists and engineers for whom there is no real demand in the country.

The fact remains that there exist massive S&T structures in some countries and a large pool of highly trained scientists and engineers that could play a productive role in the economy under the right circumstances. LDC firms could, in theory, tap this pool of scientific skills and resources, in certain countries and

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[13] See Lall (1987) for a strong critique of the Indian CSIR. Also Rosenberg (1990).

sectors, quite usefully[14]. Also, scientific labor is substantially cheaper in developing countries and could be utilized by LDC firms, especially for specific contract research.

Secondly, the brain drain itself can be a source of opportunity. A vast number of highly qualified scientists and engineers from countries such as India, Argentina, China, Taiwan and Korea are working in mainstream industries or universities in industrialized countries. Many have returned to their countries of origin to start up new businesses, bringing with them their knowledge and networks. A LDC firm can draw upon this pool of expertise and networking.[15]

Thus, while the scientific content of recent technological advances may present increased problems of entry and access to LDC firms in key areas of technology, the results of prior policy actions and historical processes may be able to redress some of these problems. There is need for research on this subject, since very little data exists on how useful these latent resources really are.

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[14] For example, the efforts by the Indian government to promote software exports based upon the large pool of highly skilled (and low cost) computer scientists and programmers.

[15] It is worth noting here the highly successful TOKTEN program (Transfer of Knowledge Through Expatriate Nationals) of the UNDP, which supports short visits of expatriates back in their home countries to advise and consult on scientific and technical matters. In another example, the Government of India has established a National Biotechnology Board which explicitly sought to include prominent Indian scientists living and working overseas.

Moving to the next dimension described by Dosi, the changing the nature of search activities in innovation, in part related to the scientific content of technological advance and in part to the increasing complexity of technology and research, creates a tendency to formalize the search and access to new research and innovations, for example by integrating R&D within firms. It also brings into prominence the important role of intelligence[16] with respect to global scientific, technological and market trends and opportunities. Modern industrial firms in the industrialized nations are increasing both in-house R&D and external technology sourcing and intelligence (TSI). They recognize that within an environment characterized by increasing technological proliferation, TSI is important for competitive reasons (ie., monitoring technological developments that could lead to potential competition), and because technological opportunities may exist outside the firm. External technology sourcing is not new (see for example, Chesnais 1988), and even a common product such as soft contact lenses was based on a license from Czechoslovakia, but it has become more global in scope and less restricted to the large R&D-intensive firms.

For LDC firms, the implications are clear. In the absence of the resources for in-house R&D, external sourcing becomes more important, and LDC firms have typically looked overseas for much

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[16] Jaikumar (1986), for instance, emphasizes the importance of "intellectual assets" as a source of a company's competitive advantage in the new "landscape" of manufacturing.

of their technological needs. In the past this search process was somewhat ad hoc and idiosyncratic but today the need for a more systematic and structured search process is becoming evident. The potential sources of technology are expanding rapidly to include not only OECD nations, but the NICs and Eastern Europe as well. Furthermore, rates of change in technology are extremely rapid, requiring an ability to continuously monitor trends and developments, especially in the "high technology" areas[17].

Dosi also describes the learning by doing aspect and the cumulative nature of technical change as important attributes of the innovation process. Undoubtedly "learning by doing" is an important phenomenon particularly with respect to the adaptation and improvement of existing technologies. A recognition of its importance is implicit in the emphasis recently on "continuous improvement" a la the Japanese model. For LDC firms, given their weak infrastructural context and poor in-house technology

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[17] An increasing number of large U.S. corporations and MNCs have established "Corporate Technology Sourcing" units or something similar. Typically, these units are charged with the mission of identifying potentially useful new technologies from around the world and "delivering" them to the appropriate division. Some units are also involved in "outlicensing" technologies to optimize the returns on their investments and expenditures on technology. See Radnor & Kaufman (1988) for a discussion of corporate experiences with technology sourcing and its relevance to developing countries. The problem of technology sourcing has interesting theoretical implications in terms of the modalities of search used by a firm, the efficiency of search, the relationship between search and utilization and the behavioral patterns associated with technological search. These are being elaborated in a paper in process, "The Technological Search Process for LDC Firms," by this author.

development capabilities, "learning by doing" assumes an even greater importance. To be successful, a firm must not only be able to use technology well, it often has to adapt the equipment or process to local conditions, and to develop auxiliary skills, such as repair and maintenance, because of the lack of such services locally. Much LDC firm innovation is of this form, as

> "...firms engage themselves in significant 'in-house' engineering and technological efforts, but the large majority of such efforts is carried out with the purpose of adapting product designs and production processes to a different set of raw materials, to a much smaller scale of production, to a different pattern of plant automation, to different organizational and subcontracting practices, etc., than those prevailing in (developed country) factories."
>
> (Katz 1990, p. 9)

But the cumulative character of innovation does not map well onto the LDC firm in the strict sense of a positive and gradual accumulation of knowledge and skills in a specific "envelope" of technological change. For Dosi, firms make technological advances based upon the technological levels they have already.

For LDC firms, the cumulativeness is more closely associated with the enlarging capability to utilize technology than with the ability to develop it.

> "it is principally this ability to learn <u>how to use</u> technology to strengthen competitiveness which distinguishes the successful NIE (Newly Industrialized Economies) firms from the less successful ones"
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> (Ernst and O'Connor 1990, p. 18)

The accumulation of capabilities encompasses technological, organizational and financial learning, and instead of technical

change being determined by previously accomplished technological levels, it is derived from the options that have been opened up by previously acquired capabilities and assets. As such, it is hard to argue that technical change per se in LDC firms is cumulative as much as it is opportunistic, even though in some cases, on the face of it, there may be no difference. This is perhaps best exemplified by the Korean chaebol which have historically relied upon diversification as a strategy rather than focusing on specific product categories.

"The rationale underlying this strategy was that Korean firms could not expect once they had captured a sizeable share of mass consumer goods markets, to sustain growth by upgrading product technology to be able to capture higher value added segments of the same markets. For the most part, they lacked the engineering and R&D capabilities to make the necessary improvements. The path of least resistance, therefore, was to move horizontally into other mass consumer goods markets and to capture the low end of those markets as well, capitalizing on the experience accumulated in low cost manufacturing methods."

(Ernst and O'Connor 1990, p. 28)

Instead of a gradual cumulative process, we therefore have a more ad hoc opportunistic process, which, if anything, seeks to avoid head-on confrontation with technical problems in favor of pursuing the best immediate opportunities. As such, the principle of the "least technological effort" proposed by Sagasti (1988) may be a more useful approach to viewing the behavior of LDC firms.

"The leading firms, and the branch as a whole, will avoid forms of competition that involve major technological innovations and will exhaust all other forms of competition first. There is a strong preference for patterns of competition that involve, directly or indirectly, the least technological effort."

(Sagasti 1988, p. 165)

This view quite effectively removes the proactive, technologically positive content that is implicit in Dosi's notion of cumulative activity in LDC firms.[18]

We have tried so far to elaborate how the question of technological innovation relates to the LDC firm and to identify the key points of difference vis a vis industrialized countries. The direct relationship postulated between innovation, as commonly understood and represented by the "stylized facts" of Dosi, and competitiveness, is simply not adequate to understand the success and failure of LDC firms. The key points of difference, or issues, appear to be: 1) that LDC firms operate in altogether different types of environments, which are less "organic" or "friendly;" 2) that they generally lack the capabilities and wherewithal to be involved in mainstream technological innovation at the world frontier, and 3) that innovation as it occurs in LDC firms is a much broader process, and is driven by qualitatively different imperatives than in a developed country firm, for example, the lack of access to

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[18] There are, of course, exceptions and some qualifying concepts. For example, there appears to be a more straightforward cumulative process in more mature and traditional sectors, such as textiles, though this is focused on the sequential and gradual accumulation of production capabilities and technological adaptation rather than on new product and process developments. For an interesting discussion of the different ways in which DC firms accumulate capabilities of various types (production, investment, technological) see Ernst and O'Connor 1990.

technology, the shortage of skills, the unsupportive environment, etc.

It is now possible for us to turn to a closer examination of the technological assets of a LDC firm.

III. TECHNOLOGICAL ASSETS AND CAPABILITIES

A number of concepts gaining currency in the literature on innovation offer useful encapsulations of specific properties of the innovation process. For instance, Dosi's (1982) "technological trajectories and paradigms," Nelson and Winter's (1982) "natural trajectories," Rosenberg's (1976) "focusing devices," Sahal's (1985) "technological guideposts" and Sagasti's (1988) "principle of least technological effort" suggest why technical change follows certain directions rather than others. The concepts of "appropriability" and "tacitness" (Teece 1986) also offer insights into why firms pursue certain innovations and why they may benefit more from some over others.[19]

A. Technological Capabilities: A Closer Look

Focusing more closely on the literature on technology in developing countries, the concept of "technological capabilities" emerges as prominent. A number of authors have based their discussions on this notion, including Lall (1987), Westphal et al. (1990), Dahlman and Cortes (1984), Katz (1984), Sagasti (1988) and Cimoli and Dosi (1988).

The concern with technology capability or competence reflects the demands of the global environment faced by firms and

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[19] For an excellent overview of the main concepts in innovation research, refer to the collection of papers edited by Dosi, Freeman, Nelson, Silverberg and Soete (1988).

nations today, one where competitiveness, quality, productivity and strategic thinking have become crucial issues and where technological "prowess" and "mastery" is increasingly a determinant of success in the international marketplace.

But it is difficult to find a consistent and coherent definition of technological capability. For instance, Westphal et al. see it in the following sense:

> "From the capability perspective, Third World technological development is a matter of acquiring the requisite capabilities needed to make effective use of existing technology through its assimilation and adaptation"
>
> (Westphal et al. 1990, p. 8)

They then go on to categorize capabilities as operative (production), adaptive (minor change), innovative (major change) and acquisitive (or investment) capabilities, which are further operationalized and used to score the firms in their sample.

Lall also does not explicitly define TC, but discusses it as the ability of a firm to undertake a broad range of technological activities and efforts. However, he sees TC as consisting of five components of a generalized manufacturing process: 1) pre-investment choice, 2) project execution, 3) plant operations, 4) technological improvement and 5) technology transfer. Furthermore, the main criterion for evaluating TC is in terms of its competitiveness in international markets.

These five elements of TC are then refined into the following categorization of how TC occurs in the firm: a) project

execution, b) product engineering, c) process engineering, d) industrial engineering and planning and, e) technology transfer. These form the basis for the framework he uses in analyzing the data in his study.[20]

Lall's conceptualization roughly mirrors that of Dahlman and Cortes, and to a lesser extent that of Westphal et al., which is not surprising since they all derive from a general "World Bank" outlook on the world, which is driven by a concern with policy implications to the exclusion of firm level prescriptions. The firm is essentially seen as a passive agent that simply reacts to its environment.[21]

Furthermore, TC as thus conceptualized is seriously incomplete. As Lall notes himself, there is a wide range of non-technical factors that affect a firm's ability to develop, acquire and use technology, including organizational structure, human resources, financial planning, information and intelligence gathering capacities, strategic alliances, links with suppliers and sub-contractors, distribution channels and systems, relations with end users, etc. There is no systematic effort to conceptually integrate these factors with the more technical

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[20] See the review of Lall's study by Wad (1990).

[21] In a more recent work, Lall (1989) does, however, begin to explore the implications of firm level behavior and the specificity of firm characteristics for the innovation process. "The concept of a neo-classical production function is itself a misleading representation of how firms operate" and "The determinants of firm-level competitive advantage are thus far more complex than conventional theory suggests..."(p. 6)

aspects and the depiction of TC in a firm therefore becomes somewhat distorted towards the purely technical.

However, there is a growing recognition of the vital importance of the non-technical aspects of TC to competitiveness.[22] Even for heavily technology-intensive firms, the ability to enter into the proper types of alliances and to make proper choices to integrate "complementary assets" is an important determinant of the returns they can gather from their technological "resources."

This current concept of TC also implies a linearity in the technical change process. The five components of TC as suggested by Lall, pre-investment choice, project execution, plant operations, technological improvement and technology transfer, imply a staged sequence of activities that does not necessarily occur, nor are these "stages" the only relevant ones to technological change. Often, new product and process improvements are triggered by market signals picked up by a salesperson or the marketing department, or may result from an acquisition, a joint venture arrangement or some form of alliance. Furthermore, success with the new technology is not determined solely by the competencies of the technical departments, but, as Teece argues, from the "complementary assets" available to the firm as well.

Secondly, there is a strong "producer" bias, as Ernst and O'Connor (1990) refer to it, in this conceptualization of TC.

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[22] See, for example, Hoffman 1989; Perez 1990.

"Most of the debate so far has focused on the capabilities of producers, grouping them into four broad categories:

- knowledge and skills required for the process of production, where shop floor experience and 'learning by doing; continues to play an important role

- knowledge and skills required for investment, i.e., the establishment of new production facilities and the expansion and/or modernization of existing ones;

- the vast area of adaptive engineering and organizational adaptations required for the continuous and incremental upgrading of product design and performance features, and of process technology;

- and, finally, knowledge required for the creation of new technology, i.e. major changes in the design and core features of products and production processes.

This producer bias comes as no surprise. After all, material production is at the heart of wealth creation and industrial transformation...Under such conditions, common sense would seem to imply that one better stick to shop floor learning-by-doing and some gradual improvements of established production processes in order to reduce cost and to improve quality.

...But common sense often is of limited value, particularly, when fundamental changes occur in the basic parameters of industrial manufacturing and when constraints on the demand side rather than in the economics of production become the main barrier to productivity enhancement"

(Ernst and O'Connor 1990, p. 13)

In an attempt to address these problems, Ernst and O'Connor suggest that TC "goes well beyond engineering and technical know-how and includes knowledge on organizational structures and

procedures as much as knowledge on behavioral patterns, for instance, of workers and customers." (p. 12)

They then identify five broad categories of TC: organizational flexibility, finance, quality of human resources, sophistication of support services and information management, and coordination capabilities. They also point out how specific TC requirements change over time and through the process of industrial transformation.

This is an important move forward in our understanding of TC and its constituent elements. It allows for a more specific and practical focus at the firm level, it incorporates the "soft" aspect of TC in addition to the "hard" technical dimensions, and most importantly, it reveals the contingent and time dependent quality of TC; what is a strong capability in one situation may not be in another.[23]

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[23] This relates in a compounded fashion to the discussions regarding intersectoral differences in patterns and levels of innovation (e.g. Dosi 1988, Pavitt 1984). In addition to the opportunities for innovation that present themselves in different sectors, Dosi argues that innovative efforts are also a function of the structure of demand and of the appropriability conditions. (Dosi 1988 p. 230) Thus, the user orientation of the firm Ernst and O'Connor discuss relates directly to the firm's ability to understand and respond to the specific structure of demand it faces, and its overall "soft" or "complementary" assets influence the appropriability conditions. The importance of all the organizational and technological resources that enable a firm to innovate, pursue the proper markets and reap the most benefits to the notion of TC is highlighted. Firms with different levels of such "resources," or capabilities, will perform differently within the same sector, and the relative importance of these "resources" to success will vary across sectors and situations.

B. An Analytical Distinction

What does emerge as a problem in Ernst and O'Connor's formulation is the lack of distinction between the relatively static and relatively dynamic aspects of TC. Indeed, this is reflected in their interchangeable use of the terms "capabilities" and "assets," and some degree of confusion between them. Thus, they write "firms need certain complementary assets and capabilities in order to create, mobilize and improve their technological capabilities."(p. 12)[24]

Technological capability is a convenient and readily communicable concept, but as discussed earlier, the content of TC requires further elaboration and refinement. Specifically, it seems to encapsulate two "moments" of innovation and organizational performance that need to be distinguished.

The first is a relatively static and situation specific aspect, which relates to what "resources," "endowments" or "opportunities" a specific firm possesses at a given moment in time with respect to successfully accomplishing its objectives. We shall refer to this as the technological assets of the firm.

The second has to do with a more dynamic, process-oriented and relatively situation-independent aspect which relates to how well a firm utilizes its "assets" and optimizes its returns from

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[24] This interchangeable use of assets and capabilities is found elsewhere in the literature as well, for example, Teece (1984) writes that, "...the successful commercialization of an innovation requires that the know-how in question be utilized in conjunction with other capabilities or assets" (Teece, 1984, p. 288, emphasis added.)

them. We shall refer to this as the <u>technology process effectiveness</u> of the firm. Let us now discuss each of these in more detail.

IV. TECHNOLOGICAL ASSETS (TA)

The concept of "assets" in relation to innovation, organizational performance and strategy is seen more and more frequently in the literature. The most prominent usage is in Teece's (1984) discussion of the importance of "complementary assets" to the successful exploitation of the profit potential of an innovation. For Teece, these "complementary assets," which provide such services as marketing, distribution and service, are required in conjunction with the "core technological know-how" for commercial success. Access to these assets is critical to the innovating firm, which must make the proper choice as to whether to integrate them or enter into a contractual arrangement. This decision in turn depends on the nature of the assets (specialized, co-specialized, generic), the investment required, the appropriability of the innovation, the importance of the "complementary asset," the nature of the competition, and the cash position of the firm.

Teece's treatment is a powerful approach to analysis of the success or failure of firms in industrialized countries which have developed technological know-how or innovations. It is eminently suitable to the analysis of the experiences of firms such as NutraSweet, IBM and Apple, which he discusses, and to the understanding of industrial strategy in advanced countries.

However, in developing countries the "core technological know-how" or innovation around which "complementary assets" are

assembled is often weak or non-existent. As discussed earlier, a typical LDC firm operates relatively far from the world technological frontier, and frequently does not have ready access to these "complementary assets". If anything, one option for developing countries may be to identify their "niches" in terms of their "complementary assets" for firms from the advanced countries. This viewpoint certainly has some validity, but it still constrains the definition of "complementary assets" to those needed by "leading" innovative firms in advanced countries. Neither approach permits a more holistic treatment of the specific and unique strengths that a LDC firm possesses by virtue of its location, structure, experience, etc.

A broader conceptualization of "technological assets" seems to be in order, one which recognizes the uniqueness and multifaceted nature of the LDC firm in relation to its domestic and international environment. In this sense, the "technological assets" of a LDC firm consist of the full range of available resources and opportunities available which enable it to participate successfully in the global techno-business environment. The value of these assets is determined partly by the policy environment of the firm and partly by the technological and economic environment. The <u>level of returns</u> from the utilization of these assets is then determined by the effectiveness of the firm's technological process.

Let us take several examples to illustrate these points. In an article on "clandestine innovation" in Tunisia, the <u>Financial</u>

Times[25] describes the case of a local brick making factory, we will call it Tunibrick. The prices of construction materials in Tunisia were fixed by the government, which the World Bank had been trying to change for years. Tunibrick had the capacity to produce bricks at much lower cost than the standards set by the SNIT (Societe Nationale Immobiliere de Tunisie). It could do this because it used second hand machines which had been altered by workers to suit the needs of the local market, and had received no financial aid from the state. In contrast, the more modern and larger brick factories used machines from France or Germany, had substantial backing from Tunisian banks, but were producing at costs too high for the average Tunisian.

In 1985, house building had slumped because of a decline in the value of crude oil exports and tourist revenues. Tunibrick, in response, cut the prices of bricks by 20 per cent and sent its large fleet of trucks to every town and village in the country to market the bricks. The truck drivers were even allowed some latitude with regard to the prices they charged for the bricks.

This move was met by strong opposition from state organizations, but on the other hand, brick prices fell and two state owned companies nearly went bankrupt. A year later, the state reversed its policy and deregulated the prices of construction materials.

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[25] Financial Times 9 Jan 1990.

One way to look at this story is as a nice example of a rebellious and energetic entrepreneur who successfully defied the state. However, let us consider what he had in terms of our notion of technological assets. First, there is the clear cost-advantage of the machinery he used; it was cheaper, presumably easier to use and permitted brick production at low cost. Secondly, the company did not have a high debt burden as did the larger more modern factories. It possessed a large fleet of trucks to carry its product to the smallest towns in Tunisia, and finally, it had an owner who, though illiterate, had a good sense of the potential market in Tunisia for bricks at the right price.[26] The Times article does not provide all the desired details, but the leeway given to the truck drivers to negotiate price suggests that the workers at Tunibrick were perhaps closely tied together as a community, shared common goals, and were trusted by their employer. This employee cohesiveness and loyalty could also be considered an asset.

By using these assets in a flexible and responsive manner, and by going to the customer, Tunibrick was able to succeed where other larger corporations could not. Furthermore, these assets are <u>context specific</u> and are derived from a <u>knowledge and resource base that is local</u>.

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[26] Tunisia has one of the highest construction housing rates in the world, according to an unpublished World Bank study cited in the <u>Financial Times</u> article.

Technological assets can also be derived from historical circumstance. For example,

> "... a Mexican glass maker was forced during World War II to fabricate its own spare parts. To do so it set up a small tool shop with a foundry, forge, and some machinery equipment. Through reverse engineering, in time the shop was able to build entire pieces of equipment. When the firm later sought to improve the productivity of a process it had bought from a U.S. firm, the shop was able to develop a new mold which doubled the speed of glass-making. Eventually the new process was exported to Brazil where further refinements were made."
>
> (Ernst & O'Connor 1990 p.21)

In this case, the technological asset had been developed in response to a specific historical circumstance. However, what is missing from this story, which would have been interesting, is some description of why and how the firm acquired the U.S. technology, and how it was able to export the new process to Brazil. Simply having the capacity to improve the U.S. technology, while an asset, would not have been adequate without a good technology sourcing ability and a good market orientation and structure. These three assets taken together would partially explain the success of the firm.

Another, more general example, is the diversification strategy adopted by many Korean chaebol. Once they had captured a share of the mass consumer goods markets, they were faced with one of two options: to upgrade technology and aim for the higher value added segments of the same markets, or to move into other

mass consumer goods markets (diversification). Recognizing that their real asset was their experience in low cost manufacturing rather than engineering and R&D, diversification was a better use of their existing assets.

These examples are provided mainly for suggestive purposes. Most are drawn from anecdotes or reports that did not explicitly focus on technological assets per se. There is a need for systematic and detailed micro-level studies of firms in developing countries that have been successful in terms of how this relates to their assets. In some cases, existing studies could be expanded to include some of the dimensions of relevance in terms of assets.

For example, Perez (1989), in a study of the electronics industry in Venezuela, describes the success of MCM (Microtel);

> "This firm brought to market a PABX of their own design; one of the first fully electronic (ones) in the world. The product succeeded in penetrating the domestic market overcoming the traditional mistrust of local technology".
>
> (Perez 1989 p.4.) (emphases added)

A key question, unanswered by Perez, is how this firm overcame the traditional mistrust of local technology since this would point us in the direction of one of their key assets. Perhaps it was the reputation of the owners, the ability to communicate the right message to the marketplace, or simply the overwhelming quality of their product.

While the concept of assets is gaining currency, empirical work still largely ignores this dimension, a gap that needs to be filled through fresh research.

A. Dimensions of Technological Assets

We can, however, from intuitive reasoning and the little we can learn from available research, conjecture some general dimensions of technological assets.

There are clearly both hard and soft assets. Hard assets would include the engineering and R&D resources of the firm, equipment, physical plant, workshops and repair facilities, etc. Much of the research on technological capabilities in developing countries has focused on these hard dimensions.

On the soft side would be included the organizational structure of the firm, its marketing and distribution strengths, its management style, the commitment and loyalty of employees, goodwill and brand loyalty, its reputation in industry and government, relations with suppliers and sub-contractors, etc.

Both soft and hard assets may be categorized in terms of whether they are housed within the firm (internal) or are external to the firm. An internal soft asset would be an excellent knowledge of the local market. An external hard asset could be a reliable and competent network of maintenance and repair facilities for the firm's product.

Assets can also be tangible or intangible, in the sense of how easily they can be valuated. A piece of equipment that has a

known market value is a tangible asset. A patent for a new process, or simply a design for a new machine, the value of which cannot be assessed easily, would be an intangible asset.[27]

Assets can also be distinguished in terms of whether they are depletable or not. A strong local marketing and distribution network, which can be an asset in negotiating joint ventures with foreign firms, for example, is not necessarily going to diminish in value. It could be used over and over again for a number of negotiations. On the other hand, cash reserves are a depletable asset, in that they can be consumed over the course of a transaction or time.

Assets can either be generalized or dedicated.[28] A good system of repair and maintenance facilities for agricultural equipment is a generalized asset that many firms can draw upon, in principle, as is a good university system and research institute network. On the other hand, assets can be dedicated to a particular firm or product, for example an in-house R&D lab or training center.

Finally, there is the dimension of durability. Assets can be more or less durable, based upon their nature and the

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[27] There is an evolving field of "intangible asset evaluation" that is based on the development of methods and procedures for calculating the values of such assets as patents and copyrights, brand reputation, etc. This has particular relevance to litigation over patent rights violation and to technology license negotiations. See McGavock and Haas (1990) for a description of "intangible asset valuation."

[28] This is quite similar to Teece's distinction between generic, specialized and co-specialized assets.

environmental circumstances. As Staley notes (Staley 1990), the ability to work with copper conductors is an asset whose value may not endure with a shift to fiber optics. Or, a strong brand reputation for a consumer good produced by a local firm in a heavily protected market may not endure an opening up of the economy to foreign competitors with equally strong brand names that simply have not been available in the local market because of protectionist policies.[29]

B. Factors Influencing the Value of Assets

As briefly mentioned earlier, the value of a specific technology asset is contingent on the environment of the firm, which includes the policy and regulatory regime, the technological environment, the business and economic environment and the political and institutional context. What may be a valuable asset under one situation may not be so under another.

Drawing upon the work of Teece (1984), Staley (1990)[30]

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[29] An interesting and slightly amusing example is that of Coke in India. Despite having been forced to leave India and having been replaced by two or three local brands, Coke is still available in smugglers shops on the streets in India at a premium price. The impact on local firms of the entry of Pepsi Cola into India should be interesting to follow.

[30] The concept of technological assets is also gaining currency in management consulting and there is the emergence of a practice area called technology asset planning (Staley 1990). This approach emphasizes the value of technological assets as a conceptual basis for strategic management, which is as important to firms in industrialized countries, which are Staley's concern, as to LDC firms. For Staley, technological assets are largely invisible to the firm, and hence not managed. They encompass product, process, service and infrastructure technologies. The key, to Staley, is to make these invisible assets explicitly part

and Dosi (1988), it is possible to suggest several environmental and contextual dimensions that influence the relative value of different assets.

The level of protection existing in a country has a direct implication for the value of certain assets. In India, even now but more so in the past, having a license to manufacture a particular product was almost a guarantee of success in the sellers' market that the protectionist and highly regulated policies of the government had created. Obtaining the license required considerable intangible assets such as access to government officials, being on the "right" side of the political fence, being able to deal with and address the bureaucratic requirements for a license, etc. As the economy tries to open up, and as domestic competition intensifies, the mere possession of a license diminishes in worth, as do the resources that enable the firm to obtain it. There is a shift in value to assets that enhance the productivity of the firm and its ability to compete in a new market environment.

Given the trend towards liberalization in many developing countries, firms need to assess the worth of those assets that allowed them to survive in the old system, and to identify and develop the new asset bases required by changed circumstances. That this is not occurring in many cases is evident by the strong lobbying efforts for continued tariff protection and "safeguard"

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of the planning process of the firm.

measures by industrialists who see their asset bases plummeting in value as the economy opens up to foreign competition.

The domain of technology within which a firm operates is also important. This includes the tightness of the appropriability regime, which determines the value of an innovation per se in relation to the complementary assets required for its successful commercialization. It also includes the relative rate of change of technology in that sector and the extent of reliance of technological advances on scientific progress. Thus, firms with capabilities in relatively mature and stable areas of technology will continue to survive, until the prevailing technological paradigm shifts and leads to new products or processes that can entirely replace existing ones. Such a situation would then raise interesting questions about protectionist policies under this new paradigm. (Katz 1984, Cimoli and Dosi 1988).[31]

The structure of the industry, and in particular the role of industry-wide or state-initiated technological efforts is another influence on the value of certain assets. For example, in-house R&D capabilities would be more valuable in the absence of any industry wide R&D consortia or public R&D institutes dedicated to

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[31] For a more detailed discussion about inter-sectoral differences in innovation , and their relevance to developing countries, see Cimoli and Dosi's treatment of the taxonomy of Pavitt (1984), in which he distinguishes between four major groups of industries: (a) "supplier" dominated sectors; (b) "scale-intensive" sectors; (c) "specialized" supportive and (d) "science-based" sectors.

that industry. However, the effectiveness of the linkages between public R&D institutions and the productive sector would qualify their value. In certain countries, such as India, there has been little direct contribution to industry by the large research and development system established by the state.

Finally, the institutional context would be important. A strong bureau of standards, for example, which establishes and enforces standards for industrial goods and services, would create a pressure for firms to attain these standards, making the requisite assets more valuable. The absence of a strong body to enforce intellectual property rights would weaken the bargaining position of domestic firms seeking to acquire technology through joint-ventures with foreign firms, unless they had other assets that would assure protection of the technology (e.g., a dominant market position, a "leak-proof" corporate culture, a strong legal department, etc.).

C. Categories of Technological Assets

We have thus far presented an overview of the dimensions of technological assets and some factors that influence their value.

Let us now consider some of the categories for these assets. Clearly, an exhaustive listing of such assets would be impossible because by opening the door to include a range of factors that conventionally do not get captured by the concept of technological capability (e.g., reputation of management), there is no defined boundary, so to speak, around a firm's assets. In

part, the ingenuity of the entrepreneur itself defines what is an asset, in the sense that he/she recognizes its worth and is able to exploit it effectively.

Our categorization is therefore a first and tentative attempt to identify at least the broad and more "visible" assets that an LDC firm could possess. It draws upon a somewhat limited base of information about firms in developing countries as well as on the mainstream management literature.[32]

There is a set of assets possessed by all firms which can be described as historical. These refer to the variety of tangible and intangible strengths and advantages that have developed and accumulated over time and which add value to the firm. They include the knowledge gained through learning and experience, the stability and strength of the networks and linkages that has built up and the reputation of the firm and its owners among the relevant business and political communities of the firm. Obtaining a bank loan, for example, is greatly enhanced when the

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[32] Notably, the literature on strategic management, e.g., Staley 1990, Marone 1989, Wolff 1989, Teece 1986, and some of the early organization theory literature which deals with organizational rationality, environmental uncertainty and organizational structure (e.g., March and Simon 1958, Duncan 1972). There has been a growing awareness recently, in the mainstream of innovation research, on the relevance of the organizational literature and the need for organizational models of the innovation process which can provide a framework for the explanation of the seemingly "non-rational" behavior patterns and decisions of firms.

applicant is a known quantity with a proven track record of success, the right connections, etc.[33]

Historical assets are generally strong and durable, but their value is dependent on a continuity in the firm with respect to people, the nature of the business and the environment. The turnover of key staff, or a drastic change in the business focus of the firm, can theoretically undermine this asset base.

Assets related to the firm's strengths in terms of its ability to monitor and analyze relevant information are its intelligence assets. Market, technology and business intelligence is a critical contributor to a firm's ability to respond swiftly and effectively to relevant environmental signals, and hence to its competitiveness. It refers to more than information gathering and analysis, but to the ability to add value to this information for business purposes. Intelligence assets[34] are very much intangible and invisible, are reflected in such things as the currency of information available to the firm, the qualifications of key people, the ability to

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[33] The important role of experience in the innovation process has been identified and discussed, notably by Arrow (1962). In his view, experience relates to the accumulation of technical information and skills through learning by doing. In our perspective, this is one aspect of a broader set of experiences and accumulations, including those of a non-technical nature, for example, reputation, which are all assets that a firm builds over time.

[34] In industrialized countries, the need for "techno-business" intelligence is being increasingly appreciated. Several major corporations have established business intelligence units, and there is a growing consulting business in market intelligence.

analyze events and information and the types of linkages and networks the firm has with sources of information.

Technical assets are those related directly to technological resources of the firm in terms of hardware and equipment, R&D, patents, workshop facilities, etc. The quality of the equipment, familiarity with its use and maintenance, proprietary know-how and also the social value of the technology are all assets of a firm. Socially desirable technologies can attract government subsidies and other forms of assistance of value to the firm. Reliable repair and workshop facilities can be used advantageously by a firm in its negotiations for a joint-venture with an overseas company. A track record of patenting can also make a firm more attractive to potential partners, to potential employees and to financial institutions.

Market assets cover a wide range of resources - distribution networks, brand names, market access, loyalty of the customer base, price competitiveness, relations with suppliers, etc. Access to local markets is an acknowledged and important asset that many LDC firms understand and use effectively in dealing with foreign partners. Also important is the firm's capability to derive "tag-along" sales, as in the case of selling vacuum cleaner bags following the sale of vacuum cleaners. Firms that have the product variety and production capacity to deliver secondary products to the market possess a distinct advantage over those who do not.

Human resource assets are those that are based upon its skills portfolio, the quality of its leadership and management, the alignment of employee values with corporate goals, the quality of training provided to employees and the emphasis given to training. Financial assets relate to the cash resources and cash flow of the company, the access to investment and risk capital, and the quality of the firm accounting and cash management systems. For LDC firms, these are critically important, because of the common problem of access to convertible currencies. Firms that have the foreign exchange, or access to it, that is required to enter into international transactions generally are better endowed.

We also include as assets, those that are physical, such as land, buildings, inventory, etc. and those that are supportive, such as legal, financial, accounting, administrative services.

Finally, there is a category of assets that derive from the environment in which the firm operates by virtue of its physical presence in that location. In general, these are related to classical comparative advantages such as access to cheap labor, raw materials and proximity to markets and suppliers, as well as more intangible advantages, for example, familiarity with local business laws and culture, governmental regulations, market dynamics and infrastructure. This "familiarity" factor tends to be underemphasized in the literature, but is deeply appreciated

by practicing business people and can often constitute the most valuable asset a firm possesses.[35]

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[35] This is true not only for LDC's but more generally; in international technology licensing, for example, the familiarity factor of the licensee is an important influence in the decision to and the price of licensing.

> "When Xerox was a small company studying its marketing plan for the European market, it had no market force in Europe; it had no capital with which to build one. Full development of that market before its patents ran out was important. This made time an important factor to Xerox.
>
> So Xerox licensed what became Rank Xerox, because Rank brought to the table capital and established marketing muscle, the capacity to penetrate the European market in a hurry."
>
> Arnold, et al 1988, p. 301

IV. TECHNOLOGY PROCESS EFFECTIVENESS

The discussion above attempted to describe the dimensions and categories of a firm's "technological assets." In effect, a firm's assets are a relative measure of the endowments and resources at its disposal in its quest for success and improved performance. Firms, however, will vary in terms of how well they use these assets. The utilization of assets is therefore a second determinant of organizational performance. The difference in organizational performance, measured, for example, by profitability, between two firms with nearly identical assets, would be a direct function of the efficiency of their processes of utilization of these assets. For a more complete understanding of the success and future of LDC firms, it is therefore necessary to examine these processes more clearly.

The ability to utilize these assets efficiently is what we refer to as "technology process effectiveness," and strong "technological assets" in combination with strong process capabilities make for successful organizational performance. However, there are two questions that such a statement immediately raises with respect to LDC firms. How is organizational performance defined, especially in a technological sense, and what constitutes an "effective" technological process. Let us briefly examine these first.

A. Organizational Performance

It is a fallacy that there is one objective concept of organizational performance. This is particularly true for LDC firms (though it is also the case for firms in industrialized nations). In an idealized world with complete information and totally free markets, an agreement could be made for a single measure of performance and profitability, but in a real world setting, profitability does not address all the nuances and variations that must be considered in determining organizational performance. On the other hand, there is an emerging focus being given to the notion of "best practice" methods, the proximity to which is seen as a major indicator and determinant of performance. But it is difficult to objectively describe what is "best practice" in a determinate fashion, since it is always colored by local specificities and distortions.[31] If performance

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[31] "Best practice" as used in the literature varies considerably. For many, the Japanese model contains the main elements that constitute "best practice" (e.g., Hoffman 1989), whereas other understand it as a general paradigm that, "involves a set of guidelines, provides thinking tools for innovating, but does not involves a single set of recipes of rules." (Perez 1989 p. 26) The particular shape this paradigm assumes will depend on the context specific conditions in a country or region or sector. The basic model is what Piore and Sabel (1984) refer to as "flexible specialization." They discuss the variations in this model that are to be found in the "Third Italy," Sweden, and Germany, in terms of how firms develop unique approaches to manufacturing, sub-contracting and management that fir best within their own milieu.

There is also some confusion with regard to the hardware/software aspect of "best practice." Even though the significance of the "soft" aspect is explicitly recognized, there is an apparent reluctance to move too far away from the "hard" side of best practice. Thus, "best practice" for many authors, including Hoffman (1989), Kaplinsky (1990), Perez (1989), still rests ultimately on a competence in advanced technological

is viewed as a contingent concept, three major factors influence how it is articulated and viewed.

1. **The Policy Environment**

The historical heritage of protectionism and import substitution and their many corollary manifestations (tariffs, market reserve, export promotion, subsidies, etc.) have distorted the metric whereby performance can be assessed.

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applications. For example,

> "it must be borne in mind, however, that although much competitive ground can be gained by transforming the organization, in the longer run, <u>this is only a precondition</u>. Once this becomes the common 'floor', movement at the frontier of competition will increasingly involve the effective use of information technology."
>
> (Perez 1989, p. 26. emphasis added)

The issue is much more complex than as depicted in this view. There are strong interactions between organizational process and technological competence, the two are not dichotomous. Furthermore, this view precludes the possibility of the coexistence of a variety of technologies, some of which are not at the frontier, but serve their users well regardless. Indeed, this view that the only technology of value is the latest technology ha led to seriously distorted perspectives among some policy makers. Finally, this view ignores the important, if not vital, role that is played by management in terms of adopting intelligent strategies to utilize their firm's unique assets to the utmost. "Best practice" encompasses more than technology and organizational process, it is better defined in terms of the optimal utilization of a firm's technological through effective process capabilities as defined by the context in which the firm functions. In a simple sense, then, defining "best practice" for a firm is an optimization problem within a framework of rationality defined by the local context. In an idealized and open world, these rationalities would approach convergence (the difference being determined by local "absolute" differences, and all firms would have approximately the same optimization problems to solve. In spite of moves in this direction, we are still quite far from a world where such convergence is likely. At best, there is a convergence among "enclaves" of "modernism" in different countries, but this is more in terms of cultural rationality than business rationality. For all practical purposes, performance is still a contingent concept.

> "Firms were not expected to reach competitiveness on their own. Profitability was to be determined by exogenous factors, such as tariff protection, subsidies and other forms of government help, rather than by the firm's own capability to increase productivity or quality."
>
> (Perez 1989, p. 28)

Thus, firms can appear to be very successful for all the wrong reasons. In fact, this protectionism can result in technology choices and learning processes that are themselves sub-optimal in a broad sense, though functional within that policy environment. This sub-optimality, or in the extreme, irrelevance, of the technological learning process can be further aggravated if it is in a sector characterized by rapid technical change. On the other hand, if the state of the art is relatively fixed, protection can result in the development of competitiveness based upon indigenous technological capabilities. However, in the midst of the present technological revolution and its all pervasive character, there are fewer and fewer areas of technology where the state of the art remains somewhat stable.

Strong performance under a protective policy environment does not assure similar performance under an open environment, save perhaps in a few exceptional cases. For policy makers, this presents a difficult dilemma.

> "Should society take it upon itself to protect a second, or even a third, round of indigenous learning in order to stop the technological gap from widening again, or should the return from the first learning sequence be expected to finance the dynamics of the evolving process?"
>
> (Katz 1984, p. 33)

For the LDC firm successful under the old regime, the problem is more acutely expressed in terms of what it needs to do and what its options are under a more competitive and exposed situation. Can conventional theories of technological capability development with their emphasis on learning and indigenization provide any useful ideas, or are the answers to be found in organizational and managerial innovations and strategies (leaving aside the option of lobbying and use of political influence).

2. Domain of Technology

Typically, firms operate within a certain domain of technology that is specified by their markets, their technological capabilities and their position in reference to the prevailing technological frontier in that area. This domain sets the tone for the types of technological learning and innovation it undertakes. In this sense, there is a close similarity with Dosi's (1986) concept of "technological trajectory", which in turn is defined with reference to the "technological paradigm" within which it exists.

Organizational performance along a particular trajectory does not necessarily assure similar performance along another trajectory or in another domain. There are exclusionary effects in working within a specific paradigm or trajectory that may preclude important learning processes necessary for success in another area. For example, Staley (1990) cites the case of a Fortune 500 firm that sought to enter the fiber optics market in

the early 1980s on the assumption that its extensive know-how in copper conductors would enable the firm to move into fiber optics relatively cheaply and quickly. The firm mistakenly did not perceive a significant shift from its trajectory, and was unsuccessful in its efforts.

In LDCs the problem is similar. Firms may be quite successful operating within a specific domain of mature technology even though the frontiers in this area are changing rapidly. But when faced with the need to shift to a new domain, as a result of demand or competition, the limitations and problems associated with the narrow focus become apparent. Knowing where the technology is headed and keeping abreast of these developments, i.e. maintaining an "intelligence" with respect to the relevant areas of technology, allows entrenched niche firms to develop capacities to quickly and effectively shift to different domains of technology.

3. **Market Demands:**

There are major changes occurring in the demands of the marketplace. There is a greater sophistication among customers and a shift away from competitiveness based upon price to one where quality, speed of delivery, after sales services and customer support and customized products are gaining importance in the decision process of the consumer. Firms that have tended to survive and succeed mainly because of their price competitiveness find the rules of the game changing.

Conventional wisdom regarding standardized and stable markets is being challenged by a growing demand for flexible product lines with customized features. This in turn has opened up the opportunities of exploiting relatively small "niche" markets for specific goods and services, markets that can be exploited by LDC firms which did not have the economies of scale to pursue more conventional large scale markets.

These changes emphasize the need for focused flexible and responsive characteristics in a firm. The successful firm is one which can recognize its special market "niches" and respond quickly to market signals and opportunities in a changing environment. These qualities derive as much from organizational innovation as from technological capabilities. The key concept here is "customer focus," which is not merely paying attention to the customer, but understanding and anticipating his needs and taking the product to him.

The performance of an LDC firm is therefore contingent on its environment, its market, and the technological domain in which it operates. Recognizing which assets are most valuable in different circumstances becomes critical to success as <u>defined in that context</u>.

On another level, the <u>motivations</u> of firms, particularly with respect to their technological and manufacturing activities, is not as straightforward and based upon a concern with cost reduction as one would think. Cost-savings is indeed a prime motivator of technical change in developed country firms, but in

LDCs, environmental and context-specific factors alter the priorities of firms in important ways. Katz finds that,

> "...cost reduction was not necessarily a priority of the technological search efforts undertaken by Latin American firms. Quite the contrary, product mix diversification, quality and the more effective use of installed capacity normally appear as important objectives of the technological search efforts"
>
> (Katz 1987, p. 38)

Thus, not only are there important variations in how success is defined externally, but LDC firms are also driven by a different set of internal priorities and a different model of what is good business behavior. Seemingly sub-optimal firm behavior may indeed be perfectly rational in a particular context.

B. New Concepts of Efficiency

In the case of process efficiency, the situation is slightly more complex mainly because of the dramatic changes in the principles of efficiency themselves.

Under the old "fordist"[32] system, efficiency is based upon equipment and a supply-driven organization of production.

Given the relatively smaller markets of developing countries, the lack of supportive infrastructures (e.g. subcontractors) and the shortage of skills, certain forms of organization and production were seen to be more "efficient" for

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[32] See, for example, Kaplinsky 1990, Perez 1989, Piore and Sabel (1989) and Schonberger (1982), for critical assessments of the "Fordist" system of manufacturing.

LDC firms, for example, a high degree of vertical integration, a bias towards discontinuous batch production, limited use of subcontractors and idiosyncratic choices of technology (Katz 1987).

However, this paradigm is in decline, according to many authors, and is being superseded by a new "techno-economic" paradigm based upon the revolutions in microelectronics and information technologies, new forms of production and new patterns of competitiveness and market demand.

This opens up altogether new opportunities for LDC firms in two respects: there is greater access to the "specific knowledge required for great numbers of products, processes, technologies, and whole industries that have reached maturity." (Perez 1989, p. 13)[33]

The new paradigm is accompanied by a new set of efficiency principles that have direct and potentially positive implications for LDCs. Specifically, the emphasis on flexible specialization and the underlying principles of decentralization, continuous learning and improvement, customer focus, etc.[34], open the door

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[33] This is not entirely so straightforward. As Perez (1989) recognizes herself, some mature industries have already been transformed by the new technologies, e.g., automobile manufacturing and textiles, thus limiting the value of these mature technologies. The entire question of what happens in the period where one paradigm is in decline and the other in its infancy is extremely complicated. Perez (1989), Freeman and Perez (1988) and Hoffman (1989) contain useful discussions in this respect.

[34] See Perez (1989) and Hoffman (1989) for detailed descriptions of these new principles.

for LDC firms to, for the first time, seriously seek to become "world class" manufacturers. These techniques and principles redefine what is considered efficiency in the modern world by laying more emphasis on "soft" organizational and process characteristics than on "hard" large scale and centralized production systems. The examples of Japan, the Third Italy (Piore and Sabel 1982), the NICs, and more recently, LDC firms that have successfully adopted these new management techniques and organizational structures bear witness to this possibility.[35]

For Hoffman, the new management practices called for within the new paradigm can be categorized into those that relate to (1) managing the workforce (e.g., teaming, open communications, employee empowerment); (2) managing machines (e.g., continuous improvement); (3) managing the production process (e.g., materials movement, lot and inventory control, line organizations); and (4) managing supplier relations (e.g., relations with sub-contractors, changes in the design relationship, just-in-time systems).

Both Perez and Hoffman, as well as Sabel (1986), argue that the rise of importance of these new practices have opened new possibilities for developing countries, that these practices are eminently transferrable to LDC firms, and that they can contribute to significant improvements in competitiveness and productivity.

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[35] See Hoffman (1989) and Kaplinsky (1990) for examples of LDC firms that have adopted new management techniques with success.

C. Dimensions of Process Effectiveness

With the emergence of this new paradigm, therefore, conventional notions of efficiency have been changed. It is now possible to suggest a simple model of the LDC firm and identify the four main dimensions of process efficiency or technology process capability based upon these new principles.

Essentially, if one views a firm as involved in some form of reception, processing and responding to technological and market "signals" from outside (i.e., technology and market signals) and from within (i.e., strategic choices, new product concepts), a simple input/output signal processing model of a firm can be envisaged. A feedback loop from output to input would address the issue of signals that are generated or "triggered" by the firms' own actions, for example: customer feedback on a new product.[36]

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[36] For Cimoli and Dosi (1988), there are three types of signals that a firm receives, "(i)the technological opportunities (and expected economic benefits); (ii) the rate of growth of demand in that and other products; (iii) the changes in costs, prices, quantities, profitabilities in its markets (and possible other markets)." (Cimoli and Dosi, 1988, p. 122) This categorization is useful for the purpose for which they intended it, that is, to distinguish between different types of adjustment processes of firms in response to these signals. These are (i) "Schumpeterian" adjustment, which relates to innovation and technological learning; (ii) "growth" adjustment, which relates to the search for the most promising growth opportunities; and (iii) "Ricardian" of "classical" adjustment which relates to price/quantity changes.

However, in reality, these neat categories of behavior do not occur, as Cimoli and Dosi themselves admit. The search for technological innovation can be stimulated by a variety of technological, market and organization signals. It would not be

This highly simplified model allows us to identify certain critical dimensions of the firm that influence the effectiveness with which it receives, processes and responds to these signals.

The first may be referred to as <u>responsiveness</u>, which describes the speed and sensitivity with which a firm responds to a specific signal from its environment. In a crude sense, the length of time that lapses between the initial identification of a market need, say by a salesman or a customer support representative, and the final delivery of the product to the market would be a measurable basis for comparing the responsiveness of two firms in similar markets. In a more complicated sense, the rate of introduction of new product models in the marketplace would serve as a measure. This would encompass the recognition of the market signal in addition to the effectiveness with which the firm can incorporate new technological developments into the new product. The example of how Japanese auto companies take three and one-half years to get

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useful to try to develop a categorization of these signals since the full set would not be known. Hence, the simplified description of signals as either technological or market driven, and either internal or external in their origins, is adequate for our purposes.

Cimoli and Dosi come to a similar conclusion, "...a maximization approach would not lead us very far in explaining the choices. Even <u>if</u> we knew that the considered firm will choose the option which maximizes the integral of the discounted profits, for a <u>given</u> time horizon, the analytical content of such a statement would practically be nil: the indeterminacy about the ways technological and market expectations are formed, and about the time horizon and the intertemporal preferences is another name for our theoretical "ignorance." (Cimoli and Dosi, 1988, p. 123)

a new model to market, as opposed to five years for U.S. and European makers, illustrates this point well (OTA 1990).

There is another aspect of responsiveness relating to "downstream" activities which addresses how well a firm serves its customers after they have purchased its product. Thus, it is not only important to be effective and speedy in responding to signals describing new product needs, but to the secondary signals about these new products once they are in the market. Structurally, this is manifested in the form of customer support departments, after sales service etc. The importance of this "secondary responsiveness" is in the impact it can and should have on (i) subsequent modifications to an existing product, (ii) intelligence with regard to desired qualities of new products; and (iii) enhancing customer satisfaction by a broadened approach to the concept of a product, which encompasses the product itself (e.g., the vacuum cleaner or car) as well as the service required to ensure satisfactory use of that product once it is sold. Responsiveness, therefore, is more than simply listening to the market; it involves responding to the customer, before and after he becomes one. This customer focus is central to current thinking about new management techniques and competitive strategy a la the "Japanese Model." For LDC firms it could represent a major shift from the "sellers market" that they have grown accustomed to in a protectionist environment. As Perez notes, "The new best practice model is agile, flexible and adaptable to

market variations and user requirements" (Perez 1990 p. 20), and responsiveness is a key determinant of performance of DC firms.

The second dimension is integrity, which refers to the extent to which the response to a particular signal appropriately addresses the indicated need or opportunity. In lay terms, it refers to giving the customer what he wants, not what the firm believes is the need. The integrity of a firm's technological process determines how accurately a signal is processed and how "true" the output is with respect to the need (example here).

There are a number of processes that occur within a firm from the time a market need or technological opportunity is identified to the final output, and there are ample opportunities for distortion and misinterpretation. The transfer of information from sales to marketing to design to production involves countless loops and sequences any one of which can cause distortions. The extent to which these distortions can be reduced or eliminated will determine the integrity of the firm's process.

The third dimension is efficiency, in the simple sense of the optimal use of organizational resources in the processing of signals. The pursuit of perfect responsiveness and integrity needs to be tempered by an appreciation of the resources required, and as such, the efficiency criterion allows us to ground our assessment of the firm in a simple utilization of resources sense. According to proponents of the new management techniques, of course, a smooth and responsive organizational

process will ensure optimal use of resources, but this is not altogether true nor clear since firms can expend considerable human and financial resources to "adopt" the superficial aspects of organizational innovations without due attention to the underlying concept. For example, in response to demands for JIT systems by Diamond-Star, auto parts and suppliers established warehousing facilities near the plant so as to be able to meet orders at short notice, thereby meeting their interpretation of the goal of JIT. However, JIT is a system of total quality management designed to pervade the entire organization and make it responsive to market and customer needs. Hence, the importance of the efficiency dimension to organizational performance even though it may sound somewhat redundant.

The fourth dimension is connectivity, which described the spectrum and quality of networks and linkages between the firm and its environment, and internally, through which it receives information and feedback, conducts business, etc. Access to technology and market intelligence, to suppliers and sub-contractors, to government agencies and financial institutions, and a host of other organizations, are critical to a firm's success. To be well connected is essential in the modern world, even in environments with well developed market structures.

Taken together, these four characteristics, responsiveness, integrity, efficiency, and connectivity determine the overall effectiveness of the firm's technology process.

VI. CONCLUSIONS

In this preliminary paper we have attempted to identify and analyze some of the key factors that contribute to organizational performance in developing country firms (LDC firms), particularly in light of the major changes occurring in the global economy and the emergence of a new technoeconomic paradigm.

The implications of these arguments are of two types, those that relate to individual firms, and those that relate to policy.

For the individual firm, there is a clear need for rethinking, or in some cases, thinking for the first time, about its unique "assets" and organizational processes. It is evident that there is no one model of success for a firm; it is conditioned by country, sector and firm-specific factors.

However, as evidenced by an increasing number of LDC firms successful in the international marketplace, there is a changing pattern of opportunity that can be pursued by such firms. In-depth case studies of successes and failures are needed to better understand the dynamic requirements of success. Based on these findings, better management techniques can be developed for LDC firms seeking to succeed in international markets. Conventional approaches to management, still driven largely by western standards, are inadequate to deal with the particularities of LDC firms. New management principles, based on new concepts of efficiency, are required.

Hoffman, for instance, argues that the "logic of the new practices suggests that Third World firms will face problems not just because of poor managers, but also because of their fundamentally flawed management approach." (Hoffman 1989, p. 84)

From a research perspective, the need for fresh empirical studies that systematically examine the relationships between the technological assets of LDC firms, their effectiveness of their technological processes and their performance is required. Detailed studies, for example, of how LDC firms search for, acquire and utilize technology, the relative contributions of "soft" versus "hard" technologies to their performance, and the effectiveness of different organizational structures on organizational performance would all help in terms of gaining a better understanding of the determinants of success in LDC firms. Perhaps this could pave the way for a typology of LDC firms in terms of their technology assets and a framework for management decision making and strategy formulation.

From the policy perspective a similar argument follows. As LDC governments intervene less in industrial activity, what measures can be taken to promote productivity and competitiveness in firms? If traditional legislative and regulatory mechanisms are not to be used, how can policies be formulated and implemented to support the right types of technological and organizational activities.

A proper policy focus could be on the development of institutions that are "enabling" in nature, or that complement

the ongoing activities of firms in positive ways. A mechanism to assist firms in technology sourcing and intelligence on a global basis, or with market intelligence, would be one example.

One approach would be to identify the institutional "gaps" that hinder the development and full utilization of firm level assets in a country (or sector), and to design institutions to fill these gaps.

There are implications for the scope of policy focus as well. The traditional approach which focuses on sector by sector may be better replaced by an industry wide focus on potential "winners" and "losers," or on winning "clusters" of firms. This would allow a more focussed policy formulation. Firms that are most likely to succeed could be targeted for policy actions, and mechanisms such as business incubators could serve to "filter" out the weaker firms and support the stronger ones.

Policy could also focus on the development of specific assets needed by groups of firms. For example, if a strong supplier network is seen as necessary for the success of a group of local firms, such networks could be encouraged through policy measures, such as a backward linkages program.

For policy makers, the basic problem is one of how to intervene without controlling, how to promote without protecting, and how to support without subsidizing. Perhaps mechanisms such as incubators offer a workable compromise in this sense. But there are a number of other institutional needs, in banking, education, standardization, etc, which seriously hinder LDC

firms, and which can only be addressed through intervention by the state.

The problems faced by developing countries, at both the firm and policy levels, are complex. Much more research is needed on the specific implications of the new global environment in order to understand the options available to different types of firms and countries. We are still a long way from a sensible model of firm behavior in LDCs.

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