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Biotechnology in developing countries: harnessing the potential of high-TECH SMES in the face of global competition

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In the global market, the emergence of new technologies are representing opportunities and challenges to both industry and the public sector of the Latin American Countries (LAC). Some of these technologies have far reaching implications for a large number of industrial sectors, creating wealth and employment, resulting in an increased competitiveness of the developed economies around the world.

Modern biotechnology is one of these key emerging technologies which LAC must harness successfully to sustain economic growth and competitiveness. The ability to commercially exploit research in this area is also of prime importance. Developed countries have made important progress in recent years, with a strong leadership of USA in this sector. Unless substantial steps are taken now by LAC the gap between developed and developing economies will only continue to widen in the short, medium and long term. In this, the role of Small and Medium size Enterprises (SMES) is of crucial importance, especially because "High-TECH SMES" firms, by their nature, are often start-ups where new products are developed. Therefore, it is up to public authorities and venture-capitalists, at both the national and regional level to help engender a more productive external business.

This paper is aimed to provide an overview of the options to harness the potential of "High-TECH SMES" for generating and accessing to new technologies, both at the national and global levels, with particular emphasis on biotechnology sectors in order to improve the LAC competitiveness.

Globalisation

Prosperity of a nation is, in part based on the ability to create a platform from which companies can produce and sell complex, highly differentiated exports that meet the needs of the sophisticated and demanding consumers -who in turn reward companies with higher profit margins. Perhaps the most radical change in the economic landscape at the end of the 20th Century has been the shift in economic activity away from a local or national sphere toward a much more international or global perspective. The measures of transnational economic activity that proves there has been a strong positive trend towards greater global activity include: statistics on trade flows (exports and imports), foreign direct investment (FDI), international capital flows, and inter-country labour mobility. This has been achieved by the elimination of the many barriers to international trade and the reduction in transportation and communications costs. One of the major forces enabling economic globalisation has been technology. There are many different new technologies but the advent of the microprocessor and the proliferation of inexpensive communications has completely altered the economic meaning of national borders and distance. Observing the speed and minimal cost with which information can be transmitted across geographic space via the Internet, fax machines and electronic communication superhighways, The Economist proclaimed “The Death of Distance” on its front page a couple of years ago (The Economist, 1995). While the telecommunications revolution has brought the cost of transmitting information across geographic space to virtually zero, the microprocessor revolution has vastly expanded the ability of many to participate in global communications and to use transmitted information.

Moreover, knowledge-based industries are becoming major components of the leading world economies. Government and investment funds look to investment in new and emerging technologies since the growth rate can be quite

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substantial and there is also a high rate of job creation. Biotechnology after a relatively long incubation period is emerging as one of the leading new technologies that impacting on a range of industries, including pharmaceuticals, agriculture, animal health, diagnostic, food, horticulture, forestry and mining in the 21st century. According to a report prepared for the Biotechnology Industry Organization (BIO) by Ernst and Young, 2000, the biotechnology industry has grown rapidly in recent years, doubling in size from 1993 (US$ 8 billion in revenues) to 1999 (US$ 20 billion) giving direct employment to 151,000 American workers.

There are many definitions of Biotechnology, however, in this report we would like to consider that one given by The Australian Biotechnology Report 2001: "The application of all natural sciences and engineering in the direct or indirect use of living organism or parts of organisms, in their natural or modified forms, in an innovative manner in the production of goods and services (including for example the therapeutics, foodstuffs, devices, diagnostic, etc) and/or to improve existing industrial processes. The market application of outputs is typically in the general areas of human health, food production, industrial bio-processing and other public good and environmental settings". Taking into account that the key components of modern biotechnology are: **Genomics**: the molecular characterization of all species; **Bioinformatics**: the assembly of data from genomic analysis into accessible forms; **Transformation**: the introduction of single genes conferring potentially useful traits into plants, animals and microbes; **Molecular breeding**: the identification and evaluation of desirable traits in breeding programs with the use of marker-assisted selection; **Diagnostic**: the use of molecular characterisation to provide rapid and accurate identification of pathogens; **Vaccine technology**: the use of modern immunology to develop recombinant DNA vaccines for improving control of lethal diseases (Serageldin and Persley, 2000).

Although, modern science and technology offers the potential to make a major contributions to improving food security and to ensure the production of sufficient food for the increasing world's population over the next 20 years (Douthwaite and Ortiz, 2001; Egwang, 2001; Kryl, 2001; Burton and Cowan, 2002; Johnson, 2002; Mansur, 2002). It is nonetheless; very important to point out that agricultural biotechnology is still in its early stages in most of the LAC and the Caribbean Countries.

The lack of activity in Latin American Countries with regards to generating and developing new technology based businesses might be seen as a confirmation that the Biotech-based industries are suffering from a lack of investment and these countries are not ensuring economic growth and competitiveness in these sectors. Without public or private money aimed at fostering technological innovation and collaboration among industries, universities and research institutes, many projects lie dormant, jobs are not created, and scientist's career paths remain within the public sector and in the long term the economy ends up with a net negative trade balance in the industry sectors that are dependent on modern technologies. However, there is little doubt of the potential that these technologies offer and as the technological pipeline consolidate and more of its products become available, they will become the basis of a new technological paradigm. It is also true that many of its potential benefits will not be reachable unless a proper environment is established for accessing and exploiting the technologies (Trigo et al. 2000).

This is a task that must be undertaken at the national level because it requires policy decisions in areas that are the prerogative of national authorities representing the public sector but also the private and the academic sectors should be involved, not only to decide about the resource investment priorities, but also to set up new institutional and legal frameworks.

Innovation and competitiveness

Innovation policy is defined as a set of instruments and institutions which aid in the local generation of technology. This may also include adaptation of imported technologies to local conditions, especially in the context of developing countries. Innovations are created by formal Research and Development (R&D) activity by firms and other technology creating agents like universities and other public and private research institutes. It can also manifest itself in the form of a host of non-R&D activities such as the purchase of capital goods, non-routine engineering, etc. R&D activity is an important input to domestic technology development, especially when carried out at the enterprise-level.

Although there are significant national differences in the innovation systems of LAC, they also share some similarities. In fact, with a few notable exceptions, industrial firms have followed throughout the import substitution period a very similar pattern as far as technology and innovation is concerned. This pattern, according Cassiolato and Lastres, 1998, is characterised by some basic features:

- The significant use of technology imports as the main mechanism of acquisition of technological capability;
- Technology imports were typically not associated with significant innovative activity by the companies importing the technology; they were usually not preceded by, accompanied by, or followed by substantial complementary research, development or engineering efforts.
- As a consequence, technology imports were only rarely assimilated into a continuous process of technical change. Obviously, there were often

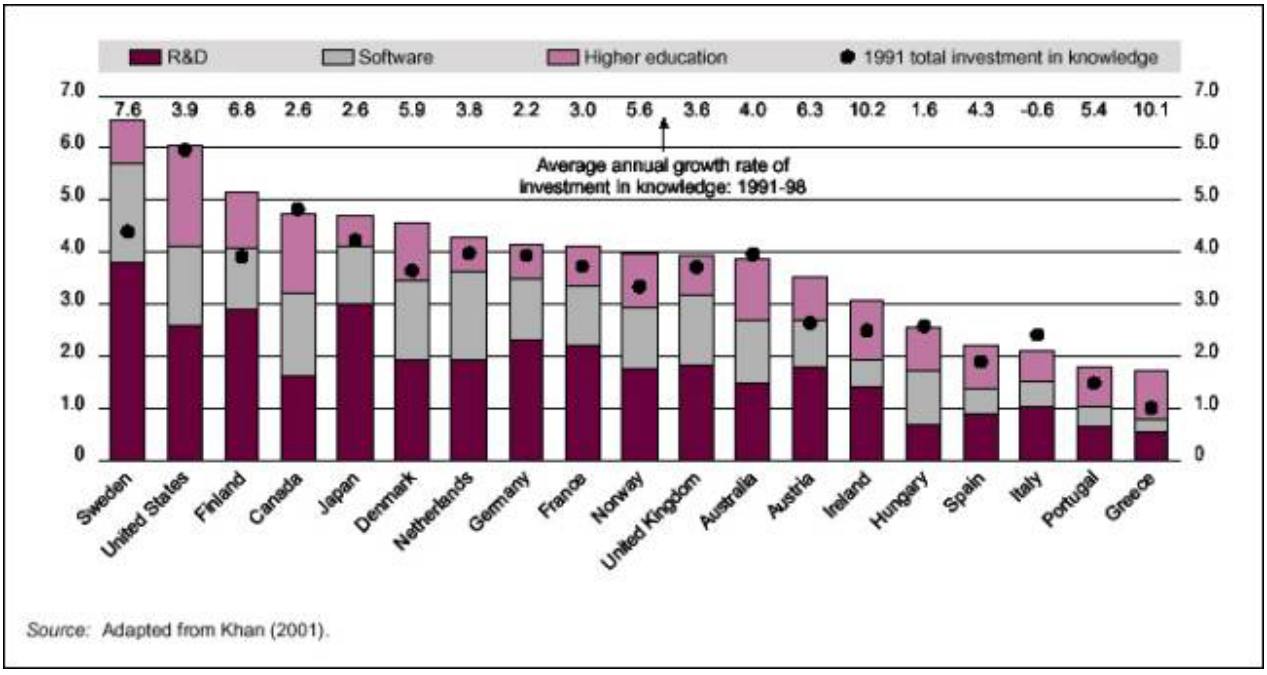
some degree of improvement in process efficiency and product performance essentially achieved by 'learning-by-doing' and minor adaptation occurred, but the intensity of such 'incremental' technical change was often inadequate to sustain competitiveness in technologically dynamic international markets, and it rarely created new a bases of competitiveness in high value-added activities.

Nevertheless, during the past decade LAC's have made tremendous progress in undertaking significant structural reforms. In many countries, state-owned enterprises have been privatised, basic structures have been built, and capital markets have been established. In the regions with more advanced economies, foreign investments have soared and trade performances have dramatically improved. These reforms are even more remarkable when placed in the context of the numerous upheavals, both economic and financial, that have affected the region as whole in the recent years.

While the region's economic and social accomplishments are undisputable, the gains vary widely among the countries in the region. Some countries have successfully implemented macroeconomic, political and institutional reforms, but there are many that have yet to create the necessary conditions for fostering competitiveness. For most countries, educational systems need to be enhanced and new technologies have yet to be fully tapped to maximize productivity. In the recent Latin American Competitiveness Report 2001-2002 published by the World Economic Forum, Chile reflects the best performance in the region, ranking 20th in the Growth Competitiveness Index. Chile has been able to build its performance based on strong and respected public institutions and a healthy macroeconomic environment. Compared to its Latin American neighbours, Chile ranks first in both of these indexes and third in the Technology Index.

However, the main competitive weakness of the Chile economy is the country's relative lack of ability to innovate and adopt technological change. The main single factor behind the low Technology Index rating is the low technological content of an export basket dominated by natural resource-based products. It seems unlikely that Chile will be able to maintain the strong performance of the past decade if innovations and new technologies are not adopted to diversify the composition of exports.

Figure 1. Investment on knowledge as a percentage of GDP between 1991-1998.



Taken from OECD Report in Science, Technology and Industry Outlook, 2001.

Moreover, a very different approach had been taken by developed economies as its shown in Figure 1. In the last two decades important changes have been observed in the patterns and characteristics of scientific and technological progress. They have been induced, among other things, by changes in policies for Science, technology and innovation, for investment and for international trade. The rates of R&D expenditures over GNP have shown a tendency to grow in the majority of OECD countries resulting in the stimulation, from the late 70s onwards, of a technological revolution, developed around the electronic complex. As it was described above, this allowed the advent of new scientific and technological systems, such as biotechnology and advanced materials and the consolidation of the

information technology paradigm. Following this strategy Finland has established itself as the most technological advanced country in the world, according to a report of the UN Development Organisation (UNDP).

New technologies and Small and Medium Size Enterprises (SMEs)

SMEs are a heterogeneous population of firms whose contributions to the economy are wide ranging and include not only R&D based new products and services ("High-Tech SMES"), but also improved designs and processes and the adoption of new technologies ("Technology Followers SMES"). In the EU SMEs are responsible for 50% of the jobs and in developing countries as Chile, SMEs are responsible for more than 80% of the jobs.

As mentioned above SMEs are a very heterogeneous population of firms, and can include everything from the corner hairdresser and grocer to high technology firms. In some industries the bulk of innovations -be the new products or processes- are introduced by new entrants or start-ups who challenge incumbents' market shares (and occasionally displace incumbents entirely). But in many other industries, SMEs contribute to the innovative process in a very different way. Relying on a minimum of internal R&D, SMEs can create innovative products by using non-R&D inputs. So while some SMEs in high tech sectors can make intense use of science-based knowledge and are active technology developers, most SMEs operate in medium to low technology environments and innovate without using formal R&D inputs.

A large body of evidence shows that SMEs, especially young firms, contribute greatly and increasingly to the innovation system by introducing new products and adapting existing products to the needs of customers. The ability of SMEs to create, access and commercialise knowledge on global markets will be the fundamental source of their new competitiveness in global markets.

However because of the heterogeneity of the SME population, any policy to increase their innovative capacities must be targeted to meet the needs of a variety of user groups, have different objectives, and use multiple approaches and tools.

- For "High-TECH" SMEs (the technology developers or lead technology users), the most important goals are to promote the development of the private venture capital industry and associated services, and to adjust accordingly the management and objectives of public R&D granting programmes.

- For the vast majority of SMEs (the technology followers), novel technology and innovation policies should better address their needs, especially with regards to: non-financial innovation advice such as consulting services; recruitment of university graduates and skilled personnel; awareness of new ideas and technologies; and incentives and institutional frameworks for improving collaborations within networks and clusters, including local technical centres or technical colleges.

Competitiveness strategies

The liberalisation of markets for goods and services presents particular issues for SMEs in developing and transition economies. In general, even in the more advanced of these economies, infrastructure endowments, financial institutions, the availability of qualified human resources and the public/private interface, are less well developed than in developed countries. The evidence would appear to suggest that sustained economic growth depends on a subtle interplay between SMEs and large firms, with SMEs playing a major role in job creation.

Similarly, sustained growth in transition and developing economies also depends on a strong contribution by SMEs - the experience of Chinese Taipei being the classic case. In many LAC, however, economic conditions and the policy environment have stifled SME dynamism. While there may be many SMEs, they are often undercapitalised and technologically weak, operating outside the formal sector of the economy.

The emerging global economy poses both challenges and opportunities for SMEs in LAC. On the one hand, companies from LAC countries have greater access to international markets and technology and finance. On the other hand, they are exposed to competitive forces for which they are not well prepared. The task for governments lies in ensuring that existing domestic distortions disadvantaging SMEs are removed expeditiously, and in establishing adequate institutional and regulatory conditions that can put them on a sounder footing to participate in global commerce.

In certain basic respects, the elements of the business environment that are favourable to large-scale enterprise investment are also favourable to SMEs: *i.e.* political stability, macroeconomic stability, a predictable, transparent set of commercial laws and regulations and their impartial enforcement. That being said, SMEs may well gain more, for example, from macroeconomic stability, insofar as they are less likely to be able to hedge against foreign exchange risk, they are likely to be the principal losers from a business environment rife with corruption and cozy business-government relations, and they suffer particularly from weak regulatory regimes in which payments from customers cannot be trusted. For many SMEs, both domestic and foreign firms seeking to invest, the unpredictability of doing business in many LAC is perceived as a major barrier; it often manifests itself in corruption or in the form of lengthy, complex and opaque

bureaucratic procedures. This in turn encourages businesses to make quick returns, rather than aiming for sustained growth.

The realization that SMEs play an active role in innovation has led to a number of insights about the mechanisms by which SMEs improve and introduce new products and services. Rothwell and Gardiner, 1989 suggest that small firms can have an innovative advantage due to differences in management structures. In an SME, the decision to innovative is made by a small number of people. Innovative activity also flourishes in environments free of bureaucratic constraints (Link and Bozeman, 1991). A number of SMEs have in fact benefited from the exodus of researchers thwarted by the managerial restraints of larger firms. Finally, larger firms also tend to promote successful researchers to management positions, while SMEs can place innovative activity at the center of their competitive strategy (Scherer and Huhn, 1992).

SMEs are thus a large and very heterogeneous group of firms whose investments in and use of innovations cannot be uniformly characterised. Thus any discussion of how to increase the innovative capacity of SMEs must start from an understanding that technology policies for SMEs must be targeted to different user groups, have different objectives, and use several approaches and tools.

However, in most countries innovation programmes that subsidise R&D are organised along different technology domains or sectors rather than targeted towards the sub-groups of companies outlined above. A great deal of policy attention has been paid to the technology developers, and an increasing number of developed countries have introduced special SME programmes to promote high technology start-ups. Only a small number of countries however, make a clear distinction between the different kinds of SMEs, or tailor their SME policies to help a broad cross section of these firms access and absorb knowledge that might improve their innovativeness.

The ability of SMEs to create, access and commercialise new knowledge on global markets is fundamental to their sustained competitiveness. This section identifies some of the principle strategies SMEs have pursued on their own, including:

- The innovation strategy, in which SMEs try to appropriate returns from their knowledge base (which may or may not involve own investments in R&D).
- The information technology strategy, which makes innovative uses of information technology in order to reduce SME costs and increase productivity.
- The niche strategy, in which SMEs choose to become sophisticated global players in a narrow product line.
- The network strategy, in which SMEs work and co-operate with other firms, be they SMEs or large enterprises in order to improve their ability to access and absorb innovations.
- The cluster strategy, in which SMEs locate in close proximity with competitors in order to take advantage of knowledge spill-overs, especially in the early stages of the industrial lifecycle.

The foreign direct investment strategy, in which SMEs exploit firm-specific ownership advantages abroad.

Nonetheless, strategies to enhance the global competitiveness of innovative SMEs should take into account that:

- New information and communication technologies facilitate global reach and help reduce the disadvantage of scale economies which small firms face in all aspects of business.
- Flexible specialisation has proven to be a particularly successful model of industrial organisation: through close co-operation with other firms SMEs can take advantage of knowledge externalities and rapidly respond to market changes.
- Despite economic globalisation and the ability to transmit information rapidly and cheaply, geographic boundaries still matter. Clustering is particularly important to gain access to new ideas and tacit knowledge, especially in young industries.
- Specialisation in a market niche compensates for some of the disadvantages of small scale.

While there are more hurdles to overcome for a small firm setting up affiliates abroad, the benefits in terms of access to new markets and knowledge can be immense.

Government policies

Despite the fact that globalisation reduces the degrees of freedom governments have in their policy responses, they can still play an important role in encouraging SMEs to innovate and to implement the strategies required to effectively meet the globalisation challenge, through appropriate regulation, incentives, and institutional learning.

Access to finance is a special problem for "High-TECH SMEs" in LAC. In the more developed economies there is a seamless chain of finance which allows firms to go from start-up micro-finance, to personal debt, to secured debt, to business angels, to venture capital, to IPO and public listing. However, the internationalisation of capital markets is not evenly spread, and the lower ends of debt and equity

markets are not as internationally efficient as they might be. This means that SMEs in LAC are often unable to realise their growth potential. On the other hand, India offers some interesting experience in the role that its expatriates can play in supporting the emergence of a vibrant venture capital business to support new economy start-ups!

Another crucial requirement for SMEs if they are to benefit from a global economy is access to, and capacity to utilise, new technologies. This applies not simply to e-commerce but to technologies related to the SMEs core businesses. Technological capabilities vary enormously across LAC, but, within a given country, SMEs are often at a technological disadvantage. Frequently, they cannot afford to invest in their own research and development (R&D) or to hire research staff. Collaboration with SMEs in OECD countries (or for that matter, large OECD enterprises) can be a valuable means of keeping abreast of technological and market trends, and also of acquiring advice on implementing new technologies, such as the Internet, and new managerial practices in their operations.

Good reliable infrastructure, especially for communications and logistics, is essential for the growth of SMEs. The provision of infrastructure can be extremely expensive, notably in rural areas where the majority of the population still lives in developing economies, if not in transition economies. Traditionally, infrastructure investment has been contingent on foreign aid programmes, though private sector financing has become much more important in the past few decades and its importance is set to grow. This is especially so for telecommunications and electricity, where build-operate-transfer arrangements are now commonplace, boosted by utility deregulation in many countries.

In addition to finance, startups, either in developed countries or LAC, require a range of affordable support services, including office space and maintenance, telecommunications and computer facilities and managerial support (procuring permissions and licenses, accounting, marketing, etc.). Business incubators are one approach to outsourcing some or all of these requirements, allowing entrepreneurs to share costly infrastructure and to concentrate on core competencies. Clearly entrepreneurs need to be in control of key managerial functions, but for less critical ones economising on scarce human capital can be attractive.

Finally, Tax Policy Incentives and tax credits for research-and-development expenditures should be legislated, both in the short and medium-terms, to help the start-up of "High-Tech SMES". Tax policies should reflect an understanding of the uniqueness of the biotechnology industry -companies that have many years of losses before turning profitable, yet must have expensive equipment on which to conduct research and produce material for lengthy studies and clinical trials. Tax policy should reflect the understanding that attracting and providing economic incentives to companies that generate high-paying research-and-development jobs will ultimately result in the construction of manufacturing plants and employment of even more highly skilled workers.

Concluding Remarks

In most countries, technology programmes are organised by technology domain or sector. They do not target different sub-populations of companies. However, an increasing number of developed countries have introduced special SME programmes. Only a few countries however make a clear distinction between different kinds of SMEs. The LAC should be follow this last strategy.

Technology developers, and especially the new technology based firms as the subgroup of "High-Tech SMEs" needs support schemes from Public R&D Agencies. Because their focus is on developing leading edge technologies, they are best able to respond to government R&D programmes. In addition, a lack of early stage seed capital meant that they needed the government for project financing. But the emergence of private capital sources might reduce the necessity of public grants for this group.

International R&D Granting Institutions have accumulated a huge amount of experience in dealing with technology start-ups, their knowledge can be used to complement the expertise of venture capitalists to help LAC to implement funding policies for High-Tech SMES. In some countries, public seed capital organisations are merging or collaborating with the institutions that administered R&D grants.

Governments should actively encourage the collaboration between these R&D granting institutes and private or semi-public seed capital industries. In some countries, if no seed capital is available, its development should be stimulated.

The "High-TECH SMES" of the biotechnology industry should be identified as a key industry sector responsible for developing high-wage research and development jobs, and thus an important target in the tax incentive legislative proposals.

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