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STRATEGIES FOR SOFTWARE EXPORTS IN DEVELOPING COUNTRIES*

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Introduction

Software constitutes the fastest growing segment of the information technology market. With sales over US$ 100 billion annually, the software sector is targeted by hardware suppliers and specialized software firms alike. Though largely dominated by enterprises from industrialized countries, software is still regarded as an opportunity in many developing countries. Some of them, as discussed in this paper, have adopted explicit policies in order to exploit such an opportunity.

The main objective of the paper is to examine the problems facing developing countries willing to enter the international market in the software field, and the strategies that may be followed for that purpose.

In order to assess the opportunities existing for developing countries in the software area, it is necessary to understand what software development and production mean in economic terms. The technical and market-related aspects of software business activities have received considerable attention. However, the economics of software generation and production have been studied to a very limited extent[1]. Some of the issues to be considered in this regard are briefly addressed in section 1. The analysis made in said section is only introductory. More in-depth studies on this subject are certainly required.

Section 2 examines the internal and external factors that influence the viability of software exports from developing countries. It examines various constraints and barriers to entry into the international market. Consideration is also given to those factors and conditions that may permit to overcome said constraints.

Section 3 presents information on software production and exports in a number of developing countries in Latin America The main source for Latin America has been previous work in the framework of the UNDP/UNIDO Regional Program for Informatics and Microelectronics for Latin America. The case of Chile, the main Latin American software exporter, is examined in more detail.

The following section (Section 4) examines the situation of software production in some South-East Asian countries and in India. This section is based on secondary sources and on the information provided by ASSCOM (the association of Indian software firms) for India. The need for a more focused and extensive empirical research on software exports from developing countries should also be noted here.

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[1] See, for instance, OECD (1985).

Section 5 deals with two countries having small domestic market whose experience in software production and export may provide interesting insights on the potential and dynamics of this activity. They are Israel and Ireland. The case of the latter, in particular, offers specially interesting features, given the explicit governmental commitment to promote software as a major export item of the country.

Section 6 presents, in the light of the previous analysis, a comparative study of the main software export strategies applied in the surveyed countries. It highlights different approaches, as well as various trade-offs in terms of value added, risks, profitability and building up of technological capabilities.

Finally, the last section briefly includes the main conclusions of the study.

1. The economics of software development

The development and production of software[2] present a number of characteristics determined by the nature of the technology and of the products involved.

First, software development is skill-intensive. The availability of qualified technical personnel clearly is a key factor, albeit not sufficient to ensure commercial success. Capital investments required -including hardware and software engineering tools- are not as substantial and do not constitute a barrier to entry as in other areas of information technologies (notably, microelectronics production).

Second, the technology for software development is science-intensive, and largely available at university and research institutions. The basic knowledge to create computer programs is well codified (formalized) and accessible to individuals of various disciplines (not necessarily software specialists) with a mathematical background. The knowledge involved in software development, however, constitutes a more complex technological package where other skills (e.g. on information systems, hardware architectures, etc.) are required, depending on the type of software to be produced, as mentioned below.

Third, despite the high degree of formalization of knowledge involved in software development, considerable room

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[2] Software "development" refers to the activities leading to the creation or modification of a computer program and its related documentation, "production" is the reproduction of the computer programmes (in diskettes and other devices) and of the documentation.

is left for creativity and ingenuity, and for tacit knowledge[3] based upon experience. Software development is often described as still being more an "art" than a proper "industrial" activity, despite the introduction of software engineering tools.

Fourth, the components of technological packages applied may significantly vary in accordance with the products. Thus, work on systems software requires particular knowledge and skills, mostly possessed by hardware producers[4]. Time and investments necessary to develop systems software are also generally higher than for application software. Within this latter category, on the other side, managerial and technical skills required also vary depending on the degree of standardization and complexity of the final products.

Fifth, technologies for software development are not proprietary, although the use of certain tools or platforms may require the negotiation of a license and the payment of royalties. Different languages and architectures offer software producers options to develop their products, with different technical (and commercial) advantages and disadvantages. In particular, the use of open or of proprietary systems has important commercial implications. In other words, there is no unique way of developing a certain product and software producers must make strategic choices taking the type of products and markets envisaged into account.

Sixth, though the use of quality standards is growing -at least in industrialized countries- quality controls and methodologies may greatly vary, affecting the quality of the final product. It is to be presumed that the implementation of stringent quality standards increases production costs and barriers to entry, and that the management of quality issues is likely to become an increasingly key competitive factor in the software field.

Seventh, like the capital goods industry, software may be produced to meet a particular client's demand ("custom") or as a standardized product ("package"). The requirements, and particularly the organization, management, and quality controls required vary in accordance with the category of product involved. As mentioned below, most software firms in Latin American and India only or mainly produce "custom" software. The production of packaged software generally pose higher quality and reliability requirements, and entail substantially larger (and riskier) investments.

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[3] That is, knowledge which is not formalized and, therefore, difficult to transfer.

[4] Some "software houses" -like Microsoft- have made, nevertheless, substantial inroads in systems software.

Eight, software is a user-driven product, in the sense that "an understanding of users' requirements is necessary for its creation/production. In this case, one can talk of creation, production and diffusion as generally collapsing into a single process. This aspect underlines the importance of devising strategies which as far as possible try to incorporate users in the early creation/production of software. This may call for accompanying measures targeted towards user involvement and, more generally, diffusion" (Molina and Correa, 1993). This characteristic strongly influences the process of software development. Developers that face unsophisticated users, are unlikely to build up capabilities to compete on the international market.

Ninth, and finally, the rapid pace of technological change and the short life-cycle of products forces software companies to undertake R&D and to invest in training for new technologies. The rate of failure in this sector is high. Moreover, as the companies grow from small, high creative, single product units into larger organizations, management problems usually arise and firms lose their dynamic qualities. An inverse economy of scale may, hence, exist in software development: "When companies grow large, they incur disproportionate managerial and administrative overheads, and the entrepreneurial and technical vigour that made them successful when they were small is diluted. There is also an apparent increase in the cost and lead-time required to create a new product release"(IDA, 1992). Big firms possess decisive advantages vis-á-vis small firms in terms of financial strength to undertake R&D, to follow riskier but more promising targets and, above all, to face the high marketing costs generally associated with the commercialization of packaged software.

If, according to the previous analysis, technology for software development and production is not proprietary but legally accessible; if software development is skill (labour) intensive rather than capital intensive and is science-based; if small size is a source of dynamism; under these conditions developing countries would seem to have a real opportunity in the software area. However, and without denying such an opportunity, reality shows that developing countries' share in world software production and trade is extremely low. Though this is not the place to address this issue in depth[5], the gap existing between the technical possibility of developing software and the commercial viability of successfully selling it should be noted. Marketing strength is as crucial as technical capability. For packaged software, marketing usually accounts for a larger share of total costs than development and production. But it is not only a cost problem; it is also the ability to properly identify users needs, to offer products that meet their growing expectations in quality, performance

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[5] See Correa (1990), Schware (1992).

and price, and to be able to reach the targeted markets[6]. These and other factors that affect the international competitiveness of firms in developing countries are analyzed in more detail in the next section.

2. Software exports: internal and external barriers

Software exports from developing countries face a number of obstacles stemming from both local and international constraints. Though, as mentioned above, entry barriers in principle are lower than for other activities, a number of obstacles and disadvantages need to be overcome in order to develop a solid software industry with an export potential.

a) Internal factors

On the one side, a number of characteristics of software development and markets in developing countries, already identified by documentation (Schware, 1992; Correa, 1993) has limited the diversification and growth of the software industry and of export activities.

i) Market size

Domestic markets -even in large countries like Brazil and India- are relatively small and are unable to provide by themselves a platform for the development of products of a certain complexity and cost. This problem is also relevant for small European countries, such as Ireland (IDA, 1992).

ii) Firms' size

Software producer firms are generally small and lack financial resources and support. A problem common to many developing countries in Latin America and Asia is the absence of venture-capital mechanisms, and the reluctance of banks to provide financing to enterprises whose main assets are intangible, frequently lacking physical assets to guarantee loans. Financial problems become more significant if export operations are envisaged, as mentioned below.

iii) Quality standards

Despite the availability of qualified personnel, the firms in developing countries are in general not used to applying stringent quality standards nor is the domestic demand sophisticated enough to require high

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[6] Access to foreign markets is limited by language, by mixed potential users for products from foreign -non U.S. or European- companies and by the cost and difficulty of entering into distribution networks (Katz, 1987).

quality and performance standards. This means that the internationalization of products developed for domestic markets is not necessarily simple or automatic.

iv) The relative weight of labor costs

Even if low labor costs may provide certain comparative advantages[7], this is mainly true for services and custom software. When packaged software is at stake, the weight of labor costs in the total price of the product is not as decisive as generally believed. For instance, the greatest part (60%-70%) of the total revenue obtained from the sale of a packaged software for general use, remunerates management, administration and marketing plus profits, and only the remainder corresponds to actual development and production costs (U.S. Department of Commerce, 1984).

v) Shortcomings in qualifications and methodologies

The qualification of labor, while high in some developing countries, often presents imbalances or deficiencies. Thus, in some Latin American countries the lack of experienced managers for software development of a certain complexity has been observed (Correa, 1993). In addition, software engineering tools such as CASE tools still have a very limited use in most developing countries. This implies that methodologies used probably entail low productivity and quality in software design.

vi) Infrastructure

The lack of an appropriate infrastructure directly relevant to the development of a software industry (e.g. standardization, telecommunications) also constitutes an important limitation.

vii) Marketing requirements

Technical capabilities are necessary for a software firm to compete but are not sufficient to succeed, particularly on the international market. Marketing is an essential and costly component, especially when participating on the market for packaged software. Marketing limitations have been identified as a major constraint for export activities in Latin America

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[7] It should be noted that the advantages derived from labor costs should be adjusted by considering differing productivity levels. This analysis is seldom made, and its absence may lead to very incorrect assessments.

(see various national reports in Correa, 1993) as well as in Ireland: "Irish companies are innovative and technically competent. Their major weakness is in the area of marketing. This is particularly acute, as Irish companies probably need to be better at marketing than their counterparts in other countries: they have to overcome difficulties posed by the small size of the home market and the relative difficulty of access to other markets" (IDA, 1992, p. 3-3).

b) External factors

In addition to the above referred internal constraints, there are a number of limitations emerging from the structure of software supply and of the international market. The software market, probably the fastest growing market in the realm of information technologies, is highly competitive and internationalized. Software supply may be briefly characterized by three main features:

i) United States firms control the largest part of the world market and have been able to preserve an uncontested leadership in operating systems and packaged software. According to IDC figures, United States holds 57% of the world software market. The next largest share would be held by Japan with only 13%, followed by France (8%), Germany (7%) and United Kingdom (6%) (OTA, 1992).

ii) Market concentration is high both at the high end of software products (dominated by IBM) and at the low end. Thus, around 60% of the market for PC software is accounted for by ten firms and 45% by four firms, among which Microsoft holds a dominant position.

iii) Software supply is divided between specialized software houses and computer manufacturers, competing both in operating systems and application software and services. The top five U.S software vendors in 1990 included three of the former and two of the latter: IBM, Microsoft, Computer Associates, Digital and Oracle (Datamation, 1991, p.22).

iv) Software packages are the main driving force of the market, with tangible trends towards an increasing sophistication and integration of products and the development of vertical markets.

The production of software packages in fact constitute an indicator of the degree of development of the software industry in different countries. As indicated by Table 1, the

TABLE 1
WORLDWIDE PACKAGED SOFTWARE MARKET BY COUNTRY
(in US$ millions)

1989-1994

	1989		1990		1994	
	$	%	$	%	$	%
United States	15,830	43.1	18,020	41.9	32,040	39.7
Japan	3,334	9.1	3,901	9.1	7,726	9.6
Germany	3,010	8.2	3,627	8.4	7,272	9.0
United Kingdom	2,790	7.6	3,320	7.7	6,142	7.6
France	2,403	6.5	3,004	7.0	5,317	6.6
Italy	1,581	4.3	1,929	4.5	4,032	5.0
Netherlands	925	2.5	1,105	2.6	2,167	2.7
Canada	813	2.2	917	2.1	1,507	1.9
Australia	754	2.1	870	2.0	1,650	2.0
Spain	653	1.8	803	1.9	1,692	2.1
Switzerland	590	1.6	717	1.7	1,481	1.8
Sweden	551	1.5	636	1.5	1,115	1.4
Belgium	521	1.4	635	1.5	1,273	1.6
Brazil	360	1.0	447	1.0	950	1.2
Austria	348	0.9	422	1.0	845	1.0
Finland	340	0.9	394	0.9	688	0.9
Denmark	323	0.9	371	0.9	640	0.8
Norway	314	0.9	358	0.8	592	0.7
Mexico	130	0.4	171	0.4	425	0.5
S. Korea	107	0.3	143	0.3	331	0.4
India	90	0.2	121	0.3	495	0.6
Venezuela	76	0.2	91	0.2	226	0.3
Taiwan	71	0.2	92	0.2	220	0.3
Malaysia	59	0.2	70	0.2	119	0.1
Hungary	48	0.1	50	0.1	62	0.1
Singapore	47	0.1	55	0.1	84	0.1
Hong Kong	31	0.1	38	0.1	80	0.1
Argentina	25	0.1	30	0.1	137	0.2
P.R. of China	19	0.1	17	0.0	47	0.1
Thailand	12	0.0	18	0.0	80	0.1
Other	579	1.6	656	1.5	1,248	0.5
TOTAL	36,733	100.0	43,030	100.0	80,682	100.0

Source: International Data Corporation (1989)

participation of developing countries in the market of packaged software is very limited. Brazil and Mexico rank above the South East Newly Industrialized Countries (NIC's). Although the latter have clearly outpaced the former in the production of PCs and peripherals, this has not been accompanied by a parallel development of software production capabilities.

Software firms in developing countries seeking to accede to the international market confront not only solid and well established competition by large producer firms. They also need to overcome various disadvantages:

i) The identification of user needs in foreign countries and the knowledge of practices and cultural features require close contact and a systematic exploration, except if horizontal applications are envisaged (a highly competitive and very difficult field for new entrants) or well defined niches in vertical markets are targeted.

ii) Language barriers are certainly important, mainly for non-English speaking countries. Good documentation is often as crucial as a good program to succeed.

iii) Users in industrialized countries will generally mistrust software originating from faraway countries. Though India has gained considerable recognition as a technically reliable software producer -as evidenced by recent notes in business journals and newspapers of wide circulation in the United States-, most firms in developing countries find it extremely difficult to reach the potential users directly. The "nationalization" of the product by a local partner or through a subsidiary is frequently a sine qua non condition to enter a given market.

iv) Marketing costs for launching a new product on foreign markets are high and normally outside the reach of firms in developing countries; an additional obstacle is the reluctance of dealers/distributors to commercialize programs from small firms, particularly in the United States (Katz, 1987).

3. Software development and exports in developing countries

a) Latin American: Brazil, Argentina and Chile

Latin American countries have advanced to a different extent in the establishment of a software industry and in the diffusion of software and hardware in their economies. Although in many of them interesting developments have been identified, including software exports, this paper deals in particular with three selected countries: Brazil, Argentina

and Chile*

i) Policies and trends

Brazil attempted to develop a national computer industry on the basis of a "market reserve" policy which has been implemented since the 1970s. This policy, recently abandoned, excluded foreign investment and production and imports in the area of mini and micro computers. The market has been opened (in October 1992) to imports with decreasing tariff protection over the next few years, while joint-ventures with foreign firms are now admitted.

The legal regime applicable to computer programs has been clarified in 1987. Brazil is enforcing copyright protection for computer programs and has flexibilized (although the software law has not been formally changed yet) obligations relating to the registration and commercialization of imported software.

In the framework of a more open policy and greater emphasis on software vis-a-vis hardware production, a program to stimulate the development of the software industry was launched in 1992, with a budget of US$ 38 million (partially financed by UNDP). The aim of the program is to enhance the competitiveness of the Brazilian software industry and to make up one to two percent of the world market by the year 2.000. The Government is also providing support to software business incubators, such as SOFTEX, established by the Federal University of Rio Grande do Sul*.

During the 1980s Argentina defined policies aimed at developing a computer industry, but national macroeconomic disequilibria, on the one side, and price declines of hardware and their rapid technological change, on the other, frustrated that attempt. A free market for computers has boosted the installation of PCs and the diffusion of packaged software in the country. The software market is not regulated, and no restrictions are imposed on imports and sales. Large software producers have established distributor agents and commercial links with local companies. Software is protected under the copyright law in accordance with case law, but many aspects of protection still remain unclarified.

Chile, finally, has consistently applied a free market approach with respect to hardware since the last decade, giving

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* This subsection is substantially based on Correa (1993), which may also be consulted for other Latin American countries, and on Molina and Correa (1993).

* The UNDP/UNIDO Regional Program on Informatics (RLA/92/014) is also supporting the development of entrepreneurial capabilities in the software industry in the region.

emphasis to the diffusion of computers rather than to the local production thereof. In the software area, as discussed below, local firms have made significant progress domestically and in the world market. Various institutions (such as PROCHILE) have selectively supported activities aiming at exploring and developing export markets. Chilean copyright law explicitly protects software.

ii) Software market and industry

The software industry in the three countries considered here share a number of common features. First, there is a considerable high degree of concentration of supply, with the five top firms controlling around 50% to 70% of the market. Second, firms with software activities are involved in most cases in hardware sales or in the provision of consultancy and/or data processing services. Pure software houses are the exception rather than the rule. Third, the industry has focused on the production of custom application software; the market for operating systems is dominated by imports, as well as the packaged software market. Fourth, a supply of well qualified personnel is available, generally at a cost considerably lower than in industrialized countries[10] . Fifth, the industry, still in its initiation stage, has not established solid R&D capabilities but is gradually improving its managerial capabilities and aiming at compliance with higher quality standards.

Data on software production and market are not collected on a systematic basis in the countries considered. The main sources of information are the own associations of software-related firms and some private consultancy firms.

In Argentina , the Cámara de Empresas de Software y Servicios Informáticos (CESSI) estimated that in 1992, 430.000 PCs, 11.500 minicomputers and 515 mainframes had been installed. The rate of growth in PC installations was particularly high (they almost doubled during 1991). The total software market was estimated at US$ 190 million, 32,6% of which was accounted for by national firms, 50% by imports from the United States and the remainder by imports from other countries[11].

There are about 300 firms active in the production and/or distribution of software in Argentina, but, as mentioned above, the degree of concentration is high (five enterprises account

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[10] This does not currently apply to Argentina, given the present rate of foreign exchange and local level of salaries.

[11] Other sources have estimated higher values for the total Argentine software market. According to Dmitruk, for instance, it would have reached U$S 300 million in 1991 (Dmitruk, 1993, p. 35).

for about 70% of total sales). The industry employs about 3.000 people in software activities and 1.500 in services supply. About half of this personnel has technical or professional qualifications. Exports have been occasional, but a few firms are actively looking for foreign partners and are regularly participating in major international exhibitions.

Brazil accounts for the largest informatics market[12] in Latin America, with estimated annual sales of US$ 7 billion. Around 1.5 million PCs had been installed in 1992. As a result of the liberalization of the market, a 20% annual increase in installations was expected as from 1993. Estimates on the value of the software market vary significantly. It was estimated at US$ 320 million for 1990, but actual figures seemed considerably undervalued due to piracy problems, particularly in the field of microcomputers. In accordance with other estimates, the software market would have surpassed US$ 700 million (Correa, 1990).

Finally, about 280.000 PCs had been sold in Chile in 1992[13]. Software and hardware sales reached about US$ 120 million in 1992, 10% of which were accounted for by software imports and 12% by software exports. Software sales increased at a 100% rate during 1990/1991. They are strongly concentrated: the largest firms totalled sales for US$ 93,2 million. Some of them have attained considerable size, and established subsidiaries in several Latin American countries. Personnel employed by industry is about 2.000 people.

The modernization of banking entities, the privatization of public enterprises, and the restructuring of the State provided significant opportunities for the development of software in Chile during the 1980s. Large infrastructure projects with informatics components (e.g. subway construction in Santiago) gave additional impetus to local software companies, in some cases working in association with foreign firms.

iii) Software exports: Chile

Chile, with the fastest growing Latin American economy, has emerged as the main software exporter in the region. As indicated before, the computer and software market in Chile is relatively small, as compared to the markets of Argentina and, particularly, Brazil.

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[12] The following data are based on information provided by the Asociacao Brasileira de Empresas de Software (ABES) and on "Investment/Latin America", 1990.

[13] Data on Chile are based on information compiled by the Comité de Empresas Exportadoras de Software (CEES).

Chile has followed a clear export oriented economic strategy, on the basis of a pro-market, macroeconomic framework. Software firms have also targeted foreign markets in order to overcome the limitations imposed by the size of the domestic market.

Software exports from Chile have grown at a spectacular rate during 1991 (64%) and 1992 (117%), increasing from US$ 3,9 million in 1990 to US$ 13,9 million in 1992[14]. Exports represent around 12% of total sales of CEES member firms[15]. Three features of Chilean software exports are particularly relevant:

First, unlike the case of India, software exports predominantly consist of packages and custom-made systems. The main exported packages[16] include systems for vertical markets. In some cases these were originally developed for non-PC equipment but lately adapted to be run on standard PCs.

Second, the main market for Chilean software export is Latin America, which accounted for 57% of total exports in 1992. The percentage of exports to Latin America is even higher for firms with sales below US$ 1 million. Sales to Asian countries represented 16% of the exports by the latter enterprises (12% on average). The participation of Europe and USA markets is almost insignificant, though local enterprises are targeting Europe as a second priority after Latin America, which is viewed as the main market for Chilean software exports[17]

Third, software firms not only undertook direct exports of package and custom-made software, but some of them have also established subsidiaries in several Latin American countries (such as in Argentina, Colombia and Venezuela).

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[14] The data presented here and in the following paragraphs have been elaborated by CEES. The expected rate of growth of software exports for 1993-1995 is 60%, according to the same source.

[15] CEES is the Comité de Empresas Exportadoras de Software. The proportion is higher (13%) for firms with sales above US$ 1 million.

[16] Exported packages have mainly concentrated in the areas of administration, banking, statistics, forestry, geography and mining.

[17] Interviews with local firms reveal that European markets are deemed more easily accessible for Chilean software products than the American market, mainly due to a higher possibility of finding in the former local partners willing to share the costs and risks of introducing new products.

Chile has clearly outperformed other Latin American countries in software exports. The factors explaining the relative success of Chilean firms rest, in accordance with earlier studies (see Correa, 1993), with: a) the unrestricted access to hardware and software in an open economic context; b) the availability of qualified personnel at the technical and managerial level; c) the selective support provided by the Government to software firms seeking export opportunities.

Chilean firms have received Government support mainly in the form of financing for commercial missions abroad, for the preparation of promotional materials and for the participation in international exhibitions. PROCHILE has also promoted coordination among exporter companies.

4. South-East Asian countries and India

The development of a software industry has been encouraged in South East Asian countries, such as Taiwan Province, Singapore and the Republic of Korea.

a) Taiwan Province[18]

Hardware production spurred in Taiwan Province during the 1980s, particularly in the fields of microcomputers and microelectronics[19], based on the activity of domestic firms as well as original equipment manufacturers (OEMs). The Government, which promoted hardware production in the country, also extended research funding and investment and tax incentives to software developers.

By 1990, about 300 firms were working in the software area in Taiwan Province, mostly in the area of application-software packages. Systems software development was undertaken in publicly supported institutions, like the Institute for Information Industry. This Institute has promoted various projects of interest to the software industry, such as the development of Chinese versions of Unix and X Windows interface for use in workstations.

The availability of tax incentives and of skilled, low-cost personnel, has induced large U.S computer corporations to establish software-development centers in Taiwan Province. This has been the case, for instance, with Hewlett Packard, IBM and Wang.

After extensive negotiations with the U.S.A. Taiwan amended its copyright law in 1985 in order to protect software.

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[18] This subsection and subsection b) below are based on OTA, 1992.

[19] Revenues from these industries amounted to around U$S 2,1 billion in 1990 (OTA, 1992, p. 210).

The law included a "fair use" clause (similar to article 117 of U.S. copyright law) but limited protection to 30 years (local groups had lobbied for even a shorter term: 15 years). The law also required registration for non-Taiwanese to obtain protection, but this requirement was waived for U.S citizens and firms based on the trade treaty in force between Taiwan Province and U.S.A.

b) Singapore

Under the auspices of the National Computer Board, Singapore has actively pursued the development of a software industry over the past decade. The Board was established in 1981 in order to:

i) Coordinate education and training in the computer area;

ii) Expand the computerization of the public sector; and

iii) Develop an infrastructure for an export-oriented software industry.

Actions undertaken included a five year program, initiated in 1982 with a US$ 80 million funding, to train computer specialists and provide financial incentives for local software development. In the framework of this program, three government-run training institutes were established. One of them was set up as a joint venture with IBM and another one received support from Nippon Electric Co (NEC) from Japan.

On the other side, and in order to promote local demand, the National Computer Board established a group of more than 400 "systems information officers" in order to promote and cooperate in the development of information systems for the public sector. The Government also designed a publicly accessible "on line" information system aimed at facilitating business planning.

The National Computer Board has also promoted applied research, through research institutions such as the Information Technology Institute (established in 1986 with a US$ 40 million budget), the Institute of Systems Science, the National Institute of Singapore and the Nayang Technical Institute. At the latter, for instance, collaborative research by Government and industry has targeted computer integrated manufacturing, while other programs focused on emerging areas like artificial intelligence and fuzzy logic.

The financial incentives offered by the Government for software development induced several foreign firms to establish in Singapore software development centers, such as in the case of Nixdorf (Germany), and Digital Equipment, Hewlett Packard and Sperry (USA). The revenues of Singapore's software industry (including services) was estimated as totalling about

US$ 1 billion in 1990.

The Trade and Development Board has developed a system of subsidies to support software exports. Subsidies may be applied to facilitate the participation in trade missions and exhibitions, the preparation of promotional materials (including video), the opening of foreign offices and product designs.

The Economic Development Board itself administers a "Business Development Scheme" aimed at helping small and medium enterprises to face costs of international operations.

The scheme of exports incentives offered to software firms by Singapore's Government was subjected to investigation by the United States Government, upon request of an American firm (Visible Systems Corp.). The investigation, initiated in 1989, referred to a "CASE" product commercialized by a Singapore's firm that received subsidies. The final decision, adopted in 1990, dismissed, however the claims of the American company.

In 1987, Singapore modified its copyright legislation in order to incorporate software as a subject matter of protection.

c) Republic of Korea[20]

The Republic of Korean Government has taken the initiative of developing software technology as a part of the National R&D Program since 1982. Importation of foreign technology was also encouraged. In addition, a large software development project, the SUPER (software usability and Productivity Enhancement Research) project was undertaken as a national project.

The SUPER project is an R&D program for enhancing the software usability and productivity, driven by the Government with wide participation of private companies, university research centers, and Government research organizations. Major research areas of the project included: software engineering technology, systems software, artificial intelligence, high-level applications software technology, including CAD/CAM, among others. The planned expenditure for the Project is 900 billion won until 2001. In 1988, the first year of the project, the Government invested 3 billion won.

In order to promote the software industry, the Government enacted the Software Promotion Law, which came into effect as of July 1988. It provided a basis for the Government to support the local software industry.

A Council for Software Industry Promotion was established by said law (Article 4). The Council is composed of Government

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[20] This section is substantially based on Yu and Kim, 1988.

officials, scientists, and industrial experts for software development and productivity improvement, manpower development, and building up a software development environment.

Based on Article 9 of the Law, the establishment of a functionally specialized software complex in the Seoul area as an industrial base for software was proposed. In the complex, the software companies would be able to specialize in one area, and thus raise productivity, as more software and software-related companies are placed in the limited area. The complex would eventually become a platform for expansion to the international market.

With the purpose of providing an effective promotion to the software industry, the Government considered guaranteeing loans from domestic commercial banks to software companies without any collateral (Article 10), and building up a system for implementation of software quality assurance (Article 7). Furthermore, a guideline for estimating the software development costs was prepared so that software is valued adequately (Article 8). This will restrict dumping, reduce the bankruptcy of software houses, lead to orderly distribution of software, and eventually lead to improvement of software quality.

While the implementation of the Software Industry Promotion Law has apparently been partial, the Government has stimulated software development and hardware production by stimulating the demand through large public informatization projects. It has also promoted standardization in order to increase compatibility and software usability. The codes for Chinese and Korean languages were revised and the Open Systems Interconnection (OSI) standard for local computer networks was adopted.

The Government put great emphasis on the development of advanced systems and provided funding up to 100 % through the National R&D program since 1982. Software development projects which required advanced technology have been carried out by the Government alone or by the joint efforts of the Government and the private companies. Between 1982 and 1986, 84 projects were carried out with total expenditure of 16.2 billion won of which the Government supported 55 projects fully with the total amount of 12.4 billion won.

In 1987 Republic of Korea adopted a law for the legal protection of computer programs. The Program Protection Law has been adopted as separate from the copyright law. But basically it acknowledges software as a kind of copyright. Article 3 extends protection to programs of nationals of countries with which the Government of Republic of Korea has established a formal diplomatic relation.

Article 8, treats programs as copyright and extends the period of protection up to 50 years. For full protection,

however, all newly developed programs should be registered within one year from their development and at the same time be enlisted to MOST (Ministry of Science and Technology). This law also includes articles on penalties for cases of infringement of protection.

d) India

India has become so far the most successful software exporter among developing countries, as measured by total revenues earned. The Indian case, however, requires a careful analysis in order to understand the nature and extent of the achievements obtained.

Until now India has pursued well defined protectionist economic policies aimed at substituting imports and attaining self-reliance in several areas. Country of contrasts, India has reached considerable technological capability in high-tech areas, such as in the nuclear field. It possesses a large scientific base, and well trained professionals in sciences and engineering. India targeted software as an important item for development and export as early as the 1970s, when the Government introduced promotional measures to expand software exports. Those measures included facilities to import hardware (otherwise restricted).

Three key factors seemed to support the Indian Government's move. First, well qualified informatics scientists, engineers and programmers were available at a cost significantly (several times) lower than in the U.S.A. and other developed countries. Second, educated people in India currently speak and work in English. Third, India had demonstrated technolcgical competencies in other high-tech fields, as well as in maintenance and other computer services.

Notwithstanding the Government's expectations, take-off of software exports was considerably slow. Promotional measures were revised and expanded several times. The Government also decided the establishment of "software technology parks" aimed at providing infrastructure and further incentives for software exports. Several foreign firms were persuaded of the advantages of developing software at low cost in India. Texas Instruments, for instance, decentralized by transferring to India certain software activities based on a direct satellite connection with the parent company. Other firms including IBM, followed suit.

It is interesting to note that the software domestic market in India is relatively small. The diffusion of informatics is very low, as compared to developed (and even some developing) countries. With the exception of some large software projects (e.g. informatization of the railways network), suppliers of software have faced a modest demand. The promotion of software exports has not been accompanied till now by efforts to expand domestic demand.

Why and in which manner has India come to be regarded as a successful software exporter in the developing world?

Figures on software exports, though not as spectacular as expected by the Government, show a steady increase, particularly in recent years (see Table 2). Three important characteristics of Indian software exports need to be mentioned.

Table 2
India: Domestic and Exported Software

	US$ millions 1991-92	1992-93	% growth
Software Exports in Rupee terms	4300	6750	57%
Software Exports	164	225	37%
Domestic Software	3200	4900	53%
Total Software	7500	11650	55%

Source: Nasscom, 1993

First, a substantial part of said exports (85%-90%) is "body-shopping" (Schware, 1992), that is, they consist of the provision of short term off-shore services by Indian professionals hired to undertake particular tasks.

Body-shopping is a low-risk, low value-added activity, with limited capability building impact on the supplier. Indian key comparative advantage -low programmers' salaries- allows for extensive use of this modality mainly for routine-programming tasks (rather than for systems design).

Second, Indian software exports have been highly concentrated, the Tata Computing Services and Tata Unisy Ltd. accounting for a major share of total exports (see Table 3). These companies' entry into the field was facilitated by previous service bureau activities and by the prestige gained with major Western clients.

Table 3
INDIA
Top Fifteen Software Exporters (1992-1993)

Rank	Company	Exports (Rs Crore)
1.	Tata Consultancy Services	175.00
2.	Tata Unisys Limited	56.00
3.	Digital Equipment (India) Limited	31.78
4.	Citicorp Overseas Software Ltd.	20.94
5.	Wipro Systems Limited	17.22
6.	Siemens Information Systems Ltd.	16.00
7.	PSI Data Systems Ltd.	15.65
8.	Patni Computer Systems	15.62
9.	Ressan Information Management Resources	14.85
10.	ICIM Limited	13.00
11.	Texas Instruments Limited	12.84
12.	Infosys Technologies Limited	12.06
13.	Mahindra British Telecom Limited	10.39
14.	Silverline Industries Limited	9.18
15.	Index Computing Services	8.28

Source: Nasscom, 1993.

Third, the comparative advantages of software firms have not only relied on low salaries and high qualifications. Rapid response to demand (quickly constituting and sending abroad programmers' teams) has apparently played an important role.

Fourth, Indian software services offer a convenient alternative for firms in developed countries willing to undertake re-engineering, scaling-down and decentralization of their information systems.

In sum, the Indian experience in software exports has very peculiar and distinct features, and can not be compared in a straight forward manner with other cases where higher value added services and products and more significant marketing exports are at stake.

5. The experiences of Israel and Ireland

a) Israel

Israel has developed a significant electronics sector, with a strong commitment to R&D[21] and various forms of collaboration with foreign firms. Activities in that field included the design of microprocessors, fiber optics components and other data and telecommunication equipment. Israeli firms participated in the development of software for the Pentium

[21] 70% of Government investment in R&D is devoted to electronics.

processor (Intel) and control a substantial share of the digital circulation multiplication market.

The computer software industry has tripled in eight years. About 12.000 specialists work in 150 companies. Sales reached US$ 550 million in 1991; exports are deemed to have grown 40% in two years. Niches carved by software companies include applications generators and development tools, data base management systems, graphics packages, robotics and computer-education.

The strategy for software production and exports followed by the Israeli firms shows clear differences from other experiences considered in this study. Unlike India and Chile, Israel has developed capabilities in electronics production and in the design of digital systems. This is likely to explain the relative sophistication of software products, such as software engineering tools. Those differences also illustrate the heterogeneity of software development and the importance of various and specific competencies to target different market niches.

b) Ireland[22]

i) The software industry

The software industry in Ireland employs 8.000 people and turns over 1,74 billion Irish punts[23] annually; it is one of the fastest growing sectors in the Irish economy and one of the top five exporting sectors.

365 companies were producing software in Ireland in 1992, 291 of which were indigenous and 74 foreign. Two-thirds of the companies were engaged in developing end-user application products, ranging from accounting systems to specialized niche products. The rest supplied services and specialist software systems, such as software tools, communications software and software for dedicated hardware devices.The indigenous companies employed 3.801 staff, of whom approximately 75% were third-level graduates. The average age of these companies was 5,25 years (as of 1992). Fourteen indigenous companies employed more than 50 people and eighty more than 20. 5% of the indigenous companies at the upper end of the scale by size accounted for over 33% of the total employment and generated 37% of the total revenue of the indigenous sector.

36% of the software indigenous companies used CASE/4GL products in 1992, that is, were employing tools aimed at improving productivity and quality in software design and development. One third of said firms used object oriented

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[22] The following presentation is based on IDA, 1992.

[23] One Irish punt is roughly equivalent to 0,82 ECUs.

programming, which enables to deal more easily with complex systems in a more reliable and cost-effective manner. 40% of the firms, finally, had adopted or were planning to migrate to open systems. No indigenous firm had been certified for ISO 9000 by the end of 1991 (although a few were expected to be certified by the end of 1992).

Ireland became an important center for software localization and manufacturing by foreign firms, with an employment of about 600 people. This created significant opportunities for the printing and packaging industries. Many foreign firms gradually upgraded their operations in Ireland and also established software development units. Concentration of overseas companies is higher than for domestic firms: the top four companies accounted for 45% of total employment.

Foreign firms also accounted for the largest part (90%) of the software sector overall revenue. All but a tiny portion of the software produced by foreign firms was exported. The main reasons for foreign direct investment in software in Ireland seem to include the access to the European marketplace, the availability of a skilled English-speaking workforce and the existence of a good infrastructure for software manufacturing, including translation, disc duplication, printing and packaging. Another benefit is the availability of Government incentives[24], and a 10% corporate rate.

ii) Software exports

In 1992, software exports from Ireland reached 1,6 billion Irish pounds and accounted for 10% of the country's total exports. Although most exports are accounted for by foreign firms operating in Ireland, indigenous companies are also active in that field: 40% of their output is exported. Three quarters of firms with less than five employees exported an average of 18.500 Irish punts per person employed.

Software exports in Ireland are product-led. Most Irish companies are niche-oriented and exports are focused on products rather than on services, although most of the companies started their operations as service companies. Furthermore, exports of products is often used to open doors for selling value added services, such as modifications, training, implementation and support. It is not unusual for a company to win a contract where the product fee is only 25% of the total revenue, the remaining originating in additional services sold.

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[24] The Governments of other European countries, such as Holland and France, also offer incentives for software companies (in the case of Holland, these include free buildings and tax benefits).

6. Software export strategies

The experiences of developing countries, as well as of Israel and Ireland described above, may be analyzed in the framework of the considerations made in sections 1 and 2. Such experiences indicate that different strategies have been used to enter the international market, and that they are linked to the level and characteristics of the software industry in the various countries considered.

Three main strategies for entry into the international market may be identified. They may viewed as alternatives or as different stages in an evolutionary process, though clearly the latter would not be the case in many of the countries considered here. In some cases, countries and firms may apply a combination of various strategies. These may be described as follows:

Strategy 1: Export of work

This strategy is based on the supply of "off-shore" services by means of short-term work at the premises of the client. This type of activity presents low entry barriers in terms of capital and marketing costs; risk is also low. Personnel and firms providing the service gain experience and knowledge of foreign markets. In exchange, these operations are mostly confined to programming, the learning process is not substantial and the value added and profits are relatively low.

Indian software exports, as indicated above, are predominantly explained by this type of "body-shopping" operations. The Philippines has apparently followed this approach too. In the case of India, the extensive "body-shopping" in the United States has to some extent been facilitated, as mentioned before, by numerous Indians working in American firms in the informatics field who helped to establish links with Indian suppliers. The loss of personnel through "brain-drain" has often been a direct consequence of said operations.

Off-shore services require a liberal immigration policy by the receiving country. More stringent visa requirements seem to be imposed currently in the United States, which may substantially limit this type of activity.

Strategy 2: Export of software development services

This strategy may assume a variety of modalities according to the type of contractual relationship established and of the specific activities involved:

i) Development of custom-made software in accordance with client's specifications. Software developers may, in general, participate in these cases in the

design, programming and implementation of the systems;

ii) Development of software in the framework of subcontracting arrangements. Activities are generally -but not necessarily- confined to programming;

iii) Establishment of software development units as joint-ventures with foreign companies. Different degrees of involvement of the local partner are possible in this case.

This strategy, particularly under modality i) implies higher commitments in terms of capital and higher risks than Strategy 1. Marketing requirements may also be significant under modality i), but not as important as in the case of packaged software. The track record, size and experience of the supplier company/potential partner with specific technologies are also relevant (mainly for i and ii).

Value added (and profitability) are also likely to be higher than with Strategy 1. The learning process would also be more substantial, particularly as to the development of skills to manage large projects. In exchange, this strategy requires a better local infrastructure and support for the industry than in the previous case. Taiwan Province, Singapore and Chile have followed this strategy to different degrees.

Strategy 3: Export of products

Capital, managerial and marketing skills required are higher. Risk is also considerably higher than for the two other strategies. Suppliers need to develop or get access to a distribution network, except if direct sales are possible, given the nature of products. Post-sales services need to be ensured. Competition is intense and advantages based on low labor costs lose their relative importance.

A strategy based on export of products results in more value-added in the exporting country than the other alternatives, and also has a greater potential of profitability. The impact on learning and the building up of technological capabilities are also larger. Products may be less vulnerable to recession than services and, at least in the case of Ireland, they were found easier and quicker to sell than services (IDA, 1992). In addition, the sale of products may be the first step towards the sale of value-added services. Marketing problems, as mentioned above, become more significant with this strategy.

Israel and Ireland have focused on this strategy; Chile is also following this approach, while supplemented by the sale of services.

7. Main conclusions

The economics of software development and production presents peculiar factors that strongly influence the competitive position of firms in different countries and economic contexts. Though the technology is mostly non-proprietary, the process of development labor-intensive and capital requirements are relatively low, entry barriers are high, as illustrated by the considerable concentration prevailing in the software market.

The analysis presented in Section 1 of this study indicates the main issues and provides some hypotheses for further research on the economics of software development and production. Its main implication is that developing countries may expand and strengthen their software industries both domestically and internationally, but considerable efforts and appropriate strategies will be required.

The obstacles for a greater participation of developing countries in the international market are not negligible. Internal and external factors erect considerable barriers to entry, mainly associated with market rather than with technology factors, though the relevance of R&D on new products should not be disregarded.

The evidence gathered on the experience of selected Latin American countries show that, despite the progress made -particularly by Chile- and the programs in course, the region still has a modest performance in software exports. The importance of marketing barriers are particularly relevant in this case.

Although the information on the South-East Asian countries considered in the study is fragmented, it points to a considerable potential in the software industry and (at least in the case of Taiwan Province and Singapore), a greater ability to establish joint activities with large computer firms than in the Latin American case.

India presents an extremely interesting case of export oriented policy in a country traditionally inward looking. The relative success obtained is illustrative of the opportunities opened to developing countries, but the Indian experience needs to be understood taking the peculiar features of the case into account. If an upgrading from "body-shopping" to more value added activities is gradually made, India may actually become an important player in the international software market.

Finally, the discussion on different strategies applied may be useful to better understand the benefits and costs of alternative approaches. It is possible that in some cases, an evolution from less value-added to higher value-added services and products may provide a viable entry strategy into the

international market (this is perhaps a route to be followed by India). But some countries, like Chile, have apparently focused on products and value-added services as the most suitable approach from the outset.

In sum, not only the software market and the conditions to participate in it are heterogeneous; the strategies that may be followed by developing countries to foster their software exports also vary considerably. They need to be defined in accordance with the particular strengths and shortcomings of each country, but having a clear understanding of their different benefits and long-term impact on the development of a local software industry.

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