National Software Industry Development: Considerations for Government Planners[1]

Shirley Tessler and Avron Barr
Aldo Ventures, Inc.
info@aldo.com

Dr. Nagy Hanna
World Bank
Nhanna@worldbank.org

Software presents an unusual set of problems for policy makers. As a major global industry, it has been successfully targeted by a growing number of countries for its potential to generate export revenue. At the same time, it is an essential, high-risk, and increasingly expensive component of ICT-related programs to increase government effectiveness and to bring local firms in other industries up to globally competitive performance levels. This paper outlines the range of considerations specific to software within ICT planning and discusses government's role in accelerating and shaping that growth in support of social and economic priorities. We draw on the experience of both developed and emerging economies to argue that government should take an active role in software industry development and to lay out the full range of possible government actions (both policies and programs). Every country's path seems to be different – the best course of action will depend on the resources available (including infrastructure and human resources), on the state of the global software industry at that specific time, and on the country's unique situation, such as languages spoken, regional or cultural ties with major markets, a tradition of entrepreneurship, or an expatriate business community.

1. Introduction

The range of ICT-related concerns facing policy makers has increased dramatically in recent years: communications infrastructure, procurement for government automation and e-government programs, intellectual property, government-sponsored research programs, incubators and technology parks, engineering education, foreign investment and, of course, the potential for export revenue. It is usually in this last area, the potential for dramatic economic growth like India's or Ireland's, that first brings software to the forefront as a separate issue within ICT.

Software is a relatively low-investment, environmentally friendly, high-growth global industry – a good target growth industry for many countries. But it has also become the most critical and expensive element of the government and business systems that every nation must build for itself. As Stanford Professor Edward Feigenbaum put it while serving as Chief Scientist for the US Air Force, we now live in a "software-first world." (Clark, 1998) The growth of the global demand that makes software exports a growth industry is driven by the continued consumption of software by

[1] To appear in a special issue of The Electronic Journal on Information Systems in Developing Countries (June 2003) on The Emergence of Software Exporting Industries in Developing and Emerging Economies, Erran Carmel, Editor. http://www.ejisdc.org.

other countries and business enterprises. Software (and its continued maintenance) has become the dominant cost of business and government information systems around the world (Gartner 2001), and a significant cost factor in a range of manufactured goods from consumer electronics to automobiles (VDC 2002). Good strategic planning about government automation projects and investment incentives to domestic business can have a positive impact on the growth of a country's software exports compared to relying on market forces alone. Furthermore, creating certain types of software exports requires coherent long-term planning and investment strategies to complement and augment market-driven activity.

Every software-exporting country has evolved a unique industry, shaped by its own resources and situation and by the particular global opportunities presented at the time. For example, Japan exports mostly software games, India exports primarily software services to large software development shops, Ireland exports software products (created by MNCs located in-country as well as by a growing number of indigenous companies), and Israel mostly exports software technology which is subsequently productized by firms in the US and Europe. The global software industry continues to evolve, and countries now looking to develop their software exports face a different global situation, and are likely to evolve fundamentally different software industries. The current shape and dynamics of the software industry should, therefore, inform ICT planning and policy, no matter what the country's stage of economic development. For countries with deficient infrastructure and tight resources (such as Ireland in the 1970's), selective government initiatives have been critical to successful software industry development.

The purpose of this paper is to clarify the various issues typically addressed by government planners in developing national software strategies and in deploying local software capabilities in support of national priorities. We have a practical approach for thinking about any nation's software strategy. Key steps would be to: develop an understanding of the national economic and social priorities; inventory current software resources and activities; identify relevant trends and opportunities in the ever-changing global software industry; formulate strategies for software industry development that build on dynamic comparative advantage; and design tactics for dealing with specific issues.

Our approach takes into account several unique characteristics of the software industry:

- The different segments of the software industry (shrink-wrapped products, enterprise products, software services, embedded systems, technology licensing, etc.), each with its own methodologies and its own global marketplace with established players, business methods, and barriers to entry;
- The different kinds of talent and skills that make up software teams in different parts of the industry. Programmers, like musicians, vary greatly in their innate abilities. There is a wide range of technical skill categories, and other skill areas, like project management, technical hiring, and product marketing, that are just as important to successful industry growth;
- The key role of innovative startup companies in the industry, the importance of entrepreneurship, venture capital, the developmental stages of a software startup, and the special supportive habitat required by small technology companies;
- The need to build new software on top of layers of existing, "base-level" software infrastructure, which demands that domestic systems use industry-standard architectures so that customers are comfortable with domestic providers and so that local innovations can be directly exported; and

- The absence of a manufacturing phase in software product development, which makes the software publishing industry especially fluid. Product specifications, technology platforms, marketing partnerships, etc. are unusually volatile. This makes planning difficult and introduces additional risk.

This paper first frames the question of national software strategy in terms of deployment of a country's "software capacity." Ireland is discussed as an illustrative example of successful government efforts to develop a national software industry. We then discuss the balance between domestic and export software industries and the appropriate role for government in establishing that balance. Finally, we outline the main elements of a balanced national software strategy that would harness software technology to address both local development challenges and global market opportunities.

2. The Strategic Deployment of National Software Capacity

With so many ICT-related concerns pressing government planners, it may not be completely obvious why software requires special attention and consideration. The reason is that software has now become a core competency and general-purpose technology that is critical to the global competitiveness of most industries (all companies have the same hardware – they compete with software) and to the effective deployment of government services (beyond the basics of data processing) in every country, regardless of its level of economic development.

Not only is software a critical part of modern industrial infrastructure and an important industry in its own right, but it is also the vehicle for implementing the other key elements of a knowledge economy: responsive and transparent government; a supportive business environment with low transaction costs; enhanced learning environments; and effective social programs. Software-related policy must therefore be distinguished from industrial policy generally. Software is a fundamental capability that is deployed across almost all sectors of an economy. Moreover, as a nascent industry and fast-changing technology, market forces alone are often inadequate to harness the industry's potential to address public services and social priorities and to serve the needs of the poor, rural areas, small and medium enterprises (SMEs), and non-government organizations (NGOs).

"Software capacity" may be defined as the total amount of software that an organization, in this case a country, can build and maintain (Tessler and Barr, 1997). Software capacity is a key to participation in the global knowledge economy. A nation's software capacity is a limited resource that must be deployed strategically, in order to balance short- and long-term goals.[2]

Figure 1 illustrates the eight ways that a nation's software capacity can be deployed. The first step in strategic planning is recognizing that, at any given point in time, the country's capacity to undertake the full range of activities is constrained, and that tradeoffs must be addressed explicitly. Will the nation's programmers be employed building systems to modernize government operations, or re-building the national financial infrastructure, or will they be working in the local facility of a multi-national electronics manufacturer, or become entrepreneurs offering software products and services

[2] For a more complete discussion of software capacity and its deployment across the different sectors of the software industry, see Barr and Tessler, 1999.

abroad? Will the development of new industries that depend on ICT, like offshore outsourcing of back office work, consume a large fraction of the available software capacity? How many of the best software people are needed to train the next generation, so as to increase the nation's software capacity?

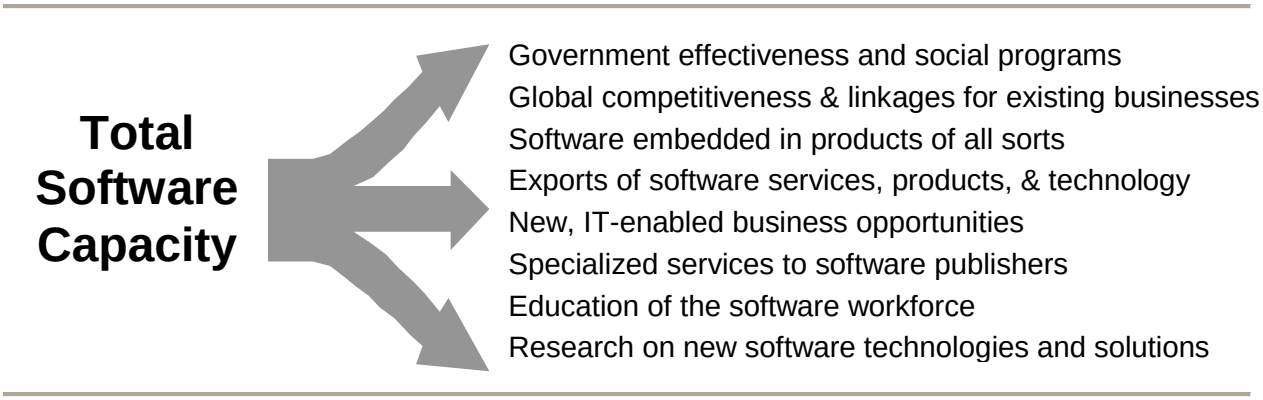

Figure 1. A nation's capacity to produce and maintain software is deployed across a variety of business and social endeavors.

To the extent that government policies and programs affect the deployment of software resources, decisions must reflect the country's economic and social priorities, for example, industrial modernization, employment, government effectiveness and social programs, hard-currency exports, foreign direct investment, knowledge economy development, or increased national prestige. Software services exports, for example, would be particularly appropriate to employ a large number of under-employed engineers, while ICT-enabled services businesses might be a better strategy for employing educated, non-engineers with adequate language skills.

Also, the time involved for developing the segments varies. IT-enabled businesses, for instance, could be flourishing in less that two years, once infrastructure is in place and policies and regulations are reformed, assuming an appropriate workforce is available. Developing a robust software products publishing industry, on the other hand, could take many more years, even after the prerequisites are in place.

3. Successful National Strategies for Exporting Software: Ireland's Example

Table 1 summarizes the successful national software industry strategies of the three countries that achieved billion-dollar software exports in the last decade. Each of these countries had a different set of goals in developing its software capacity, each started with dramatically different resources, and each capitalized on opportunities in a different part of the software industry at the time. In every case, however, government action was pivotal: policy change, investment, and proactive government programs. Some were more strategic in their approach than others, but all three have had success. Several other countries that have set their sights on software exports, including Malaysia, China,

Russia, Korea, and Singapore, are still struggling to crack the export industry.[3] Some have taken a more balanced approach, giving at least equal or more weight to the use of software, and ICT generally, in support of the knowledge economy or information society. Countries having good success with that approach include Korea, Singapore, Estonia, and Finland.

	Ireland (started in early 1970s)	**Israel (early 1980s)**	**India (late 1980s)**
Resources	English speaking workforce; European location; relatively cheap telecommunications.	State-of-the-art technology developed in military R&D projects.	Tens of thousands of highly trained, underemployed, English-speaking engineers.
Strategic Goal	Create jobs in Ireland at all levels. Learn the software industry (low capitalization and environmentally friendly vs. manufacturing jobs).	Commercialize military technology; create export industry; employ tens of thousands of Russian immigrant programmers.	Create export industry for job creation, foreign exchange earnings, and technology self-reliance.
Opportunity Targeted	Flow of US, Asian technology into the EU. Product localization and support difficulties of MNC's in dealing with multi-lingual market. High telecom costs on European continent.	Increasing demand for software technology, especially advanced security technology, in the US as networking became commonplace.	Shortage in US & Europe of low-level programmers created by demand for ERP installation, Y2K preparations, and e-commerce conversion.
Key Government Actions	Offer tax & other incentives to software MNC's to set up shop in Ireland.	Create Yozma and other industry investment programs; BIRD alliance programs; technology parks.	Combine on-site labor with offshore outsourcing facilities; invest in telecom & computing infrastructure, and quality certification to establish credibility.
2001 Export Revenue	$ 1.3B, exported by indigenous companies, almost entirely software products[4]	$ 3B, products and technology licensing	$ 7.5B, almost entirely software services

Table 1. National Software Strategies. The result of the variation in their circumstances and goals, and of the opportunities presented at the time, is that each country has a different type of software industry. Export revenue represents both product and services sales. Sources: NASSCOM, Enterprise Ireland, and the Israeli Association of Software Houses.

Ireland's case is particularly illuminating (see Crone, 2002). In the early 1970's, Ireland was facing continued emigration of its most educated people (a third of college grads were leaving permanently every year), a general population decline, and high unemployment. The government sought to reverse these trends. It identified high-tech as a high-growth, environmentally friendly industry and decided to focus its resources on developing that industry. It created a strategy to lure high-tech multinationals to Ireland through tax incentives and through aggressive promotion of Ireland's

[3] Barriers to significant growth in software exports include: high piracy rates at home, small talent pool, lack of engineering innovation, language barriers, and difficult business and regulatory environments. If its regulatory barriers continue to decline, China is likely to become the next $B software exporter because of its enormous workforce, investment in education, and global network of business contacts.

[4] The export revenue figure for Ireland jumps to $8B when flow-through from multinational software companies (the "overseas" firms) located in Ireland is included. See Enterprise Ireland, www.enterprise-ireland.com. Unfortunately, the figures for Israel and India also include flow-through from multinationals, but the authors have not found reliable figures for the export activity of just the indigenous companies in these latter two countries.

advantages: an educated, English-speaking workforce, proximity to Europe, and lower telecom rates than on the European continent. The centerpiece of its tax incentive program was a top corporate tax rate of 10%.

Ireland's long-term goal was that Irish nationals employed by the MNC's would learn the high-tech business first-hand, and then move on to create their own high-tech businesses. After 20 years, it became obvious that this strategy had not worked as planned, in spite of its success in slowing the emigration of talent and increasing both employment and exports.

Ireland discovered that the people employed by the MNC's did not spin off a great many new companies. The problem was that the people who were capable of spinning off a new software company were not the kind of people that the MNC's were hiring. The MNC's created new jobs, but not for the most creative and software-knowledgeable people. They hired folks to answer technical support questions at call centers, create and test local-language versions of software and documentation, etc. Few top-level programmers or business innovators were needed. Furthermore, many of the satellite businesses that were started to serve the MNC's were also low-margin, low-tech businesses like printing and packaging – not software services firms.

Irish software industry government planners discovered that innovation came, not from the MNC's, but primarily from the same sources that traditionally spawn innovation in the US and Europe: from corporate IS departments of both high-tech and non-high tech companies, and secondarily, from university and other research environments (Crone, 2002). They recognized that innovation in software is stimulated by those with good technical education, lifelong learning opportunities, access to enabling base-level software systems (as those found in corporate IS departments), and real on-the-job experience allowing a creative worker to see that some task could be done better.

In 1993, Enterprise Ireland was formed to focus specifically on creating an indigenous software industry. It introduced the Irish version of the two key programs that had been the cornerstones of the Israeli software industry development strategy: a venture capital program for supporting software entrepreneurship, and an R&D program for broad support of technology innovation and adaptation. Like Israel, both of these initiatives encourage cooperation with foreign organizations. Also, as in Israel, the Irish agency continues to spend a considerable portion of its yearly budget on global promotion activities. As a result, in 10 years' time the indigenous Irish software industry has grown from almost nothing to $2.8 billion, including $1.3 billion in export revenues (Arora, 2002). The indigenous industry also now accounts for a full half of the total 25,000 people employed directly in the industry.[5] At approximately $100,000 dollars in revenues per employee (and growing), Ireland already enjoys a highly leveraged and productive software workforce.

The MNC's did, however, contribute something of great value to the growth of Ireland's software industry: they helped to create the "habitat." Their very presence in and around Dublin started a migration of high-tech professionals from within Ireland and eventually from abroad (both returning expatriates and a second-wave of MNC's), all aiming for Dublin. New foreign firms could find experienced software professionals in Dublin, and could also find a variety of support firms. These firms were not just the low-level services firms mentioned above, but also some with high-level, specialized expertise in areas such as logistics and distribution to EU nations, call center setup, and

[5] In fact, as of 1999, the high-tech industry became the second largest employer in Ireland after the food industry.

the like. The expertise developed in these domestic support firms to serve the needs of the MNC's is now an important source of support for the indigenous industry. In turn, the indigenous software industry is driving new business creation in an ever-growing variety of specialized high-tech support firms, as well as fueling the expansion of the private venture capital industry.

Balancing the development of the software industry to address the needs of potential local users as well as the opportunities for export is important to an effective national software industry strategy and to overall development. As Ireland discovered, focusing on software exports alone is not always a winning strategy. Without a software industry that is attuned to domestic users, neither software exports nor social benefits will develop optimally. For example, in the case of Ireland in the 1980's, the heavy emphasis on export growth led to limited diffusion of ICT among local small and medium enterprises, and thus missed opportunities to contribute to overall employment and competitiveness of the economy.

4. Balancing Software Export with Domestic Needs

The global shortage of software engineers and the fast growth of demand for software applications in advanced economies have attracted the attention of both software talent and policy makers in emerging economies. The global opportunity has led to an almost exclusive focus on software exports. This bias is further reinforced by planners' tendencies to focus on a single concern: generating hard-currency exports, driving up employment, or pursuing idiosyncratic first projects for political reasons (such as to demonstrate leadership and or gain additional support). In order to achieve any reasonable goals on a sustainable basis, a strategy must be balanced. Directing the deployment of software capacity towards social and governmental applications, as opposed to export-focused strategies, should be part of that balance (Hanna, 1991, 1994). Moreover, opportunities to manage local software projects and serve local users are often essential to gain experience in software project management and advanced technologies. (Schware, 1992)

The domestic software industry includes the development and maintenance of government, business, finance and telecommunications software systems, as well as any products and services suppliers into that development. It also includes the locally developed software for consumers, including educational and game software. We offer several caveats to government planners concerning the domestic software industry. First, there are few regions remaining in the global software industry that are so insulated from foreign competition that they can sell second-class software. In every software segment, local providers will have to compete for local business with powerful offshore vendors. It is important that local suppliers be given a chance, but they must be required to produce state-of-the-art results.

Second, without world-class software, even "low-tech" industries like tourism and agriculture will be handicapped. Modern firm and supply chain operations in all industries require sophisticated IT, but innovation and strategic competition typically require new software development. Whether it's marketing on the World Wide Web or collaboration with business partners abroad, new ideas about how to improve products and services are often implemented, measured and managed with new software systems.

Third, the alternative to expanding software capacity domestically is to buy the software that industry and government needs from offshore suppliers. While no country or major industry can afford to rely solely on foreign-supplied software, offshore suppliers do play an important role: 1)

they force domestic systems to be at (or at least to recognize) the state of the art in terms of base-line technology; 2) they can undertake projects that must be done very quickly when domestic sources are unavailable; and 3) they can function as learning and investment resources through alliances with domestics companies.

Finally, the prestige of software careers is directly affected by the IS departments and services firms that work on domestic projects, both social and commercial. It is the prestige of the available careers that draws talented young people into software, which in turn is the key to continued development of software capacity. In particular, government hiring and HR policies can directly influence the perceived value of software talent. As the Irish learned, innovative technical ideas often come from software workers in domestic industries (Crone 2002). In turn, the export industry grows out of the domestic industry; and vice versa, since the export industry needs a domestic market to experiment with new ideas, test products, and serve as reference sites.

It is important not to lose sight of the potential impact of software exports. National strategies must balance export potential with internal growth or both will be impaired. Software continues to be a high-growth industry compared to most industries in either manufacturing or services sectors (see Enterprise Ireland, 2001). It is one of the few modern industries that is open to new entrants with limited financial resources and, because it affects all areas of a nation's economy and is environmentally friendly and sustainable, it is a particularly attractive target for emerging economies.

5. What Is the Government's Role?

Governments can play several roles in support of the development of software exports and in the application and diffusion of software or ICT in priority sectors of the economy. For example creation of a supportive regulatory environment for telecommunications and Internet; protection of intellectual property rights; targeted investments in software education and research; and broad promotion of ICT literacy are actions that would promote long-term progress in both domestic and export activities. In addition, government can promote its domestic software industry effectively in a number of ways, such as by investing in government automation and e-government projects and adopting competitive procurement practices for software products and services. Government can also undertake a variety of actions to develop its export industry, such as partnering with software exporters to promote the national high-tech positioning, adopting quality assurance standards, and stimulating high-risk capital and foreign investments.

The range of government roles is expanding and lessons of relevance to emerging economies are accumulating, although much more systematic evaluation of various programs in this emerging field is urgently needed. (See Hanna, Boyson and Gunaratne, 1996, and Kraemer and Dedrick, 1999.)

Even in the USA, where markets are most developed and competitive private enterprises and entrepreneurship are plentiful, the federal and state governments have played many important roles. The US government played a lead role as rule maker, such as in providing incentives for risk capital and relaxing regulations on the use of pension funds for venture capital. It was also active in reforming or updating laws on intellectual property rights, telecommunications, bankruptcy, labor, etc. Secondly, it played a major role as a lead customer, setting requirements and standards. Moreover, under the Small Business Act, the Small Business Investment Corporations (SBICs) were created, to match government funds with private investments in new business startups. The SBIC program proved to be a critical element in the creation of a private venture capital industry. Finally,

the federal government funded research that was targeted to semiconductors, telecommunications, and computer science (software), focusing on centers of excellence such as Stanford and MIT. The history of the Internet, for example, demonstrates this role of the federal government as a key funder and early adopter of new technologies. The roles played by the state and local governments in the US are too diverse to be covered here, but they also proved to be catalytic and influential, if not always successful.

The role of government in promoting software and knowledge industries in emerging economies cannot be to automatically emulate the USA or other OECD countries. On the one hand, government capabilities in investing, influencing and partnering vary significantly, and most developing countries' governments are limited by severe financial and human resource constraints. On the other hand, the local private sector, in the software industry as well as in many other industries, faces some basic constraints: under-developed infrastructure, poor investment climate, and uncertain or restrictive regulations. In this context it is instructive to examine how the software technology parks of India, initially financed by the federal then state governments, did address some of the basic telecommunication and physical infrastructural problems facing software SMEs, as well as provide incentives and export facilitation measures. In the process they helped create demonstration effects and the beginning of some dynamic clusters. Significant lessons could be also learned from the relatively successful and extensive business incubation programs of the governments of Brazil and China. (Hancock, 2002)

Experience suggests several broad principles or best practices in establishing a national software strategy. First, the government's role is primarily about providing an enabling environment through supportive regulations, incentives, and strategic investment and promotional programs. Direct governmental intervention in leading-edge technology initiatives most often produces unsatisfactory results. If these top-down technology initiatives do not fail outright (such as the Fifth Generation Program in Japan, for example) then they often end up successful in form only, with far less private creation of innovation or new business than would be anticipated based on the level of government expenditure, as in Singapore and Malaysia (Mellor, 2001). It is best if government sees its role as complementing what the market is doing, and plans eventual withdrawal from incentive and investment programs on a pre-determined time-frame, to give private sector entities a chance to emerge or a new market to develop. For example, five years after the Israeli Yozma program was implemented to create an indigenous venture capital industry, its goal was achieved and it was privatized. (Sadovski, 1999)

Second, to reduce the risk of failure of a national software industry development plan, strategy decisions must involve people with deep knowledge of the industry. Political and social objectives must be tempered by technical and market realities – ever-changing realities. Risks of different kinds must be addressed for each strategic alternative, including the risk of doing nothing at all.

Third, although national prestige is not often an explicit goal of government policy, it should be. Successful software strategies have raised global awareness and respect for the high-tech activities of Ireland, Bangalore, and Andhra Pradesh in a matter of a decade or so. This kind of success can be turned into the energy and political will for even greater achievements.

Finally, expectations must be managed. Metrics must be appropriate. A national project whose main goal is development of software capacity (e.g., through R&D in some emerging technology area)

should not be judged a failure if it achieves its primary goal, but fails to also result in export revenues, for example.

6. The Elements of a Software Industry Development Strategy

Many elements of software industry development will be driven by private initiative. Some industry problems, however, require policy and regulatory reforms or investments in human resources and other requirements, because the market forces are too weak or too slow to meet urgent development priorities. Government action can involve reforming policies and eliminating regulatory impediments (labor, trade, finance, customs), creating or enforcing needed regulations (telecommunications, e-commerce laws, intellectual property protection); or providing long-term investment (infrastructure, research funding), direct investment (seed funds, export promotion), tax incentives, and, of course, expenditures for government automation and electronic delivery of public services.

Developing the Telecommunications Infrastructure

Reliable affordable telecommunications and Internet infrastructure are critical to software exports and to its deployment throughout the economy. All economic development is increasingly dependent on this infrastructure, and most countries are comfortable making the required infrastructure investments if they can. In India for example, the government initiated a program for developing software technology parks, which helped prime the pump for software exports in the early 1990s and enabled small and medium enterprises to bypass the underdeveloped telecommunications infrastructure. However, low telecommunications density in India and in many other emerging economies continues to limit the diffusion of ICT and software applications in support of domestic needs, as well as impede country advantage in exporting low cost software services. Increasingly, countries are relying on private sector investment to improve and expand their telecommunication infrastructures, by privatizing public telecommunication monopolies, liberalizing entry and private investment in telecommunications, and creating effective telecommunications policies and independent regulatory commissions.

Despite this market-driven approach to telecommunications, rural connectivity remains very low in most developing countries, even among those nations that liberalized their telecommunication sector for a decade or more, as in most of Latin America. Thus, innovative approaches to complement the market must be found. Chile pioneered a least-cost subsidy approach to provide incentives to private operators to meet certain connectivity targets in the rural and isolated areas. Other countries such as Sri Lanka are also considering the use of such smart subsidies to extend these infrastructures to their rural areas and poor communities. In principle, this approach can also be extended to promote the development of community access or public information centers. Such infrastructure development considerations go beyond those concerned with software exports, but they are integral to any strategy to promote the use of software and local content to address problems of rural development, small enterprise development, employment generation, and poverty reduction.

Developing the Domestic Market for Software

The domestic use of software technology is perhaps the most important driver of software industry growth for emerging economies. Government information systems projects can create demand for trained people, stimulate the growth of services companies, and establish models for careers for software professionals, while at the same time improving government operations and services to citizens. The same is true of private sector demand for software – stimulation of the software industry is part and parcel of improving business systems and competitiveness in other industries.

As we mentioned in our discussion of the Irish software industry, the domestic economy needs an indigenous software industry as a key component for development. Conversely, the indigenous software industry needs domestic business in order to flourish. Even India, Israel and Ireland, which are all seen as primarily software exporters, had to evolve local opportunities for software capability development: the defense industry in the case of Israel, serving local subsidiaries of multinationals in the case of Ireland, and some demonstration projects like the railways reservation system in India. Now they have all developed significant indigenous industries: India ($2.36 billion in domestic revenues in 2001, Israel $1.2 billion, and Ireland, $1.12 billion).[6] But the lack of broad domestic market for software in the case of India may have also limited its software exports to the relatively low-value segment of the market.[7]

One important role of the domestic market for enterprise systems (business and government) is as a proving ground for innovative ideas, new products, and startup companies. In order to serve this role for innovative firms that hope to sell globally, government and business organizations must offer a "base level" of automation consistent with standard practice in the target markets. This base level involves standard platforms (hardware, middleware, database, communications protocols, etc.), widely-used applications (like Enterprise Resource Planning and Customer Relationship Management), and standard software architectures, programming languages and tools. Demand for innovative systems in the private sector, as well as for base-level automation, is often stimulated by tax credits. Rewards for IT innovation can be used as a stimulus for both government and business institutions.

The financing innovative systems to support SMEs, rural populations, national education programs, and so on is more problematic. (See, for example, Hanna, 1995, regarding OECD programs for IT diffusion to SMEs.) One approach might be to create innovation funds whereby governments would share the cost of R&D with software companies and NGOs to promote the development of innovative societal applications that would meet local needs, particularly for students, small farmers, and other underserved segments of the domestic market.[8]

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[6] In comparison, we recall the 2001 export revenues from these three countries: Ireland, $1.3B; Israel, $3B; and India, $7.5B.

[7] Where there is extensive software piracy, there is no domestic market for many classes of software products. This problem does not affect software services, and is less critical for enterprise systems than for consumer software, but governments should consider the health of their own national software industries in their IP protection policies and anti-piracy enforcement programs.

[8] One of the authors, Nagy Hanna, is assisting the government of Sri Lanka is developing such an innovation fund for societal applications.

Innovative systems, those beyond the base level, may seem like an unnecessary burden for the already difficult process of automation of government and private organizations. In fact, to avoid risk, organizations often prefer to work with "experienced" offshore vendors and consultants. It is important to note, however, that these vendors get their experience by making mistakes. The success rates for many kinds of information systems projects are astonishingly low, even in the US. (Standish Group, 2000) The potential additional risk of working with domestic suppliers must be weighed against the gradual improvement of domestic services and growth of the industry.

Developing Human Resources

The global market for IT professionals of all sorts continues to grow. (NSF 2002; OECD, 2002) However, it fluctuates from year to year, moves from one technical specialty to another, and often results in brain drain of the most talented people to the most active industry centers. Since software capacity is correlated directly with the size and skill of the available workforce, there is no more important element of a country's efforts to increase software capacity than the development of its corps of software professionals.

It is important to note that only some IT professionals are software programmers. Every software team is composed of people with a variety of skills. People who design programs are at a different level of talent than those who test and maintain other people's code, and they use different tools and need to know about different software technologies. Team composition varies across sectors of the industry. Typically in software publishing, for instance, one software architect could drive the work of dozens of talented software developers. Software project management is another skill area that is often in short supply, with costly consequences.

In dealing with the range of skills required in software industry development one point must be emphasized: software abilities are based on innate talent, not just intelligence and training. (Barr and Tessler, 1996) Offering education and training to all comers will not necessarily draw the talented people into the industry. Without them, the effort to build software capacity will fail. In some countries, immigration can be used strategically to increase capacity, but talented youngsters must be attracted into the field. The best long-term approach is to create demand for talented programmers and experienced managers. Creating stable, long-term software career paths will attract talented people into software. This need should be a consideration in government civil service practices too.

Universities are particularly challenged by software education. Not only is rapidly changing technology and methodology hard to capture in the curriculum, but also practical experience with software projects is as important as the theory. Much of the important knowledge has not been codified and can only be taught by experienced practitioners. One approach is to establish professional software schools modeled after medical schools or architecture schools, where practicing professionals teach alongside leading researchers. (Barr and Tessler, 2002)

Private software education and training is supplementing university training in many countries, and producing large numbers of programmers. Ideally, software engineering and computer science schools should produce in adequate numbers the next generation of teachers and cutting edge researchers, as well as technical managers, software architects, designers, programmers, and testers of all sorts, and software-savvy professionals from engineering, humanities and business disciplines, who will support the use of IT in their own fields. This ideal mix may be difficult to achieve and one

that might take twenty years to get right. In the interim, some strategic programs to provide scholarships, R&D grants, and other incentives will help to produce the right balance of people.

Labor laws have a critical impact on human resources for the production and deployment of software. Many countries need to adjust labor laws to address issues specific to the software industry, especially to the startup companies that are so important in software and the knowledge economy: hiring and termination regulations, compensation and promotion practices, immigration, and so on. In ICT-enabled businesses, call centers and back office services, for example, flexibility is required in term of shift hours, and demands for different language skills or other knowledge may vary considerably as new clients come and go. In software services, project-based staffing is typical, and different skills may be required for each new project. Workforce mobility, the ability of workers to move freely among employers, has been cited as a major advantage of Silicon Valley since this practice shortens the learning curve across all companies in the region. (Saxenian, 1994)

Encouraging Innovation and the Creation of a Supportive Habitat for Entrepreneurs

Innovation is key in the software industry – both technical and business innovation. And increasingly, innovations in all aspects of our lives are achieved through software. New technologies, new solutions, and new ways of doing business characterize the new economic milieu. Governments typically stimulate innovation through university research grants and scholarships for graduate students and incentives (tax write-offs) for corporate R&D. One other area where governments can be quite effective is in creating opportunities for innovation in their own information systems (as we discussed above in the section on developing the domestic market). The result of fielding systems that show new ways of governing can have a direct impact on national prestige and on local firms (who are engaged in systems integration and process reengineering tasks) that will later export those innovations.

There is a growing recognition of the need to form learning or innovation clusters around software companies. Professor William F. Miller of Stanford coined the term “habitat” to describe the nexus of advisors, investors, and practitioners that formed around the Silicon Valley high-tech startups. (Lee, Miller, Hancock and Rowen, 2001) The habitat is not only vital to the growth of the software industry, but taken together, the specialized support firms of the habitat are an important source of business and job creation.

These software habitats may represent a specialized case of innovation or industrial clusters that have been studied elsewhere. They reflect the changing nature of competition and market-based innovation systems. Successful and innovative firms are seldom alone; rather, they tend to cluster together and create affiliations with each other based on specialized knowledge and production flows. Cluster studies, mainly in industrial countries, indicate a need to redefine the role of government as a facilitator of networking, a catalyst of dynamic comparative advantage, and institution builder – creating incentives to promote innovation and networking. (Roelandt and den Hertog, 1998) The role of the state in OECD countries is shifting from direct intervention to indirect inducement, such as initiating broker and network agencies and schemes, and providing platforms for constructive dialogue and knowledge exchange. But it still includes other initiatives beyond information sharing, such as cluster development programs in Finland and the Netherlands; regional development agencies in the UK, Germany and the USA; the Flemish R&D support to clusters; and the initiation of joint industry-research centers of excellence in many of OECD countries. (Also Roelandt and den Hertog, 1998) The US government did not create Silicon Valley,

but the significant research funds that it granted to area universities and defense businesses certainly had an important indirect impact.

There are pitfalls, however, in promoting clusters. Cluster-based initiatives should not be government-driven, but rather the result of market-friendly approaches, with government acting as broker and catalyst that brings actors together and supplies supporting structures and incentives to facilitate the clustering and innovation. Governments have discovered belatedly in Japan, Korea (Agarwalla, 1998), Malaysia (Mellor 2001) and elsewhere, that neither government decree nor investment in real estate necessarily creates a cluster. The most successful clusters or habitats seem to arise "spontaneously" with the confluence of skilled people and technical resources.

Stimulating New Business Creation and Finance

Another unique aspect of the software industry is the degree to which small companies dominate the rapidly growing front in most market segments. In software publishing, software technology licensing, IT-enabled businesses, and even software services, new ideas and innovative solutions are often brought to market by startup companies.

Several countries have already pioneered ways to address potential regulatory pitfalls in areas like new business creation, high-risk capital investment, foreign ownership of intellectual property, mobility of the workforce, corporate governance, and flexibility of business operations. Their "lessons learned" form a whole literature on enabling software entrepreneurship. (See Lee, Miller, Hancock and Rowen, 2001; Rosenberg, 2002)

Many countries have also participated in the stimulation of technology startups with investment funds. The best practice here is to partner with industry-savvy investors, i.e. to put up matching funds for co-investment with seasoned professionals, as Israel's Yozma funds required. Similarly, Taiwanese VC's say that their experiences in partnering with Silicon Valley VC's and sitting on the Boards of high quality US startups were extremely valuable contributors to their success. (Kenney, Hana & Tanaka, 2002)

One important trend in the software industry may make it much easier for emerging economies to participate in the most advanced areas of software entrepreneurship. The "transnational software startup" is a sophisticated arrangement, pioneered by Israeli and Taiwanese high-tech entrepreneurs and financiers, which involves forming an international startup business from resources located in several countries, with facilities located in the globally optimal locations. For example, suppose an Irish software R&D lab invents a LAN security algorithm. They might partner with a Singaporean device manufacturer to design and build a portable LAN security-testing device. They might get financing in both Singapore and New York, then move their headquarters to Washington, D.C., their first regional target. In this model, players with only part of the solution, e.g., an invention or a software development capability, can still participate in the software industry.

Supporting Software Exports

Software publishers and services providers as well as ICT-enabled services vendors have some special difficulties related to global marketing. For example, the initial investment in language training, computer literacy, job training, and systems setup is considerable. This problem is particularly apparent in customer support for software publishers, and for ICT-enabled services

vendors selling low-cost help desk services to foreign companies. Another difficulty, of greater concern to systems integrators and product publishers, is the lack of a domestic market in the initial stages of their market segment growth. These companies must market abroad immediately, without the benefit of experience and validation from domestic customers (not to mention domestic revenue).

Small software companies are particularly challenged in identifying, understanding and penetrating foreign markets – they just don't have the specialized marketing expertise. Often it does not exist in the country. Moreover, some vendors have significant problems selling abroad because their country or region is not perceived as one producing quality software. The establishment of the India software services industry exemplifies an apparent chicken-or-egg problem. Many years of work with few successes were required before the country became known as a reliable sourcing alternative. Then it "suddenly" became a globally accepted industry participant and grew rapidly. (Tessler and Barr, 1997)

Software is a global industry with intense global competition, and more coming, in every segment of the software and ICT-enabled services industries. As a result of the adverse circumstances, like those mentioned above, countries like Ireland and Korea have been quite proactive in helping their software industries develop foreign markets with various programs:

- Marketing programs to position their country and their companies and to build country image and "brand."
- Establishment of trade missions to introduce emerging software enterprises to market influencers and intermediaries as well as to venture capitalists.
- Programs to bring potential customers and market influencers over to their country to visit tech centers and meet potential suppliers.
- Extensive market identification research and analysis and marketing support to help local vendors understand and target markets they've never seen.
- Support for software quality programs for exporters, to help establish a reputation as a high-end provider, as Korea and Singapore have done.
- Use of successful government projects as reference sites for domestic vendors.

Countries at the very beginning of the development of their software industry must wait until they have something viable to take to market before even considering this kind of effort and investment, but whatever their domestic industry creates, they will likely need help taking it to the global market.

Mobilizing the Diaspora

Many emerging and transition economies have considerable links to sizable friendly communities in the USA and Europe, and these can play critical bridging roles. In Silicon Valley, for example, Indian and Chinese (including Taiwanese) immigrants are playing a major role in keeping the Valley dynamic and cost-competitive. Between 1995 and 1998, the Chinese and Indians were found to be running about 29 percent of the region's high-technology companies. (Saxenian, 2001) More important from this paper's perspective is the contributions these Diaspora communities are making to their countries of origin. Based on an understanding of both environments in the USA and

country of origin, "they have created a rich fabric of professional and business relationships that supports a two-way process of reciprocal industrial upgrading." (Saxenian, 2001)

Many Taiwanese engineers began returning to Taiwan, drawn by active government recruitment and incentives, and by the opportunities created by rapid economic development. Another growing cohort of highly mobile engineers began commuting across the Pacific regularly. This expatriate community helped accelerate the technological infrastructure of Taiwan by transferring technical know-how and business models, by influencing technology policy in Taiwan, and by forging marketing and other ties with Silicon Valley. The Indian engineers helped promote India as a viable location for software development, and to a lesser extent, started to stimulate investment and to transfer the information and know how about the new markets and technologies.

Many other countries, smaller and even poorer, currently have transnational communities that can play a key role in the development of the software industry. This potential contribution cannot be realized, however, without coherent and effective national strategies to mobilize scarce entrepreneurial and technical talents.

7. Adapting Policies and Strategies to Levels of Development

As the previous discussion suggests, there is no one-size-fits-all set of policies or an off-the-shelf software development strategy for countries with different initial conditions and levels of development. Lessons of experience are emerging concerning the main elements of national software strategies and the appropriate roles for government and public policy. But these lessons must be carefully related to the local realities, technological capabilities and potential comparative advantages of each country (Hanna, 1996).

While there is no single typology that can capture these differences among countries and the corresponding policies and strategies in support of software export and capacity development, we offer some general comments:

For countries with advanced technological capabilities and dynamic national innovation systems, such as Israel and Finland, strategies are likely to focus on innovative segments of software exports, on commercialization of intellectual property, on joint research and strategic partnership with multinationals, and on working with leading domestic users. In contrast, for countries with less advanced innovative capabilities but a potentially large domestic base of user industries, such as the Philippines, Indonesia or Vietnam, the focus of national software development may be on targeting those segments that are critical to the competitiveness of key local industries and leveraging such producer-user linkages to build competitive capabilities for software export in these segments. This approach would apply equally to developing software to modernize key service sectors such as finance and tourism, and for e-government applications, as in India and Brazil.

Countries with small domestic markets but large presence of multinationals or their subsidiaries, as in Ireland and Singapore, may leverage this presence to develop software products and services to support these MNCs, first locally, then globally. Countries with substantial pools of science and engineering resources with relatively low wages, such as India and China, may rely first on relatively low value-added outsourcing opportunities, then systematically move to higher value-added segments of software services, or perhaps leapfrog into selected niche markets of software products, as may be the case for Russia and some East European countries.

Even the least technologically developed and poorest countries cannot afford to be left out of the increasingly knowledge-based global economy. Their software capacity developments might focus on those capabilities necessary to support and maintain their national information infrastructure, including public information and services, and trade facilitation systems.

Countries may deploy different software export or outsourcing strategies in response to physical, cultural and/or temporal distance from their primary markets and these strategies often lead to different software specializations (Carmel and Agarwal, 2001). For example, India is able to engage in low level design, contract programming, and maintenance as these relatively structured activities demand less coordination and reduce the need somewhat for intensive collaboration in global software development.

For all countries, regardless of level of development, the fundamentals must be right; that is, public policies that support openness, competition, digital literacy and private sector led ICT infrastructure. But to compete and share in the dynamism of this large global industry, countries with potential dynamic competitive advantage must move beyond these common prerequisites.

8. Conclusion

The impact of software cuts across all sectors of the economy, and the progress of other sectors will, in turn, spur further growth of the software industry. Strength in software (i.e., both knowledgeable software professionals and a software-literate workforce) has become an important factor in foreign direct investment. It is also now a major component of modern industrial and commercial infrastructure and government administration. Finally, software is the implementation vehicle for major social programs such as distance learning, telemedicine, and on-line cultural offerings.

While the creation of effective software industry support policies is complicated by this broad ranging impact on business, government, and the public, the bottom line is that support for the software industry in any emerging economy is likely to be an integral component of the social and economic development agenda. Every country has to meet a new minimum "knowledge standard" that includes a software-literate workforce, and enough of a software industry to make the country a credible participant in the global knowledge economy.

9. About the Authors

From 1994-2000, Tessler and Barr directed a major study of the global software industry at Stanford University with Professors Edward A. Feigenbaum and William F. Miller, under a grant from the Alfred P. Sloan Foundation. This research project focused on the overall economic analysis of the global software industry. In addition, a research grant from the Chong-Moon Lee Foundation and subsequent consulting work for the South Korean Ministry of Information and Communication have given the authors an inside look at the strategic policies and programs of an enlightened government with the will and means to stimulate software industry development. Their papers are available at www.aldo.com/papers.

Nagy Hanna led the World Bank assistance on software industry development for many countries, staring with India's software export development in early 1990's. Currently he focuses on ICT-enabled development strategies and serves as the Bank's senior advisor on e-development. Among

his relevant papers and books, see: *The Information Technology Revolution and Economic Development, 1991; Exploiting Information Technology for Development: a Case Study of India, 1994; The Diffusion of Information Technology: Experience of Industrial Countries and Lessons for Developing Countries, 1995; the East Asia Miracle and Information Technology, 1996; and e-Development: Towards an ICT-enabled Development, 2002 – all published by the World Bank.*

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