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Human Resource Development Policy in the Context of Software Exports: *Case Evidence from Costa Rica*

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Abstract

Software industry development is acknowledged as an important engine of economic growth for many developing countries. The role of national policy has been identified as a catalyst to software industry development and, more specifically, to software export development. Software development is a service that is both labour- and skill-intensive. Thus an important aspect of related policy is concerned with provision of appropriately educated and trained human resources (HR) in sufficient quantity. This paper provides an analysis of human resource issues facing policymakers in developing countries engaged in software export policy formulation. The complexities are highlighted through the case study of Costa Rica where there is an ongoing strategic planning effort to increase software exports. Action research work in Costa Rica based on a model of developing both "high spectrum" and "low spectrum" software skills shows there are constraints to both HR quantity and quality. Some ways forward for early-stage software exporters like Costa Rica are relatively easy to prescribe and implement. Others, though, will be harder to achieve since they are contextually constrained by both formal and informal institutions.

Introduction

Software industry development is acknowledged as an important engine of economic growth (Kambhampati 2002). Recognising this potential, stakeholders in many developing and transitional economies (DTEs) have become actively interested in developing the software industry sector, particularly exports (Al-Jaghoub 2004, Carmel 2003). High profile success stories such as India and Ireland have contributed to this growth in interest. For example, a 50% growth of software firms in India has led to a 3% contribution of the software sector to gross domestic product. The growth of India's software sector has also contributed to productivity spillovers in other service companies and demonstration effects to other sectors (Arora et al 2001). There have been similar benefits in Ireland where the number of software firms more than doubled (from 291 to 690) during the 1990s. The growth in both countries had significant implications for employment generation. For example the Indian industry is reported to employ about 250,000 people with predictions of large future expansion, especially in the IT-enabled services (ITES) sector.

The role of national policy has been identified as an important driver of software industry and software export development in both DTE and industrialised country contexts. For example Kambhampati (2002) describes the important role of policy measures in India. Watson and Myers (2001) discuss how policy has stimulated growth in Finland's software industry. An important aim of such policies, especially in DTEs, is to identify the export niche(s) in which the industry can operate and be marketed. This must take into account domestic strengths and weaknesses, global competition and the nature of global demand. Successful policy frameworks have therefore contributed to shaping industry trajectories; for example the focus on products in Israel, foreign direct investments in Ireland, and software services in India.

Prior research has pointed out links between a country's software exports and strengths in telecommunications and human resources (Carmel 2003, Ein Dor et al 1997, Heeks and Nicholson 2004, Watson and Myers 2001). Of particular interest here is the human resource (HR) angle since software development is both labour- and skill-intensive. Because of this, an important aspect of policy concerns the development of appropriately educated and trained human resources in sufficient numbers (Carmel 2003, Heeks and Nicholson 2004). The Irish government, for instance, consciously took measures to increase their computer science graduates. India has historically capitalised on large numbers of qualified staff at relatively low cost to satisfy the skills shortages of clients primarily in the US and increasingly in Europe.

While there are important lessons for policymakers in aspirant new entrant software export countries, policy makers need to recognise that the *initial conditions* for India and Ireland's software industry development were characterised by very different exogenous and endogenous features than the contemporary situation. During the 1990s, IT skills shortages meant that the strategy for human resources could be based on quantity at low cost. Today's scenario is characterised by demand for greater levels of sophistication and there are a larger pool of countries and firms to choose from. Along with these challenges, are also increased opportunities as global software outsourcing has become largely normalised as a business practice; a contrast to the situation in the 1980s (Sahay et al 2003). There are presently many more firms and countries looking for offshore suppliers and relatively fewer barriers to entry, such as those related to visas and immigration laws (for example, Germany's Green Card scheme). Supporting the creation of appropriate "educational capital" is a challenge for policy makers to address. However, many developing countries are constrained by limited access to

computers and Internet, low English literacy, and an educational curriculum that often tends to emphasise technical skills over critical thinking and management competencies (Kambhampati 2002 p25).

The aim of this paper is to analyse some of the complexities DTEs face in software export policy formulation with a focus on human resources. These complexities are highlighted through the case study of Costa Rica, a nation where a strategy process is underway to strengthen its software export sector. The authors were part of the strategy formulation process and report from that experience. The learning gained from this analysis can provide insights for other countries at a similar stage to Costa Rica in order to evaluate their strategic options with respect to human resource issues.

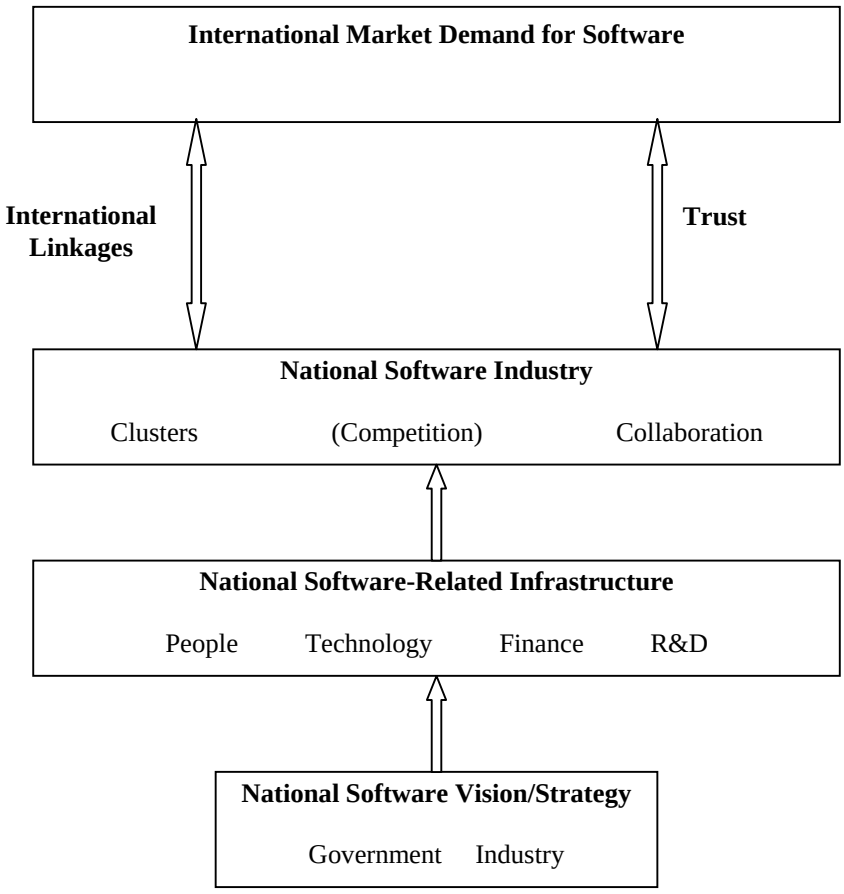
The rest of the paper is organised as follows: in the next section we present a theoretical framework related to software export policy and the role of human resources. Having briefly reviewed our research approach in section B, we then present the Costa Rican case study and analysis in the following section. Finally, in section D, a summary and some implications are discussed.

A. Literature Review and Theoretical Frame

A starting point for our analysis is the Software Export Success Model (SESM) (Heeks and Nicholson 2004). This exploratory model (summarised in Figure 1), was initially developed based on a review of relevant literature from competitiveness theory (Porter 1990) and literature search of software export policy frameworks (Correa 1996, Ein Dor et al 1997, Schware 1992). An analysis of the experiences of Ireland, India and Israel helped to identify important "success factors" that were grouped into categories considered central to software industry development. Using secondary data, this model was subsequently applied to the analysis of three "second-tier" nations: Russia, China, and Philippines. The model comprises five basic categories: demand for software, national software vision and strategy, international linkages and trust, national software industry characteristics, and national software-related infrastructure that includes human resources issues. The model was subsequently used empirically for analysis of the software sector and development of policy recommendations for Iran (Nicholson and Sahay 2002).

Given the aim of this paper, we focus on the issue of "people related infrastructure" i.e. HR issues. The software industry in any country is people intensive and is shaped by various issues including scale, costs, skills (technical and managerial) and availability. The software sector can be viewed as consisting of a "spectrum of labour"; meaning the skills and qualities of human resources. The high end of the spectrum consists of very capable individuals sometimes known as "talent" who have critical thinking and problem solving abilities related to customised IS development projects: analysis and design, project management activities, and the development of technical products. The lower end of the spectrum represents those with skills that can be learned in a relatively short period of time such as rudimentary programming (Carmel 2003). Activities requiring skills at different levels of the spectrum thus require concomitant human resource development strategies. To illustrate this, in the following sub-sections we briefly highlight key features of the strategy adopted by three relatively successful software exporting nations (India, Israel and Ireland) and the concomitant human resource initiatives.

Figure 1: The Software Export Success Model



India: Addressing Issues of Scale and Skills

A majority of the initial software work in India up to the early 1990s was of the type derogatively called "body-shopping" whereby the developers would go to the client site (mostly in the US) for the length of the project. Work done in India at that time tended to be at the lower end of the spectrum such as software coding and maintenance. While the initial challenge was addressing the required quantity of qualified staff, a gradual transition to undertaking more complex and higher value added work for clients needed different kinds of skills; for example, related to foreign languages and project management. This transition – and the related change in HR strategy – was important so that the industry would be sustainable and not subject to easy substitution with new entrant suppliers in other countries.

Therefore, human resource policy measures needed to address these two facets: expanding quantity and building higher spectrum skills. The industry tried to meet this challenge by recruiting engineering rather than just computer science graduates for software jobs, such as graduates from mechanical, electrical and civil engineering. A number of universities also started Masters, Diploma and subsequently Bachelor level courses in computer applications (MCA, DCA, and BCA respectively) in order to increase the quantity of labour supply. Private training institutes in India like NIIT and Aptech played an important role in providing skill-based training (in Java for example) which to some extent helped to fill the gap caused by the inertia of university bureaucracy to revise curriculum in line with fast changing industry demands.

Education programmes geared to the especial "high spectrum" needs of global software work – not just the language and project management elements noted above but also marketing, finance, and team working in conditions of cultural, temporal and spatial diversity – are hard to find in India. However, an interesting approach has been that of the Software Enterprise Management graduate course offered by the Indian Institute of Management, Bangalore. This programme is designed for the specific needs of professionals working in the Indian software industry and started in 2002 supported by endowments from leading IT "partner firms". Senior businesspeople serve on the advisory board to enable better linkages between theory and practice. The programme has been designed such that a participant can graduate with a diploma at the end of three academic years, while continuing to work at his/her regular place of employment (Arora et al 2001). By being work- and high-skill-related, it hopes to build just the skills that are hardest for other competing nations to substitute.

Israel: Developing R&D Networks for Software Products

Israel's specialisation in products for Internet security and the communication sector was fuelled by military-trained computing graduates who, after completing their military service, would enter into a flourishing civilian computing sector. Jewish immigrants with scientific expertise who came from the Soviet Union between 1989 and 1991 provided another engine of human resource growth. The output of computer science graduates was expanded to meet the demands for a "high spectrum" educated workforce of sufficient quantity. Research institutions were provided with significant incentives to form linkages with industry, and the curriculum content was designed keeping in mind the criteria of relevance to the private sector. This link also provides mechanisms through which ideas generated can be commercialised and creates a vibrant structure to move from "invention to innovation". Interesting examples of efforts to stimulate collaborative R&D networks are the Yozma programme, and the Bi-national Industrial Research and Development Foundation (BIRD), established in 1977 in collaboration with the United States (de Fontenay and Carmel 2002).

Ireland: Multinational-Driven Human Resource Strategy

O'Riain (1997) traces the foreign direct investment-driven growth of the Irish software industry from 1973, when major multinational corporations were attracted by the Irish Industrial Development Authority's policies of financial incentives and significant investment in education and telecommunications. Unlike in India, Ireland avoided reliance on contract programming or body shopping. Instead, many large multinationals including Andersen Consulting, Intel, Digital, SAP, Sun Microsystems, Ericsson and Prudential Insurance were encouraged to locate in Ireland and this was made possible by the ready availability of high spectrum skilled staff.

Trauth (1999) discusses the specifics of how the Irish educational system was aligned with the skills needed by the "handpicked" multinational companies. Equality of access to education was established in 1968 and two new universities were established in the 1970s and 1980s with a technical, vocational curriculum. Traditional universities were adapted to incorporate business and IT skills into their curricula, and technical colleges were established around the country. Finally, adult evening classes were established. The government also sponsored training programmes for those with a university degree but without requisite skills for work in the IT sector. The Irish government thus made focused attempts to scale up the numbers and capacities of computer science education programmes and also increased their diversity by

setting up joint degrees where computing was combined with, say, a foreign language. Incentives were also provided to attract the Irish diaspora to return to their home country, especially from North America, bringing their skills with them.

Summary of Experience with HR Strategy

The three brief examples presented above help to illustrate how human resources strategies vary with software industry focus. We present this interpretation in Table 1. Of course, newly aspiring countries need to interpret the strategies in the particular historical context within which they evolved. They must understand how the changed situation today requires a radical rethink of what may work and how difficult it is to implement in practice. Next, we discuss this in relation to our empirical investigation in Costa Rica.

Table 1: Relation Between Skills Emphasised And Human Resources Strategies

Type of Skills	***Role***	***Human Resource Policy***
High spectrum	Project manager Business analyst Systems analyst Foreign languages	University-R&D linkages University-private sector linkages Joint degrees Focused incentives Attracting diaspora Enhancing numbers, quality and capacity of computer science programmes
Low spectrum	Coding Testing Data processing	Computer language training Role of private training institutions Increasing number of colleges and programmes Attracting graduates from non-computer science backgrounds

B. Research Methodology

This particular research was initiated when some key actors from the Costa Rican software industry approached the authors after reading earlier publications. They proposed a project to support the Costa Rican government's efforts to develop a strategy for enabling software exports. We responded positively to this request as we felt it would be a unique experience to work closely with the government in an "action research" framework (Baskerville and Wood Harper 1996).

Initially, we developed a plan for the empirical work after conducting a literature search of the Costa Rican software industry to identify the current state, the key stakeholders, and particular technological and geographical focus of the industry. We were provided access to a recent report on the national software industry that helped to gain an initial understanding of the character of the software industry, though very little was shown in this document on export potential and strategies.

Following the literature search and initial information-gathering exercise, the authors visited San Jose, the Costa Rican capital, for three weeks in August 2003. During this period, a total of 18 interviews was conducted covering a wide range of officials including the Minister of

Science and Technology and his advisor; university administrators, faculty and researchers; managers and leaders of several private sector companies, an international aid organisation, financial institutions, and trade associations; plus officials from various government and semi-government organisations involved in marketing and promoting the software industry both nationally and globally. Interviews were primarily semi-structured and they were used in an attempt to understand the background of the respondents, their interests with respect to software exports, the issues they considered relevant in developing a strategy, and to gauge their level of commitment to the development and implementation of a national strategy. These interviews also provided a platform to develop greater awareness about the importance of a national strategy and the aims and objectives of our study.

In addition to the interviews, two focus group sessions were conducted; one with representatives from the private sector and the other with university staff. In these focus groups, discussions were held on issues such as university-private sector linkages and problems experienced by small and medium firms. One large national level workshop was held on the topic of global trends in the software sector. This workshop provided the platform to bring together various stakeholders from the industry, government and university sectors in order to provide a broader awareness and gain their "buy in" to the strategy formulation process. In addition, we conducted three smaller and more focused workshops on identified themes relevant to policy formulation and implementation. In Table 2, a summary of the various sources of data collection are summarised. The meetings, workshops and interviews were mostly conducted in English and when the respondents preferred to discuss the issues in Spanish, the services of a local translator was drawn upon. During the national level workshop and one of the smaller workshops, professional simultaneous translation was provided.

Table 2: Summary of Data Collection Sources

Data Collection Mechanism	***Number***
Interviews	18
Focus groups	2
Workshops	4

A guiding frame of reference towards the interviews and their interpretation was the Software Export Success Model (Heeks and Nicholson 2004) that emphasises the importance of creating synergies between a complex range of interconnected factors such as national policy, education, infrastructure and international demand. For example, the SESM emphasises an important precondition for effective exports to be the existence of strong university-private sector linkages. We thus tried to identify relevant actors from both the university and private sectors and discuss with them the nature of existing linkages, the challenges experienced and how they felt these could be best addressed. Data analysis took place through a process of extensive discussion between the authors and with the various stakeholders responsible for the design and implementation of the national strategy. A report was presented to these stakeholders on conclusion of the study and the feedback received on it provided further useful inputs to the analysis. A limitation of this work is that a single case study does not offer statistical generalisation. However, the Costa Rican case offers deep insight into the process of implementation of plans for software exports and the effects of endogenous institutions.

C. Case Study of Costa Rica

The Costa Rican software industry began operation relatively recent and, in 2002, consisted of about 100 firms, 75% of which could be classified as small and micro firms (less than 20 employees) with only 5% having more than 100 employees. The overall revenue of the industry was estimated at about US$170 million, about 60% of which was exports, primarily to Central America and Mexico. The sector employed between 3,500-3,700 persons, the majority of whom were graduates from public universities. The software sector gained significant global publicity when the IT giant Intel established a development unit in San Jose, enabled through the direct involvement of the Costa Rican President.

Beyond this overview, we focused our study particularly on human resources, and identified a number of issues that reflect both HR quantity and quality.

C1. Quantity: The Problem of Scale

Micro-sized firms experience serious problems, especially when they try to scale up from less than 10 to about 20 persons, and the owners need to adopt management roles in addition to technical roles. This problem was described by a chief officer of a software firm who had grown over a decade from a "one-man in a garage" start-up to about 100 people:

> "A challenge is when a company tries to move from micro (less than 10 people) to mini and small scale. The companies are not specialised to handle the management issues that arise and they don't have the people to do that."

While growth in size often came with increased opportunities for software export, this was also accompanied with the challenge of lack of specialised human resources; for instance related to financing and marketing. A manager of a small software company said:

> "We know it is easier to sell locally, because of geography. Only for large companies it is easier to sell overseas because they have the money. We have problems in marketing, as we do not have the resources to hire specialised managers. Maybe we can have system of mentoring."

Another aspect relating to scale was the absence of technology parks that could provide a cluster of geographically co-located software firms. Such clusters, as seen from examples of Silicon Valley in the US and Bangalore in India, enable sharing of knowledge, experience and resources. Also clustering IT firms alongside universities or priority sectors (such as biotech or new materials companies in Costa Rica's case) provides the potential for development of cutting-edge applications and resultant patents. The increased scale that a cluster naturally provides allows firms to share resources for common activities like training or quality control that in the longer run could potentially contribute to developing HR capacities.

C2. Quality of Human Resources

Quality of people is crucial given the knowledge-intensive nature of software development activity. The potential to export is particularly dependent on the quality of the university

graduates that enter the workforce. Three key issues were identified as contributing to quality:

- weak university-private sector linkages,
- poor English language capabilities, and
- inadequate management capabilities of technical staff.

Weak University-Private Sector Linkages

Contributing to weak linkages were a number of factors including poor intellectual property (IP) laws, the inertia of the university structure in responding to industry demands, a weak culture of applied research, and a lack of critical mass of researchers interested in supporting the processes of software exports. A senior manager in one private sector firm described how the links between his company and the university were steadily decreasing because of the weak laws of the university to support IP, and the declining availability of funds to support the type of long-term research desired by the university:

> "The intellectual property laws are poor and it is hard to keep secrets as there are no patents. Strange things can happen in the University. While we are interested in applied research, we do not have the funds to support long-term research. So, we are looking at internships rather than PhD kind of research."

However, while establishing student internships was relatively easy, they were difficult to sustain because of the short period of internships which limited the production of useful outputs. A manager of a small firm described this problem:

> "Interns need a lot of supervision, and by the time they become able to contribute, they are ready to leave. It was different with some interns we had from Canada; they were ready to contribute right from the start."

While it appeared that interns from foreign universities like Canada were better equipped than the local students to contribute to the work of the companies, there existed no formalised and institutionalised structure within which these linkages could be sustained. Another issue with internships was the university laws that made it difficult for private sector staff to use public resources (such as computers and rooms) in public universities. Dealing with these irritants was very frustrating for private sector people who were used to "getting on with things" efficiently. A private sector manager described his frustration as follows:

> "The linkage does not exist. While the public universities are the best, they are very difficult to link up with. They set a lot of limits. They have created foundations to be like intermediaries, but they really don't get on well with the companies. What we would really like to have is research on what the rules are in the university and to document them and give to the companies. If we ask CENAT [the University governing body] to do that, it will take years before anything is done."

Another manager echoed similar thoughts:

> "I can think of many projects but what are the rules of engagement and also who would I pay and what will happen with the intellectual property?"

The university policy of "theoretical work takes precedence over applied" also contributes to widening the divide between the university and private sector, and as a result no effective

interface exists for firms to approach universities to deal with their research inquiries. A senior staff member from a public university explained the problem as follows:

> "There is a lack of culture in research and development, because both the academic programmes and also the professors do not promote the culture. We cannot change anything until the culture is changed. We have to also make the research more applied and work more closely with the software firms."

Another senior staff member described the problem in similar terms:

> "The factors which do not help to create a union between firms are universities are: no culture or conscience to spend money on research; no incentive from government to industry to support research; the universities have limited budgets that limits research; our buildings, laboratories, equipments are all obsolete; there is a lack of maturity in professors to learn and do research. We do not have a critical mass of researchers."

The problem of lack of critical mass of computer science researchers was also emphasised by another senior Professor who contrasted this situation with Biological Sciences. In this instance an existing critical mass of researchers in the department had been successful in furthering their research agenda. There also was no culture in the computer science department to write grant proposals, leading their faculty to be trapped in a "vicious circle" of no research funds leading to additional teaching loads and consequently even fewer opportunities to write grants. As a consequence, there existed no research centres around computer science in universities in contrast to the relatively strong biotechnology area. Public universities, as is the case in many developing countries, are poorly resourced and provide little incentives to do research. Poorly paid staff preferred to do consultancy rather than research work. While efforts like internships, company-sponsored research, etc, are useful to bring about change, they are still not capable of changing the institutional conditions such as the poor salary of staff, lack of time allocated to research, and the division between research and teaching staff in departments. A senior staff member in a public university lamented this problem:

> "The problem is that historically the public universities have very little resources, and because of that we cannot do research. We are doing our best, but that is not good enough to do quality research. So, what we need is more budgets to hire more people, and more incentives for doing research. Right now most professors will prefer to go to the university rather than do research because of problems of money."

Poor English Language Capabilities

English language capabilities are a vital resource for software people working on global projects, especially given the primary market of interest is the US. This skill was currently seen to be deficient by many respondents, including this senior manager of a private sector firm:

> "We must improve our English proficiency. It is good now, but it should be better. We should speak like a US citizen."

While English capability was not seen as a universal problem in Costa Rica, the problem was pronounced among technical staff including software technicians. Most of the good English-

speaking people were seen to be working in the tourism or hotel industry. This was an opinion echoed both by the industry:

> "You find good people with technical skills, but if bilingual, that's where we find bad people. The people that go for tourism study English, and so they don't have technical skills. If we look for ten English speaking software engineers, we cannot find them."

and also the university staff:

> "In computer science, students can read English because they read a lot of technical things in English. But they are not able to speak or to even write."

While it is possible to have large-scale programmes to develop English language capabilities, a paradox exists in that a bilingual work force would make the already relatively expensive people costs in Costa Rica even more costly (the average cost of a programmer in Costa Rica is significantly higher than in India). A senior industry manager told us:

> "We also have a language barrier. It would be hard to translate some of the products into English. We would need to make a change in the composition of the labour force to make them more bilingual, but that would make them more expensive."

Inadequate Management Capabilities

Another challenge with the existing educational system in Costa Rica was that people with technical skills often have limited management skills related to marketing, human resources, project and financial management. There are no institutionalised programmes, especially for practicing executives, to come for refresher courses to the universities and develop management capabilities. The lack of these management skills was seen as a crucial constraint to marketing products, operating in the global marketplace, and for making financial decisions. In short, the workforce had limited "middle management" capabilities, a point emphasised by two industry staff:

> "We are very weak in marketing skills, we have good technical people but they have no idea about the kind of questions that are asked when we go to sell the product."

> "I realised that software companies have good technicians but they don't know about marketing, managing or about intellectual property. So, a lot of companies were suffocated because they began with someone paying for a program, but there was no one to manage and so they were stuck."

Some attempts were being made by the government and private sector to try and address this challenge of developing management capabilities. PROCOMER, the national software export promotion council had put in place schemes designed to improve competencies in small and medium companies to conduct software exports. A private university "ULATINA" had designed curriculum improvement in collaboration with the Inter American Development Bank-funded "Prosoftware" programme and identified gaps in the existing university programmes especially at the middle management level.

CENFOTEC, another private institution established through private sector venture capital, was trying to bridge the gap between industry needs and the pace of university change by designing courses for practicing software staff for management skills. Another initiative had

been undertaken by a consulting house under a project financed by ICCI-2 (the Costa Rican Initiative for International Competitiveness) to develop specific courses to increase human resource capacities related to financial and innovation issues. This same agency had also developed a year long programme called "The Bulletproof Manager" to develop a set of 24 soft skills. In addition, reduced fees for ISO9000 and Capability Maturity Model training and accreditation – both of which are seen as positive certifications of software process quality – had been introduced.

However, in general, efforts by the government to introduce schemes for developing HR capacities were suffering because of poor dissemination of information to the software industry about these schemes. For example, one manager in a small firm told us he was unaware of government schemes to financially support executives wanting to take up distance education courses. However, poor take-up was not simply due to lack of awareness: for example, many software firms did not see the benefit of formal accreditation such as ISO.

D. Discussion and Conclusions

Table 3 draws on the theoretical frame presented in section A in order to summarise analysis of the problematic issues in Costa Rican human resource development for software exports.

Table 3: Summary of the Empirical Analysis

Skills	***HR Policy***	***Situation in Costa Rica***
High Spectrum	University R&D links	Small size and resources of most firms; lack of clusters; poor IP laws and restrictive laws on use of university resources for private work. Inertia of university structures; poor salaries and resources in public universities giving little incentive to do research or links. Weak culture of applied research; lack of critical mass of interested researchers; lack of culture of grant application leading to vicious circle; lack of formal structure for links and internships.
	University-private sector links	
	Joint degrees	Some isolated initiatives such as ULatina and CENFOTEC.
	Focused incentives	ICCI-2, Bulletproof Manager, ISO9000 and CMM all in existence but poor dissemination of information and lack of take up.
	Attracting diaspora	No specific policies but only a relatively small Costa Rican diaspora to attract.
	Number, quality and capacity of Computer Science programmes	More important reported lack of English in graduates, and limited management training in finance and marketing for executives
Low Spectrum	Computer language training	No specific policies; limited or no effort in addressing lack of English language capability.
	Role of private training	
	Increasing numbers of colleges and programmes	No specific policies.
	Attracting graduates from non-computer science background	No specific policies.

In summary, with respect to HR capability in Costa Rica, the following key points can be made:

- Costa Rica in general has a small labour pool and compared to the major competition at relatively high costs.
- The educational focus in Costa Rica is primarily on computer science, and information systems-related management skills are generally weak.
- English-speaking skills of the technical people in Costa Rica are generally weak.

- There are no technical training institutions aimed at providing software developers with technical skills in specialised areas like biotechnology and biodiversity both of which are key economic clusters in Costa Rica where linkages would be beneficial.
- Costa Rica lacks diaspora returnees in any great numbers.
- The linkages between university and industry are fragile.

In our work with the Costa Rican planners, we have tried to facilitate the policy and industrial development process by informing and setting up task force groups of stakeholders from the various organisations (private and public universities, software firms, policymakers). These individuals have been tasked with systematically analysing the problems identified in Table 3 and making recommendations to policy makers for change. Clearly some areas of change are less difficult to implement than others. For instance, formal and informally stated beliefs about applied research and rules on use of resources in the public universities are historically institutionalised and derived from political action and other priorities. Altering these priorities and institutions may ultimately require changes in formal constitutions and job descriptions as well as informal support from growth in applied research. Changing such institutionalised practices requires clear commitment and a strong sense of incentive from all concerned. On the other hand, forming new ventures aligned to the strategic direction involving joint courses such as CENFOTEC would be easier to implement, although there are resource constraints. Attracting training organisations such as India's NIIT may also be a shorter term strategy.

The Costa Rica case provides insight into the particular problems faced by many DTEs in developing the software industry as a vehicle for economic growth. Specifically, the case illustrates the limits of the routes to development presented by successful software nations. Costa Rica's size, population and institutional setting does not provide the quantity and quality of human resource to follow the Indian early growth trajectory of low spectrum, low price and high quantity. Instead, the early Costa Rican strategy efforts focused on developing the high spectrum which presented several paradoxes and dilemmas. The country lacks focused R&D and with no military to provide technology transfer there are problems in following Israel's trajectory. Imitation of Ireland's multinational-led strategy is hampered by, amongst other issues, a private organisation (known as "CINDE") responsible for foreign direct investment (FDI) that is not focused on software cluster development. The consequence has been a scattergun approach to FDI undirected by government policy.

Policymakers in Costa Rica and other DTEs who desire entry to the software exports arena are forced to consider the exogenous environment in terms of market trends of buyers and suppliers in different countries. With regard to the endogenous setting, the analysis shows some aspects of how the formal and informal institutions (North 1990) may enable and constrain the development of routes to growth. In democratic Costa Rica, the policymaking process is attempting to take into account and coordinate the multiple institutions and organisations involved in software exports with varying degrees of success. Further work will focus on the continuing process of software industry development which will provide further insights into software industry development in small DTEs.

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