Universities and transition to sustainable development: lessons from the Costa Rican case

P R E L I M I N A R Y D R A F T

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Abstract

Universities can play a relevant role to determine the rhythm and direction of the technological change in the industry. This is especially true in countries where most of the firms are small or medium size. Universities can contribute to de design and transfer of technologies with better environmental performance in sector where firms have difficulties to develop this kind of technologies. It is essential to note that universities and public labs are not only the source of personnel trained in science and technology fields. In a number of industries they are also a source of scientific and technological knowledge relevant to the innovative activities of firms, and research and problem solving capabilities that can be directed to problems relevant to firms. These knowledge and capabilities provide a broad support to the innovative activities of business enterprises. In turn, firms, while trying to identify solutions for technical problems and bottlenecks in the context of their innovative activities, provide universities with demands that may lead to new research questions, scientific findings, dissertations, papers and others.

A relevant finding is that most of the effort of R&D in the Costa Rica is done by universities. Firms also have R+D but few of them have a formal department. Because of that, it is crucial to understand new mechanisms of contribution of universities to industrial R&D. One conclusion is that Costa Rican universities are contributing to the development of local capacities for sustainable development, mainly for their contribution of scientific and technological knowledge. However, the links with industry are still weak and hindered by several obstacles. The paper reports the results of two surveys, one to researchers in universities and public research institutes and one to firms, both in Costa Rica. Some results indicate that the key channels through which university research impacts industrial R&D include published papers and reports, public conferences and meetings, informal information exchange, and consulting. The main mechanisms are training and information. Although the average of firms having interactions with universities is low; most of the firms with this kind of interactions are satisfied with the results.

1. Introduction

The rhythm and direction of innovation and technological change are key factors to determine the possibilities of a country to get the challenges of sustainable development. The challenges are multiple and diverse. Some are related to the economic dimension and in a clear link with growth. But other challenges are related with social issues, including health, income distribution, and access to opportunities, education and similar goals. The eco-system is also part of the dimension.

The study of development is not an abstract task. Actually, development in general and more concretely the technological and economic progress of a country is normally based on the system of innovation. Stressing on the necessary transformations it is possible to establish the link between the debate about sustainable development and the debate about *systems of innovation*. Actually, most of the key questions in the study of systems of innovations are related to the explanation of why nations differ in economic performance, including the environmental dimension.

Different actors play a role in the transition process. For example, universities are relevant components of the system of innovation. In countries where most of the firms are small or medium size, universities can be very useful for the development and diffusion of technology. They can contribute to de design and transfer of technologies with better environmental performance in sector where firms have difficulties to develop this kind of technologies. However, the knowledge developed by universities is useful for firms only in certain conditions. In order to appreciate the role of universities and public research centers on innovation processes by firms, it is important to have a systemic approach. It is essential to note that universities and public labs are not only the source of personnel trained in science and technology fields. In a number of industries they are also a source of scientific and technological knowledge relevant to the innovative activities of firms, and research and problem solving capabilities that can be directed to problems relevant to firms. These knowledge and capabilities provide a broad support to the innovative activities of business enterprises. In turn, firms, while trying to identify solutions for technical problems and bottlenecks in the context of their innovative activities, provide universities with demands that may lead to new research questions, scientific findings, dissertations, papers and others.

A relevant finding is that most of the effort of R&D in the Costa Rica is done by universities. Firms also have R+D but few of them have a formal department. Because of that, it is crucial to understand new mechanisms of contribution of universities to industrial R&D. Firms in Costa Rica have concentrated in few objectives for the interactions with universities. The main have been to contract research that firms can not develop and to contract useful activities into the innovation processes by the firms. Support in processes of quality control has been also relevant. Firms recognize that university's laboratories and other resources that can be very useful to facilitate innovation processes for firms. However, the interactions between universities and the industry are still relatively week. The paper reports the results of two surveys, one to researchers in universities and public research institutes and one to firms, both in Costa Rica. Some results indicate that the key channels through which university research impacts industrial R&D include published papers and reports, public conferences and meetings, informal information exchange, and consulting. The main mechanisms are training and information. Although the average of firms having interactions with universities is low; most of the firms with this kind of interactions are satisfied with the results.

The barriers for stronger interactions are different for firms than for researchers. Firms mention mainly a week joint agenda, but researchers mention that bureaucracy at research centers and universities hinder the interactions with firms. The fact that most of the firms in Costa Rica has innovation activities aimed mainly to incremental innovations -as improvements in products and small changes in processes-, can also be a factor hindering stronger efforts joint projects in R+D. To complement the analysis, the paper report on several successful cases on the interactions between universities and the industry, especially in biotechnology projects.

One conclusion is that Costa Rican universities are contributing to the development of local capacities for sustainable development, mainly for their contribution of scientific and technological knowledge. However, the links with industry are still weak and hindered by several obstacles. Researchers in universities are improving their capabilities, but the amount of researcher and the time they have for research are not enough. A strong difference with respect to universities in developed countries is that there is not a culture of patenting. The lack of patenting has not been compensated by other kind of institution to promote the appropriation of the results of R&D projects. This lack of institutions is an obstacle for the interaction with the industry because both, universities and firms, feel uncertainty and distrust about the appropriation of results. Firms are reluctant to finance joint R&D projects with universities. The mechanisms of technological transfer are limited then to few general strategies, as seminars, exchange of free information and similar, but not to joint projects. In this context, universities should find new strategies for interaction with the industry if they want a stronger contribution to the transition to sustainable development. The contribution is crucial in Costa Rica; with a predominant presence of small a medium firms without R&D departments.

2. Conceptual framework

2.1. The role of systems of innovation in the process towards sustainable development

It is convenient to consider that development should be understood combining two perspectives. One define the vision or, more concretely, the challenges, which are multiple and diverse. Some challenges are related to the economic dimension and in a clear link with growth. But other challenges are related with social issues, including health, income distributions, and access to opportunities, education and similar goals. The eco-system is also part of the dimension. The second perspective of development is the idea of process of transformation, the way, strategies and actions for moving from a point to another in which the challenges are reached.

In this second perspective, it is clear that the study of development is not an abstract task. The process of transformation and, more concretely, the technological and economic progress of a country are normally based on some key sectors. There are some sectors leading the process of transformation and contributing with the conditions for the evolution of different institutions and for the economic performance of a country. The leading sectors normally differ in distinct countries and the processes in which the same sectors in different countries catch-up, may also present different trajectories. The contribution of the sectors to the development of the countries can also differ according to specific characteristics of the evolution of the sector.

The understanding of the concept of development is not an easy challenge. There has been a continuous discussion for several decades and more recently concentrating in the concept of sustainable development. '*Sustainable development*' as a concept was popularised by the Brundtland Report as that meeting 'the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987: p43). This concept was originally proposed as a starting point in exploring solutions for potential conflicts between several challenges or interest groups. The challenges or sub-goals can be summarised in four groups:

- Increasing or maximising human welfare of present generations
- Maintaining sufficient opportunities for welfare realisation of future generations,
- Conservation or improvement of environmental quality and natural resources availability,

- The preservation of biotic and genetic diversity.

The concept of sustainable development covers broader challenges and not only environmental protection. Instead, trade-offs should be considered, in terms of the possibility to achieve multiple challenges. The trade-offs would be present in terms of multiple use, multisectoral, spatial and temporal dimensions. This involves simultaneously solving problems of scale, allocation, equity and adjustment via investment and technological advance (Van den Bergh, 1996).

As a political concept 'sustainable development' has had a strong impact, opening a vast debate but also the adoption of political orientations toward the necessary transformations. So, in spite that the concept did not give a precise definition, it is clear that several countries and organisations have introduced changes in order to move in that direction. In the debate there are people highlighting different topics. One of the critics is that the concept does not make distinction between the vastly different needs in the First and Third Worlds not between the human needs and the consumers wants (Ekins, 1995). One more discussion is about if economic welfare is enough for 'meeting the needs' or if is necessary to totally change the concept of welfare (James, Nijkamp and Opschoor, 1990).

The concept also introduced the idea of limits for economic growth, not absolute limits but limitations imposed by the present state of technology and social organisations on environmental resources and by the ability of the biosphere to absorb the effects of human activities. This debate is about if sustainable development and GDP growth are or not in conflict and about what kind of changes should be stimulated.

One more point in debate is about what should be sustainable. The essentially economist's approach defends that is the level of welfare that is to be sustained or perpetuated through economic, institutional and technical change. That implies maintenance over time of aggregate resources stocks, such that the potential to generate welfare is not permitted to fall below the current level (Pearce 1986, Repetto, 1987). But other approaches of sustainable development focus on the physical or natural resource base of an economy (Daly, 1990; James, Nijkamp and Opschoor, 1990).

Summarising, from the discussion about the concept of sustainable development it is clear the need to consider several kind of challenges (economic, social and environmental) as well as the trade-offs between them. It is also important to use the concept as a political orientation for the necessary transformations toward a situation in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional changes are made consistent with this diversity of challenges (Van den Bergh, 1996).

Stressing the necessary transformations it is possible to establish the link between the debate about sustainable development and the debate about *systems of innovation*. Actually, most of the key questions in the study of systems of innovations are related to the explanation of why nations differ in economic performance (Lundvall (ed), 1992; Edquist (ed), 1997). However, this focus on economic performance should not exclude the consideration of the other kind of challenges for sustainability (Segura, 1999).

It is convenient to study of the trajectories of the sectors following a sectoral innovation system approach (see Malerba F, 2004). This means to put emphasis in the trajectories of three different issues: the knowledge base, the actors and networks, and the institutions. The *Knowledge and*

technological domain is relevant because any sector could be characterized by a specific knowledge base, technologies and inputs. As argued by Malerba, in a dynamic way, the focus on knowledge and the technological domain places at the centre of the analysis also the issue of sectoral *boundaries,* which usually are not fixed, but change over time.

The dimension of *actors and networks* is also relevant. Actually, a sector is composed by heterogeneous agents, both organizations and individuals. Organizations include both firms (e.g. local firms, subsidiaries of multinational corporations, users, producers and input suppliers) and non-firm organizations (e.g. universities, financial institutions, government agencies, or technical associations), including sub-units of larger organizations (e.g. R&D or production departments) and groups of organizations (e.g. industry associations). Agents are characterized by specific learning processes, competencies, beliefs, objectives, organizational structures and behaviors. They interact through processes of communication, exchange, cooperation, competition and command. In a sectoral system framework, innovation is considered a process which involves systematic interactions among a wide variety of actors for the generation and exchange of knowledge relevant to innovation and its commercialization. Interactions include market and non-market relations that are broader that the market for technological licensing and knowledge, inter-firm alliances, and formal networks of firms, and often their outcome is not adequately captured by our existing systems of measuring economic output. *Institutions* are key factors, because agents' cognition, actions and interactions are shaped by institutions, which include norms, routines, common habits, established practices, rules, laws, standards and so on. A lot of institutions are national, as for example the patent system, while others are specific to sectors, as for example the sectoral labor markets or sector specific financial institutions (taken from Malerba, 2005).

For empirical use, the concept of sustainable development needs to be transformed into operational targets measured by indicators. In order to evaluate the impacts of innovation and catch-up processes on development, it is necessary to turn to a more pragmatic way of defining indicators related to the normal targets in the different dimension. The challenge is to have a set of indicators and to analyze the trajectories in different phases of development of the sectoral systems of innovation.

The concept of sustainable development is mainly used at a macro level. However, most of the challenges depend on transformation of the patterns of production, consumption and social behavior. From the supply point of view, a relevant dimension is on the patterns of production, which depends on transformations at sector and firm level. This implies to consider sustainability also at these levels. The concept *sustainable performance* is a way to have an operative approach of sustainable development at firm and sector level. The core aim is to stress the idea of different challenges to be considered in a holistic and systematic approach. More precisely, sustainable performance is defined as the simultaneous achievement of desired scenarios of performance in three dimensions (economic, social and environmental). In operative terms a process towards sustainable performance can be understood as an evolutionary process of setting multidimensional targets and strategies to reach the targets. To evaluate the contribution of innovation and catch-up process on sustainable performance of the sectors, it would be necessary to consider specific indicators which characterize the challenges in the different dimensions. It would be necessary to select a set of indicators which can be comparable among different countries and to evaluates how the evolution of the sectoral systems have impact such indicators (Orozco, 2004).

The question is then how to study the role of sectoral systems of innovation on the performance of the sector and on the process of development of the country. The role of the systems of innovation on performance is derived from their role on innovation processes, especially on the fact that innovation is an interactive process. Edquist (2001) argues that the most important function of the systems of innovation is to produce, diffuse and use innovations. The relationships between institutions and organizations in a system of innovation influence innovation processes and thereby also the performance of the system (Edquist and Johnson, 1997).

The role of the systems of innovation is strong even in particular firms. Actually, firm efforts and competencies are supported and shaped by the system or, as Nelson has pointed out, "what firms do, and the technologies they employ and develop, are influenced to a considerable extent by the environment they are in" (Nelson, 1998: 512). A similar idea is presented by Cimoli (1998), arguing that the interactions between competencies (referring to a firm, organization or country abilities to solve both technical and organizational problems) and performance (as measured by variables such as competitiveness and contribution to industrial growth) are shaped by the systems of innovation. He also argues that economic performance depends on how each country implement policies and organizes its institutions, which are also part of the system of innovation. Some other studies emphasizes that growth and catch-up potentiality are clearly related to a country's historical path and to the development of the systems of innovation (Katz, 1997).

It is also necessary to consider an international dimension on technology transfer between countries. Receiving countries develop by adapting, debugging and improving technologies and competencies developed in some more advanced countries. Sectoral systems of innovations approach is a very useful tool for analyzing the possibilities of catching-up growth through importation of knowledge through different channels. The emphasis is on sectoral systems of innovation. However, firms and sector belong simultaneously both to national, local and sectoral systems. Because of that, even when the analysis is at sectoral level, it could be useful to use a national or a local approach of systems of innovation and to assess how the sectoral system contributes or not to strengthen the local and national systems. In some sectors, for example, a strong presence of transnational companies could contribute to strengthen a sectoral system but in an international level. Some of the components of the system are out of the local and national boundaries. The sector gets inputs (knowledge, financial resources, etc.) from foreign organizations, but does not strongly contribute to the countries development, because does not contribute to strengthen the local and national systems of innovation. In this situation it is possible to find some sector with weak linkages to international systems of innovation and with poor capabilities to incorporate knowledge. The transformations towards the challenges of sustainable development could be slow.

One important feature of the conceptualisation of system of innovation is the stress on the concept of system, considering the components, relationships and attributes. There are various approaches. We can distinguish input/output analysis, 'development blocs', national innovation systems, the Porter's 'diamond', sectoral innovation systems, local industrial systems, technological systems, and competence blocs (Carlsson et al, 1999).

As Lindegaard (1997) summarises, some common characteristics of the approaches to innovation system analysis are: technological change, innovation and learning are at the centre; most are holistic, interdisciplinary and historical approaches; they focus on variety and the differences between systems and sub-systems; interdependence and non-linearity are emphasised; they focus on the role of organisational change as a key factor for technological change and productivity

growth; the role of institutions is also highlighted; they present a conceptual and analytical framework indicating an appreciative rather than formal view to economic theorising (see the discussion in Edquist, 1997).

One open question is about how to measure the performance of the systems of innovation. There are some contributions, but it is still an open research issue. Carlsson and colleagues (1999) argue that to evaluate the performance of a system means to evaluate each of these players, not primarily as single entities but connected in the entire system. They continue arguing that it is quite difficult to measure the performance at the system level, making it necessary to rely instead on a series of partial measures at the sub-system level.

One more open discussion is about how to use the system of innovation as an ex-ante approach. Arocena and Sutz (1999) argue that system of innovation is an 'ex-post' concept, that is, a concept built upon empirical studies trying to show similar patterns or comparing the differences between the systems especially in developed countries. But for less developed countries it is more useful an ex-ante and normative approach, where the concept may give some political orientation about the kind of policies stimulating the innovation processes.

2.2. U-Industry linkages

In order to appreciate the role of universities and public research centers on innovation processes by firms, it is important to have a systemic approach. Universities and public labs are not only the source of personnel trained in science and technology fields. In a number of industries this kind of research institutes are also a source of scientific and technological knowledge relevant to the innovative activities of firms. Improving research capabilities in universities can be a powerful strategy to address problems relevant to firms. These knowledge and capabilities provide a broad support to the innovative activities of business enterprises. However, firms must develop the capabilities do communicate with universities and research institutes in order to concrete specific demands for new research questions, scientific findings, dissertations, papers and other mechanisms to communicate knowledge.

The role of universities and public research centres inside the innovation system is relevant because of their focus on the generation and transfer of knowledge and learning capabilities building. These are fundamental factors affecting innovation processes (Ruiz, 2007). The links between universities and society have been an issue in the agenda for technological and innovation policies, especially for developing countries. The linkage involves three fundamental actors: the State, Universities and Firms. It is important to have a holistic approach, considering the context and economic situation affecting the scientific development and the opportunities for technological innovation. The knowledge created by universities and its use in the industrial processes is a cause of controversy and discussion. Strong links among universities and public research centres may be a strategic element for capability building, knowledge transfer and innovation in the industry, especially in developing countries where most of the R&D investments are done by this kind of research centres.

Cohen and Levinthal (1990) recognize the importance of the strength of external relationships in the development of absorptive capacity in firms. Development of close relationships may contribute to a firm's absorption capacity because such relationships can create and strengthen

information channels and facilitate the knowledge flow, hence increasing the efficiency of transfer of tacit knowledge.

When studying the interaction firms-universities (through research centres), we must keep in mind that this kind of links are in constant evolution and may change from one country to another (Albornoz, 1990). The dynamic relation between researchers in universities and public institutes with the industry sector has been a key for the development of the national system of innovation. It is important to consider both, the research capabilities in universities and public research centres and the absorption capacities by firms. These factors define in different ways the possible interactions and the processes of evolution across the time.

A relevant role of universities for sustainable development is their contribution to define the research agenda. This is especially true in developing countries, where the industry sector don´t have a strong participation in R&D activities. As pointed out by RICYT (2003) and by Sutz (2005), the industry sector in Latin America is very week in R&D activities and therefore has a poor influence in the research agenda. In these conditions, the incorporation of the challenges of sustainable development in the research agenda seems to be a clear task for universities. There is also a space for the use of specific regulations and incentives by the State, which orient the demands of research according to goals oriented by the dimensions of sustainable development.

3. Methodological framework

This section describes the research method and the techniques used for the recollection of the data. We used two complementary methodological components. The first one is a survey to researchers in universities and public research centres. The other is a survey to firms.

Survey to researchers in universities and public research centres

An important motivation that impulse this research has been to create a data base about the links among universities and public research centres with the industry from the perspective by the researchers. The creation of a database with representative statistical information was crucial. We used a Simple Random Sample (SRS) from the list of researchers in universities and public research centres.

The first challenge was the definition and verification of an appropriate sample frame. The first task was to create a data base with researchers and research centres, and then verify it. This list was the base for a representative sample. Using information from the main universities and public research centers we got a sample frame with 178 researchers. We decide to use the formula of the SRS for proportions, due to the characteristics of the subject of study, where a considerable amount of the variables in the research are qualitative, and, in some way because they refer to the proposal percentages of observations that can be found inside the investigated categories. The result was a sample of 128 researchers. We finally were able to capture information from 98 researchers[1], getting of 76.6% of responses from the sample.

1 The software "Statistical Package for Social Sciences" (SPSS) was used in the process of capture the information. Also MS Excel and SPSS where used in the quality assurance of the information, the analysis and tabulation of the data.

Survey to the industry sector

As part of researchers at CINPE, we had the opportunity to coordinate the National Survey of Science, Technology and Innovation of Firms (2006-2007), developed by the Ministry of Science and Technology of Costa Rica (MICIT, 2008). The data in this paper is taken by the section on research centers link with the industry in this official survey.

The survey considered the following manufacture, energy and telecommunication sectors, including the sector of technologies for information and communication (ICT[2]). According to the official data by the National Institute of Statistics and Census (INEC), these sectors have 2.285 firms all together.

INEC provided the sample using a simple random sample method for proportions. The result was a sample of 396 firms, spread thru all the considered sectors. From this sample, it was possible to reach responses by 376 firms. So 95% of answers where reach in the national level.

4. U-Industry linkages and the challenges of sustainable development in Costa Rica

4.1. The role of universities and public research centres in the innovation processes by firms

The kind of links between universities, public research institutes and firms in Costa Rica are very similar to the situation in other Latin American countries. The situation is quite different to the one in more developed countries. The evidence indicates that most of the interactions oriented in promoting innovation processes have been very poor or inexistent. Some firms seem to have very indirect and casual interactions. However, this kind of interaction is mainly to use the labs of universities and public. Research institutes, universities and firms are generating additional some efforts to strengthen the systems of innovation. In some countries some policies are used to promote stronger links. But in Costa Rica there is a lot of work to do, especially in generating thrust among the different agents in terms of financial sources and other kind of institution to facilitate interactions.

Table 1
Costa Rica: Investment on Scientific and Technology Activities (STA)
2006 – 2007

Scientific and Technology Activities	Expenditure (millions of US$)		% regard to GDP	
	2006	**2007**	**2006**	**2007**
Total	284,72	326,87	1,26	1,24
Research and Development (R&D)	87,82	84,27	0,39	0,31
Formation and Education	142,10	170,00	0,63	0,65
Scientific and Technological Services	54,80	72,53	0,24	0,28

Source: MICIT, 2008

2 The TIC´s services subsectors are excluded.

National Scientifics have more linkages with foreign colleagues, than among them. Most of the funding for projects comes from foreign sources. The capacity of attracting foreign funds should be stimulated, but this is not enough. The country must generate a bigger capacity to capture national funds for research and development (MIDEPLAN, 2006).

The diagnosis by "Estrategia Siglo XXI" and the data from the national science, technology and innovation (2008) survey, shows that investment in science and technology, and particularly in research and development (R&D) activities, is extremely low for development aspirations of the country. A weak integration between science and the productive processes is evident. Besides, an insufficient effort is been done in the formation of scientific and technical professionals.

Table 2
Costa Rica: Investment in R&D, by sector
2006 – 2007

Sector	Investment in millions of dollars		Percentages	
	2006	**2007**	**2006**	**2007**
Total	87,82	84,27	100,0	100,0
Public Sector	11,33	13,45	13,0	16,0
Academic Sector	28,64	38,18	33,0	45,0
Non Profit organizations	4,13	4,88	5,0	6,0
International Organisms	0,03	0,03	0,0	0,0
Firms Sector (R+D)	43,68	27,73	50,0	33,0

Source: National survey of science, technology and innovation to Firms. Costa Rica. 2008. MICIT-CINPE/UNA.

4.2 Costa Rica Science and Technology Activities

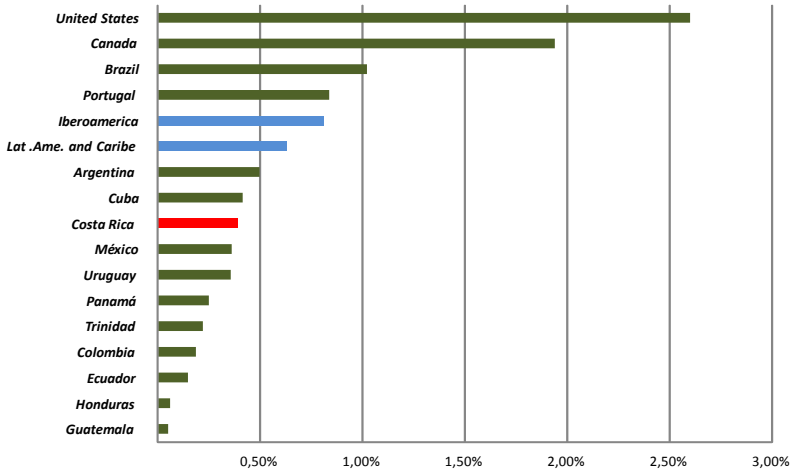
The investment in science and technology activities in Costa Rica is low in relation to the GDP. Most of the efforts concentrate in teaching and training activities, but less in R&D and scientific services. It is interesting the reduction in the investment on R&D activities in 2007 compared with 2006, especially in the industry sector. Table 1 shows how investment in R&D is relative low as a percentage of the GNP.

The role of academic sector is important, not only in absolute term, but because of a sustain tendency into these kind of activities within the sector, even with a considerable rise from 2006 to 2007. This data evidence that even with the efforts made in R&D in the private sector, the academic sector continues as the one that concentrates a major contribution and continuity in these kinds of scientific efforts. Universities may become a solid base supporting the industry

sector. The industry sector reveals considerable changes from one year to the other. The composition of R&D investment varies considerably. The industry sector moved from providing 50% of R&D investment in 2006 to 33% in 2007. There was an absolute diminution from US$43.68 millions to US$27.73 millions for that sector.

Another finding is that 62% of the enterprises said they have carry out R&D activities, but only 29.2% make them regularly or in a continuous way, centralised in an exclusive R&D department. 12.5% of the firms have regular but decentralised way R&D activities. This means that they do not have a specialised R&D department. 52.8% of the firms carry out R&D activities but occasionally and in decentralised way (MICIT, 2008).

Graph 1. Investment in I+D with regard to GDP, year 2006



Source: Own elaboration with data from RICYT and MICIT, 2008

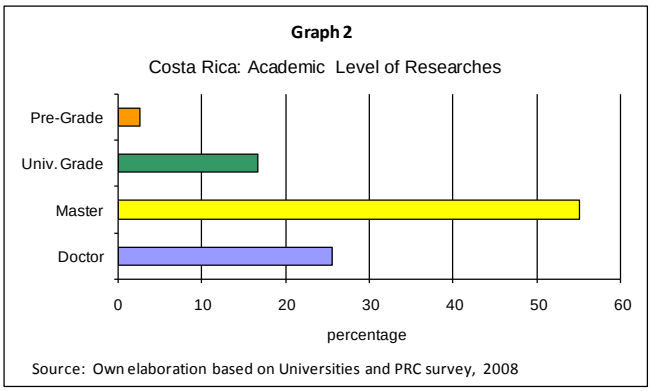
As appreciated in Graph 1, no matter was has been done until now by the academic sector and the private sector, the investment in R&D as a percentage of GDP is still below the Latin-American average. Actually, the Costa Rican situation is very low with respect to the regional leader, Brazil, and more developed countries as United States or Canada.

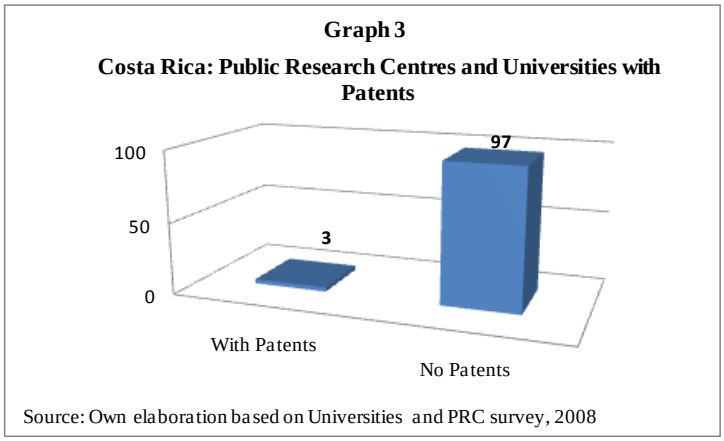
Contribution of Universities and PRC to Innovation Processes

Costa Rican academic sector plays a fundamental role due to its contribution in scientific and technological activities in general, but also for its investment in research and development activities. However, the interactions with the industry sector are still weak and keep facing some barriers.

Education and Capabilities Levels of the Researchers within the Academic Sector

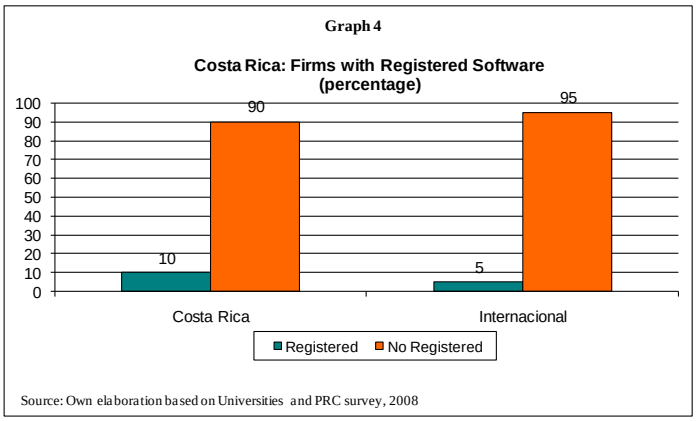
The universities and public research centers have invested in building research capabilities. A growing amount of researches are getting masters (55%) and doctors (26%) degrees. Those results show a relevant local base that may be very useful for R&D projects and for joint projects with the industry sector.





The amount of request and granted patents by research centres is an indicator of the scientific efforts. In Costa Rican case, very few research centres patent. Only 3% of the interviewed centres had obtained patents properly registered in Costa Rica Patent Office. These reflect that patenting is not part of the development strategy of public research centres. Most of those centres (94%) do not apply for a national nor international patent. The few centres that have decided patenting seem to stronger interactions with multinational firms located in the country (see graphs 3 and 4).

Another indicator of local capabilities to promote innovation and technological change is the use and development of their own software. In Costa Rica the study shows that even when the PRC do not patent their own software, a 30% of them used any kind of own made software, with a rise tendency in last few years. Then local capabilities have been creates for a greater development in this aspect.

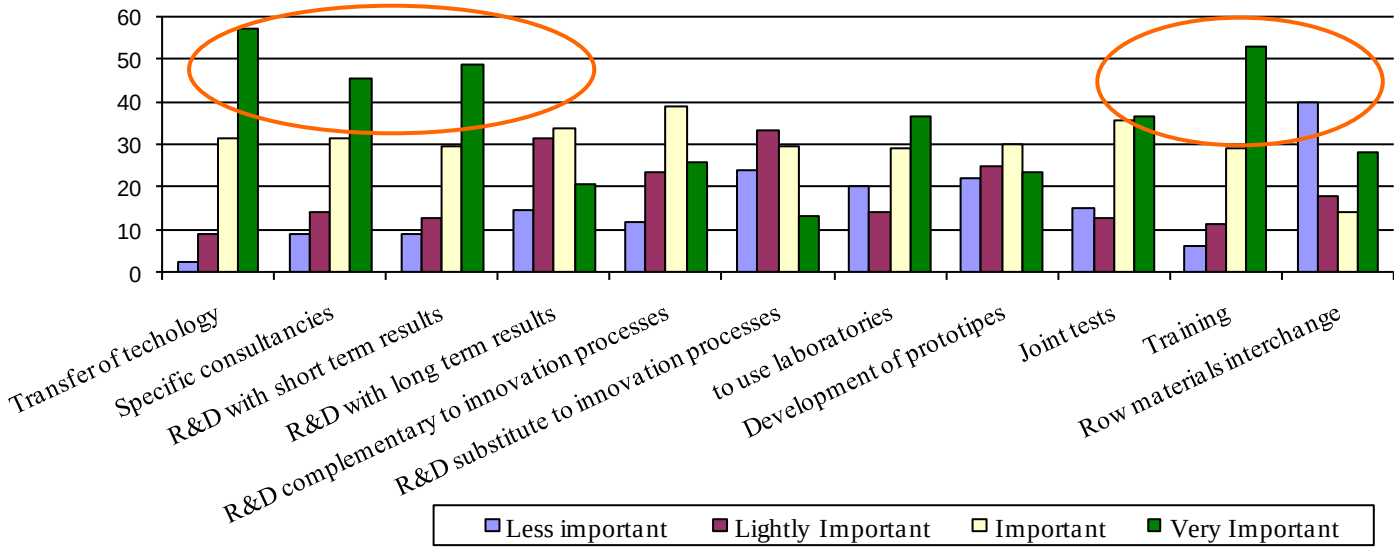


Different types of Universities and PRC – Firms Linkages

A central aspect of the dynamic linkage between universities and firms is the participation of research centres in the knowledge transfer, solving technical and technological problems and training to the productive sector. It is necessary an important change by universities and PRC in how they create interactions with firms, taking into account research activities that complement productive processes. Researchers should become able to participate in teams with firm´s workers in order to solve real problems. A result would be the creation of capabilities inside the firms. Most important kind of linkages are the projects that imply technological transfer, consultancies about concrete technological problems of the firms, R&D projects and training and capability building by the research centres (see graph 5).

Graph 5

Costa Rica: Importance of different types of U-PRC interaction with firms (%)



Source: Own elaboration based on Universities and

Main results from the Linkages between Universities and firms

From the researcher's point of view, professional capability building (for 73% of researchers), dissertations and publications and thesis, are the most important results in the interaction with firms. Otherwise, the acquisition of new patents or any kind of own software (see graph 6) are less important. Notice that the research centers are not focus in creating new firms3 neither the development of new software for firms or patents.

R&D ant linkages with universities

As mentioned, only a small part of the firms have linkages with universities. However, the linkage seems to be useful, even in terms of R&D in the industry. Actually, most of the firms having linkages with universities are investing in R&D, as shown in the table 3. The percentage of firms investing in R&D is significantly lower in the segment of firms without linkages with universities. It is difficult to get a conclusion. Two hypotheses seem to be reasonable. One is that firms investing in R&D have more internal capabilities to interact with universities and take advantage to that kind of interactions. The other is that effectively the linkages with universities are useful in the R&D processes by firms.

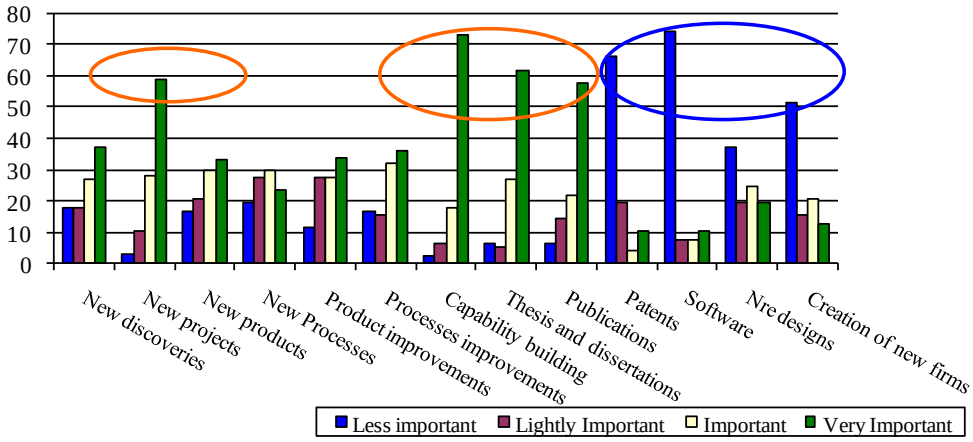
Table 3
Relations between R&D and Industry-university linkages, by size of the firms
In percentages

		Do not invested in R&D	Invested in R&D	Total
Having linkages with universities	25,4	23,3	76,7	
Small firms		28,6	71,4	100,0
Medium firms		29,0	71,0	100,0
Large firms		8,3	91,7	100,0
Without linkages with universities	74,6	60,0	40,0	
Small firms		63,1	36,9	100,0
Medium firms		62,2	37,8	100,0
Large firms		54,0	46,0	100,0

Source: Own elaboration with data from Costa Rica: National Survey of Science, Technology and Innovation, 2006-2007

[3] The software sector has an important development in Costa Rica. The amount of firms in this sector is notorious. So, probably firms satisfies their software necessities in the private market and do not have this issue as a goal for interaction with universities and PRC. For major detail of the software sector development see CAMIC, 2003.

Graph 6
U-PRC interactions with firms in Costa Rica : main results (percentages)

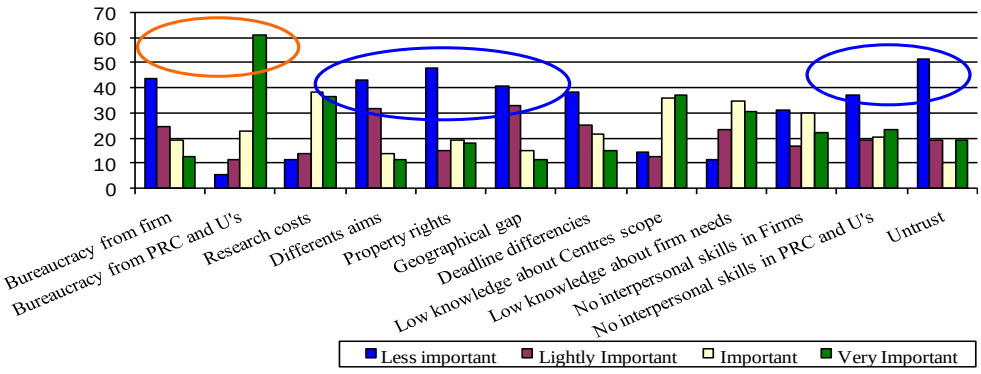


Source: Own elaboration based on the survey to Universities and PRC

Obstacles for linkages

The recognition of internal and external obstacles give us an idea of how important these are in universities-firms linkages, in a way that manifest an important phenomenon related not only with the universities dynamic but with the socioeconomic characteristics of the surroundings. Bureaucracy in universities and research centers is recognized as one of the main obstacles when executing and formulating projects. Lack of knowledge of activities realized by centers and the costs of investigation are other important obstacles (see graph 7). Even when some of these aspects have been discussed, not so much have been done to improve them. The role of public policies may be crucial as facilitator agent for better linkages, but an important responsibility falls on the universities and research centres, which must promote mechanisms that facilitate interactions with the industry.

Graph 7
Costa Rica: Main barriers in the relationship with firms (percentage)



Source: Own elaboration based on Universities and PRC

4.3 Interactions from the Firm's Perspectives.

The results on this section come from a national effort to generate indicators on science, technology and innovation, brought by the National Ministry of Science and Technology of Costa Rica (MICIT), with support of several organizations, among them CINPE / UNA. From a special module within the survey applied to firm sector, was possible to detect 33% of the firms in the country with linkages related to universities or public research centres (PRC). Such percentage, low in relative terms, evidences challenges both for universities and firms, where interactions based on trust and recognition of mutual benefits are the axis for collaboration schemes.

TABLE 4
FIRMS´ OPINION ABOUT THE COLLABORATIONS WITH UNIVERSITIES AND/OR PUBLIC RESEARCH CENTRES, ACCORDING OBJECTIVES, LEVEL OF IMPORTANCE
-PERCENTAGES-

Objectives of the collaboration	Less Important	Very Important	TOTAL
In order to have an earlier contact with future professionals	*48,40%*	*51,60%*	*100,00%*
To support quality control process	*51,60%*	*48,40%*	*100,00%*
To contract important researches for normal innovation activities of the firm (complementary activities)	*52,40%*	*47,50%*	*100,00%*
To use labs and other resources available on U's and PRC.	*50,00%*	*50,00%*	*100,00%*
Technology transfer from U's and PRC	*55,60%*	*44,30%*	*100,00%*
In order to get technological support from researches to problem solving	*37,90%*	*62,10%*	*100,00%*
To increase the limited capability of the firm to knowledge absorption	*49,20%*	*50,80%*	*100,00%*
To get information about engineers or scientists on R&D fields	*54,00%*	*46,00%*	*100,00%*
To obtain information on R&D tendencies	*58,10%*	*42,00%*	*100,00%*
To contract research that the firm cannot develop (substitutive activities)	*68,60%*	*31,50%*	*100,00%*
In order to test products or processes	*61,30%*	*38,70%*	*100,00%*

Notes: Percentages are regarding 124 firms that have had any relationship with Public Research Centres or Universities.

Source: **National Survey of Science, Technology and Innovation. Costa Rica, 2008. MICIT-CINPE/UNA.**

62% of the cases with any kind of interactions with research centres considered that specific problem solving is the main reason to have collaboration with PRC. The mechanism in practice has been based on professional consultancy. Around 50% of the firms contact universities or PRC for their availability of laboratories or other resources, including the possible support on quality control. Another motive of interaction for 51% of firms is the possibility of having early contact with the students and academic departments. This gives the opportunity to strengthen future professional recruitment. For the industry sector, key objectives as research and development are not important objectives to generate interactions with universities and research centers.

One important aspect is that a 64% of the firms with linkage experiences consider this as successful in terms of reaching the goals they have proposed. In addition, 25% of the firms have actual interactions and think that the objectives are going to be reached on time and as planned.

TABLE 5 SUCCESSFUL LEVEL OF COLLABORATION BETWEEN UNIVERSITIES AND PUBLIC RESEARCH CENTRES WITH THE INDUSTRY (IN TERM OF ACHIEVEMENT OF OBJECTIVES)	
	Percentage
a) Yes, Collaboration have been successful to reach the objectives	*63,7%*
b) No, Collaboration have not been successful to reach the objectives	*8,9%*
c) Collaboration is ongoing, but objectives will be reached on time	*25,0%*
d) Collaboration is ongoing, but objectives will not be reached	*2,4%*
TOTAL:	*100,0%*
Notes: Percentages are regarding 124 firms that have had any relationship with Public Research Centres or Universities. Source: **National Survey of Science, Technology and Innovation. Costa Rica, 2008. MICIT-CINPE/UNA.**	

5. Conclusions

One possible contribution of universities to sustainable development is by the influence on innovation and technological change in firms. The responsibility of universities is to orient their research agendas considering the different dimensions of sustainable development. The curricula must be actualized in order to produce professionals that solve problems considering the principles of sustainable development. The linkages with the industry must be also oriented by the principles of sustainable development, especially in those projects that directly contribute to R&D processes.

We may conclude that universities and public research centers have been doing important efforts in science and technology fields in Costa Rica. Actually, most of the R&D efforts in the country are done in the universities and public research institutes. Because of that, the kind of research developed by universities is very relevant in the country. However, several limitations avoid stronger interactions with the industry, hindering innovation processes. Many of those limitations are originated inside the universities and public research centers. Most of the may be overcome with institutional changes to avoid the bureaucracy and excess of requirements that delay the links with firms.

It is crucial to strengthen the trust among different actors. A positive indicator, in spite of the small amount of firms having linkages with universities, is the high level of satisfaction with the results. There is some accumulated experience, as demonstrated in several projects, like in the biotech sector. Therefore, there is a clear space to improve the contribution by universities and public research centers to innovation processes in the industry. Strengthen of collaboration networks seem to be the clear mechanism to improve the contributing of universities and research centers to innovation in the industry.

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