

## INTERACTION OF ACTORS IN THE SECTORAL ICT INNOVATION SYSTEM IN COSTA RICA

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### Abstract

This paper identifies the actors involved in the sectoral ICT innovation system in Costa Rica and describes their interactions for three key activities: human resources training, R&D&I, and creation of new enterprises. We use a qualitative approach and consider five stages: literature review, conceptual delimitation for the ICT sectors in Costa Rica, identification of actors, and analysis of their interactions. The analysis showed coordination problems among actors in the industry, government and academic sectors for these three activities. New institutions are proposed to solve these problems and improve the coordination among actors.

**Keywords:** Sectoral system of innovation, ICT, actors, Costa Rica

## INTERAÇÃO DOS ACTORES NO SISTEMA DE INOVAÇÃO SECTORIAL TIC NA COSTA RICA

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## Resumo

Este artigo identifica os atores chaves que participam no sistema de inovação sectorial das tecnologias da informação e da comunicação (TIC) na Costa Rica e descreve suas interações para três atividades principais: capacitação de recursos humanos; o pesquisa, desenvolvimento e inovação (R &D&I); e criação de novas empresas. Para realizar este trabalho utilizamos uma abordagem qualitativa e consideramos cinco etapas: revisão de literatura, delimitação conceitual para os setores de TICs na Costa Rica, identificação de atores e análise de suas interações. A análise mostrou problemas de coordenação entre os atores do sector, governo e sectores acadêmicos para estas três atividades. Novas instituições são propostas para resolver esses problemas e melhorar a coordenação entre os atores.

**Palavras-chave:** Sistema sectorial de inovação, TIC, atores, Costa Rica

## Introduction

The Costa Rican Information and Communication Technology (ICT) sector has been studied, but in a fragmented way. Pinto et al. (2009) studied the formation of human capital in this sector. The Association of Information and Communication Technology Companies (CAMTIC) periodically conducts sectoral surveys (see CAMTIC and PROCOMER (2015)), which are mainly focused on the member companies of this association. Ciravegna (2012) carried out a more comprehensive analysis of the actors involved in the ICT sector in Costa Rica. However, his analysis does not focus on innovation.

The main objective of this article is to identify and describe the key players that characterize the sectoral ICT innovation system in Costa Rica and to analyze their interactions towards the consolidation of the ICT sector in Costa Rica. At the same time, it is intended to present a process of articulation and cooperation among actors in this sectoral system using the triple helix model (see ETZKOWITZ (2008) and ETZKOWITZ and LEYDESDORFF (2000)), considering the main actors involved in the sector (industry, government and academia) and describing their functions and interactions for human resource training; research, development and innovation (R&D&I); and the creation of new enterprises. Such activities are fundamental to the functioning of the ICT sector.

To carry out this work, a qualitative approach was used, considering the following stages: literature review, conceptual delimitation for the Costa Rican ICT sector, identification of actors, and analysis of their interactions.

This article is divided in five sections. The first section presents a review of the literature on sectoral innovation system. The ICT sector in Costa Rica is presented in the second section. The components of the sectoral ICT innovation system in Costa Rica are described in the third section using the triple-helix framework. This provides the basis for analyzing the interactions among the main actors considering the activities of human resource training, R&D&I, and the creation of new companies, which are presented in the fourth section. Finally, the fifth section contains the conclusions and recommendations.

## Sectoral innovation systems

The concept of a national innovation system, developed by Freeman (1995), Lundvall (1992) and Nelson (1993), "emphasizes that technology and information flows between people, companies and institutions are key to the innovation process" (OECD, 1997: 9). Innovation and technological

development are therefore the result of a complex set of relationships among actors in the system.

The importance of national innovation systems is focused on promoting science and technology policies that contribute to economic growth by allowing a systemic approach that shows the innovation capacities generated by a network of economic, political and social agents (EDQUIST, 1997; LUNDVALL 1992; Nelson 1993; OECD 1997).

From the concept of national innovation systems, regional innovation systems (COOKE, 1992) and sectoral innovation systems (BRESCHI and MALERBA, 1997; MALERBA 2002) are derived. In this regard, Malerba (2002, 2004) states that innovation is composed of three factors: i) knowledge flows, ii) actors, relationships and networks, and iii) institutions. Because innovation systems are integrated by several agents, it is through their interaction and shared activities that new innovative products and services are created and marketed.

This idea is further extended by Etzkowitz (2008) and Etzkowitz and Leydesdorff (2000), who -through the triple helix framework- focus the analysis of interactions on three main types of actors: industry, government, and academia. These actors, although have very clear roles in their own areas of competence, must work together in a harmonious way to foster an enabling environment which favors innovation and allows the creation of a dynamic and competitive sector. Important in this framework is the existence of organizations that carry out activities across two or more sectors.

Additionally, the development of technological clusters is useful to understand the spatial and temporal relationships among the companies involved in certain sectors (BRESCHI and MALERBA, 2005), such as the case with the ICT sector. The advantages of proximity are well known and are reflected in ICT clusters that have demonstrated this reality, for example Silicon Valley in the United States, Cambridge in the United Kingdom, Bangalore in India, Hsinchu-Taipei in Taiwan, Helsinki in Finland, and Tel Aviv in Israel (see BRESNAHAN and GAMBARDILLA (2004a) and ROSENBERG (2002)).

The above concepts are related. Etzkowitz (2008), for example, states that most triple-helix initiatives occur regionally due to the specific contexts of industrial clusters, academic development, and the presence or absence of government authorities.

## The ICT sector in Costa Rica

The ICT sector can be defined as the manufacturing and service industries whose main activity is related to performing or allowing the capture, processing of information and communication by electronic means, including its transmission and visual presentation (OECD, 2013).

A simple definition of the Costa Rican TIC sector can be obtained by considering the economic activities related to the development, production, marketing and intensive use of ICT, which can be grouped into five main industries: software development, hardware and components, telecommunications, direct ICT services and ICT-enabled services.

The establishment of the ICT sector in Costa Rica precedes the decade of the 80s (MATA and JOFRÉ, 2001). However, the export-oriented development strategy of nontraditional products and the attraction of foreign direct investment (FDI) -implemented in response to the economic crisis during this decade- benefited this sector with the arrival of new multinational companies (MATA and MATA MARÍN, 2008). Particularly important was the decision by Intel in 1996 to install a microprocessor assembly and testing plant in the country (KETELÖHM and PORTER, 2006). This decision had a domino effect, causing other ICT-related multinational companies to establish operations in the country (MATA and MATA MARÍN, 2008). This juncture served as the basis for the development of an aggressive policy of attraction of FDI by the Ministry of Foreign Trade (COMEX) and the Development Initiatives Coalition (CINDE). As a result of this policy, Costa Rica became the fourth country with the highest percentage of ICT exports (VILLALOBOS and MONGE-GONZÁLEZ, 2011).

According to CINDE -not-for-profit organization which acts as the national agency for the promotion of foreign investment in the country- 142 multinational high-technology companies were located in Costa Rica in 2014. In total, such companies generated over 46,000 direct jobs and accounted US\$ 6,048 million in exports for the year 2013, showing exports for this group a remarkable increase from the US\$ 1,682 million reported for the year 1999 (LA NACIÓN, 2014a).

## Components of the ICT Sectoral Innovation System in Costa Rica

To develop an analysis of sectoral innovation systems Malerba (2005) proposes three components: i) knowledge flows that correspond to those that affect the ability of a cluster of companies to generate and absorb innovation; ii) organizations in charge of modulating the processes, actions and interactions established by agents through norms, rules, laws independent of the management criterion (formal or informal), particularly

important in this category are government organizations; and iii) individuals, as entrepreneurs, and/or organizations, such as companies and industrial associations.

This study focuses on the characterization of key actors in the industry, government, and academic sectors, participating from a systemic perspective, and considering the components described previously by Malerba and the triple helix model (ETZKOWITZ (2008) and ETZKOWITZ and LEYDESDORFF (2000)). The actors in these components components in the case of Costa Rica are described below.

### **Industry sector**

The private sector, also known as industry, is mainly composed of productive organizations whose activities have common characteristics, but at the same time are also heterogeneous (MALERBA, 2004). Firms have the function of producing goods and services for society (ETZKOWITZ, 2008). Companies constitute one of the main innovative agents of the economy, due to the competitive processes in which they are immersed. Therefore, the interaction of companies in the sector with public organizations, and with the existing knowledge infrastructure in the country becomes key. In this sense, Lundvall (1992) and EDQUIST and JOHNSON (1997) point out that companies in their learning processes interact not only with other companies but with other agents such as universities and research centers, financial organizations and networks created to promote the transfer of technologies and capabilities.

Table 1 presents statistics of the ICT sector for the year 2010. As shown in this table a total of 1,215 ICT companies were estimated for that year (93% national and 7% multinational). Most national ICT companies are small and medium enterprises (SME), which explains their low contribution to sales, exports, and employment for the sector. On the other hand, multinational companies -although smaller in number-, tend to be large companies; they represented 71% of the total sales and 85% of the total exports, accounted for 57% of the total employment for the sector for the year 2010. Therefore, multinational ICT companies bear a heavy weight in the Costa Rican economy.

**Table 1:** Statistics for the ICT sector in Costa Rica for 2010, per national and multinational companies

<b>Statistic</b>	<b>All the ICT sector</b>	<b>National ICT companies</b>	<b>Multinational ICT sector</b>
Number	1,215	1,125	90
Sales (in US\$ millions)	3,456	1,013	2,443
Exports (US\$ millions)	2,832	415	2,417
Employees	81,405	35,305	46,100

Source: Own elaboration with data from CAMTIC (2012)

A key organization at the industry side is CAMTIC -previously mentioned. This association brings together around 180 ICT companies, most of them national. This organization aims to strengthen and support the ICT sector in the country, promoting an ecosystem that favors the development of its affiliated companies.

In the industry component in Costa Rica, there are also companies that support the development of new ICT companies or finance activities of existing ICT companies. These include incubators and accelerators from non-academic organizations, organizations that are part of the Development Banking System, and angel and venture capital funds. It is important to clarify that, although the organizations that are part of the Development Banking System are private, the policies and laws that regulate this type of financing emanate from the public sector.

## Government sector

The government sector is mainly composed of governmental organizations and para-governmental organizations. Government is a regulatory agent that defines government policies and development programs in varying degrees of scope, and focusing on specific sectors. According to Etzkowitz (2008), the government is responsible for the regulation, supervision and development of policies that favor interaction among actors in an innovation system. In Costa Rica, the government has the functions to define and modify i) the regulatory regime, ii) the macro policies, iii) and the contribution of public funds related to science, technology and innovation in the country.

In addition to its regulatory role and definition of public policies, the government offers services to society, such as education. In this regard, advanced technical education in the country is provided by the National Institute of Learning (INA). The Ministry of Public Education (MEP) also offers

vocational education in the country through a subsystem of high-schools, in which technical education is framed into three modalities: commercial and services, agricultural, and industrial. Both MEP and INA regulate technical education at the national level, the first in the case of middle technicians, and the second in the case of advanced technicians. Unlike public universities, MEP and INA do not enjoy autonomy, and are under the direct control of the government.

On the policy side, the Ministry of Science, Technology and Telecommunications (MICITT) is the main governmental organizations related to the Costa Rican ICT sector, acting as the rector of the National System for Science and Technology. This ministry was created in 1990 first as the Ministry of Science and Technology, and in 2013 assumed the rectorship of the telecommunications sector. It is responsible for defining the country's scientific and technological policy through the National Science and Technology Plan and its integration into the National Development Plan. On the other hand, there is the National Council for Scientific and Technological Research (CONICIT), which is another governmental organization whose main function is to promote the scientific and technological development of the country and which serves as a technical arm of the National System of Science and Technology. In addition, it administers funding for scientific and technological activities. CONICIT precedes MICITT, been created in 1972.

Funding for science and technology activities in the country is done jointly by MICITT and CONICT, mainly through two specialized funds: the Fund for Incentives -which finances participation in international events, as well as research projects - and the SME Support Program (PROPYME) - which funds projects aimed at promoting the competitiveness of SMEs through technological development and innovation. Thanks to a US\$ 35 million loan from the Inter-American Development Bank (IDB), a third financing mechanism is available, called the Innovation and Human Capital for Innovation Program (PINN). This program has two axes: the first one is to finance graduate scholarships, professional training, and talent attraction; and the second one is to provide companies non-reimbursable funds for business innovation projects. The allocation of all these financial resources is done through the Commission on Incentives for Science and Technology - created by the law-, which has the participation of the private, public, and academic sectors.

The Ministry of Economy, Industry and Commerce (MEIC) is also related to the Costa Rican ICT sector. This ministry has as one of its functions the promotion and development of SMEs. Since the majority of national ICT companies fall into this category, as mentioned above, this

ministry has an important role in the development and strengthening of national ICT enterprises.

The Ministry of Foreign Trade (COMEX) is in charge of the FDI policy and the Costa Rican Coalition for Development Initiatives (CINDE) -a private non-profit organization, but closely linked to the government- serves as the national investment promotion agency. Together, these organizations carry out activities to attract multinational companies to the country and assist them in their installation, primarily in free-trade zones.

### **Academic sector**

Universities are important players in the innovation process (NELSON, 1993). These organizations play a relevant role in the formation of qualified human resources and in generating new knowledge through basic and applied research, which promotes technological development. Mazzoleni and Nelson (2006) point out that universities and other organizations are key to innovation because they provide advanced training and research, which can ultimately be adopted by companies.

The Costa Rican higher education system is made up of 5 public universities and 51 private universities. Although public universities receive funding from the Ministry of Public Education (MEP); they enjoy full autonomy in their government, development of activities, and legal capacity to acquire rights and obligations, as established in the Constitution of Costa Rica.

The academic offer for the ICT sector consists of 190 programs in branches of knowledge related to basic sciences, computing, and engineering, which represent 17% of the total of 1,139 academic opportunities offered by both public and private universities. However, the programs offered shows clear differences per university type, with public universities offering a greater number of programs in ICT-related areas (116 versus 74) (PROGRAMA ESTADO DE LA NACIÓN, 2014). This situation is notable because most universities in the country are private. Also, from the 2,661 diplomas in computer sciences and related careers granted in 2013, 41% correspond to public universities and 59% to private universities.

The previous data confirms the fact that public universities are the most visible agent in the academic group for the ICT sector in Costa Rica in the training of human resources. In addition, ICT research centers and projects and specialized labs are concentrated in public universities (PROGRAMA ESTADO DE LA NACIÓN, 2014). Therefore, public universities have a pivotal role in the ICT sectoral innovation system in Costa Rica.

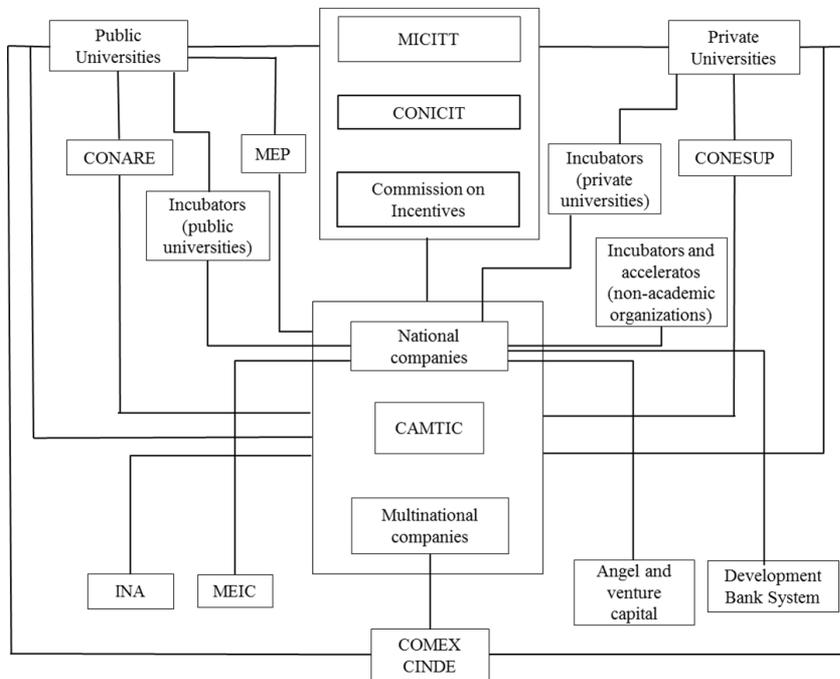
Following practices abroad, universities in Costa Rica -particularly, the public ones- have also created technology transfer offices and incubation units as a way to extend its academic and research activities in support of the economic development of the country, in what Etzkowitz (2008) refers to as a move towards the “entrepreneurial university”.

Among the regulatory organizations at the academic level is the National Council of Rectors (CONARE), which is the supervisory body for public higher education whose focus is on coordinating and articulating teaching, research, and extension activities in the five public universities of the country. In the case of private universities, there is another independent supervisory body: the National Council of Private Universities (CONESUP).

### **Analysis of interactions among actors**

Figure 1 presents the actors described above for the three components of the ICT sector innovation system in Costa Rica.

An analysis of interactions among industry, government and academic actors is presented below. This analysis is conducted for three important activities in the Costa Rican ICT sector: human resources training, R&D&I, and creation of new enterprises.

**Figure 1: Actors in the ICT sectoral innovation system in Costa Rica**

Source: Own elaboration

## Human Resource Training

Figure 2 presents the actors involved for human resources training for the ICT sector within the triple-helix framework.

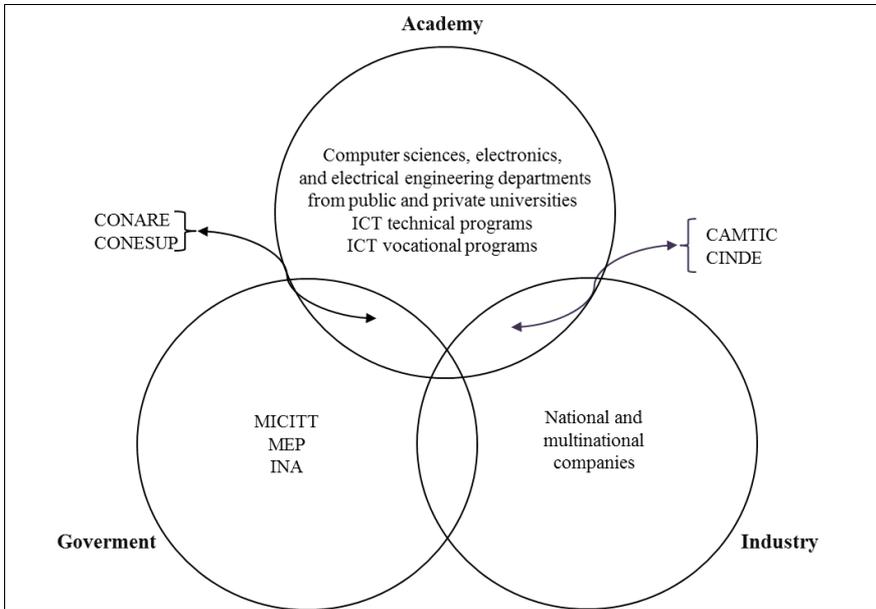
The demand for qualified ICT human resources in Costa Rica is generated mainly by ICT companies, both national and multinational. The development of the ICT sector in the last 25 years has changed the recruitment for such professionals, who were previously demanded mainly by the government and companies in industries not directly related to ICT.

On the other hand, the supply professionals for the ICT sector is provided by public and private universities that have computer, electronic and electrical engineering departments; whereas, the supply of technicians is handled by the technical and vocational programs in charge of INA and MEP, as previously discussed.

MICITT, MEP and INA are the main governmental agencies in the case of human training. MICITT and MEP are responsible of negotiating with

CONARE the Special Fund for Higher Education (FEES), which defines the budget allocated to public universities by the government.

**Figure 2:** Actors in the ICT sector in activities related to training of human resources



Source: Own elaboration

Supervision of the university programs, and coordination of these organizations with government, is the responsibility of CONARE -in the case of public universities-, and CONESUP -in the case of private universities. Therefore, these two organizations can be considered at the interface between the academic and government in the triple helix for human resource training.

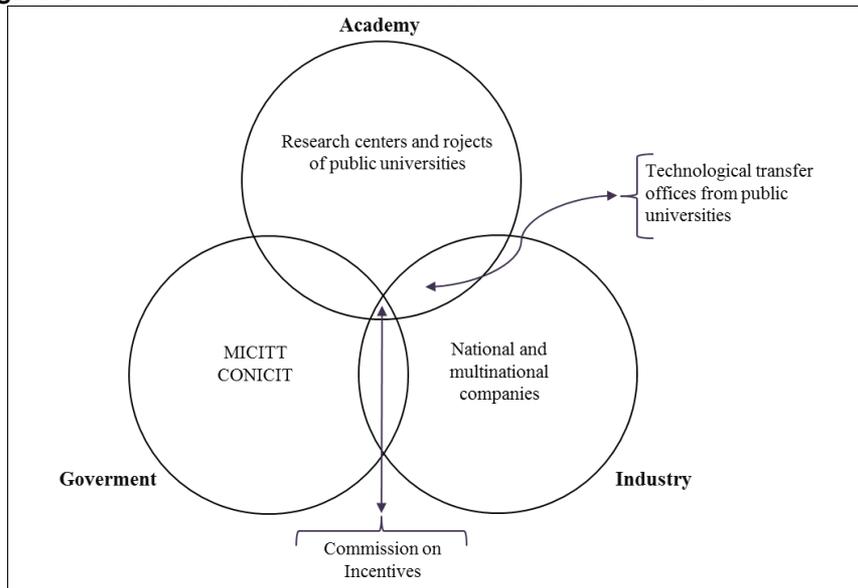
On the other hand, CAMTIC and CINDE can be considered at the interface between industry and academy. CAMTIC conducts studies on human resource needs for the ICT sector (see for example MATA and JOFRÉ (2001) and PINTO et al. (2009)), and has developed the "Specialist Costa Rica" program, which aims to boost technical careers in ICT in the country (CAMTIC, 2009). In a similar way, CINDE carries out human resource studies and interacts with academic organizations in the country, to guarantee qualified human resources for multinational companies that are installed in the country.

The effectiveness of these actors can be questioned, due to the discrepancy between supply and demand of human resources. A recent publication in the national press indicates that the academic sector is in debt to graduates of technological careers, indicating that business demand exceeds the supply of university academic centers by 30 to 40% (EL FINANCIERO, 2013a). The lack of human resources in the ICT sector in Costa Rica has existed for several years. For 2007, this deficit was estimated at approximately 2,300 people, a figure similar to the one projected for the total supply of the whole educational system (academic and technical) for the same year (MATA et al., 2012). On the other hand, CINDE estimated at 36,000 the demand for technical and academic degrees for the period 2014-2019 (LA NACIÓN, 2015), figure difficult to reach due to the trends in enrollment and graduation of students in the national educational system (PROGRAMA ESTADO DE LA NACIÓN, 2014).

### Research, Development and Innovation (R&D&I)

Figure 3 shows the organizations involved in R&D&I in the sectoral ICT innovation system in Costa Rica.

**Figure 3:** Actors in the ICT sector in activities related to R&D&I



Source: Own elaboration

Investment in R&D&I is key to the ICT sector. During 2013, Costa Rica invested in R&D&I US\$ 276 million, from which 38% was invested by the academic sector, 31% by the business sector, 29% by the public sector, and 2% by non-profit organizations (MICITT, 2015). Therefore, the largest investment in R&D&I was made by the academic sector, particularly by public universities. Furthermore, public universities concentrate R&D centers in the country; several of them even have specialized ICT research centers and laboratories (PROGRAMA ESTADO DE LA NACIÓN, 2014).

On the other hand, the demand for R&D&I from ICT companies is low. In this regard, the Sectoral Survey of Digital Technologies 2014 (CAMTIC and PROCOMER, 2015) reveals that, although 80% of the participating companies in this survey have a budget for R&D&I activities, such a budget does not exceed on average 8% of the sales for these companies. Furthermore, the focus of multinational ICT companies residing in the country is on manufacturing or offshoring of business services, for which the corresponding R&D&I is commonly carried out in other countries, where such companies have R&D centers (MATA and MATA-MARÍN, 2008).

Although technology transfer offices of universities in public universities have been created to offer R&D&I services to businesses - operating these offices at the interface between academia and industry-, their activities are still very limited, especially in the case of the ICT sector. Therefore, these offices have not been able yet to provide a good linkage between academia and industry in terms of R&D&I.

Funding for research projects in Costa Rica comes primarily from two sources: public universities and public funds from the National System for Science and Technology, especially the PROPYME fund. Public universities provided from their own budget an amount close US\$ 80 million in funding for their own R&D&I projects in 2013 (CONARE, 2015), whereas around US\$ 1 million was allocated to PROPYME in the same year (CRHOY, 2013). Not only there is a huge difference in the amount of funding for R&D&I provided by the public universities, in comparison with PROPYME, but also the criteria for assigning funds is different. Public universities particularly finance projects of their researchers based on internally established criteria, which do not necessarily consider the needs of the industry or the development of products that may eventually be marketable. PROPYME, on the other hand, take such considerations into account; however, the funding allocated to this program is so limited to promote real innovation projects in the companies (MONGE-RODRIGUEZ and RODRIGUEZ-ALVAREZ, 2013), and their demand by the industry has been very limited due to ignorance or lack of interest (GUILLÉN, 2011).

Therefore, the effectiveness of the Commission on Incentives for Science and Technology -which appears in the center of the triple helix of Figure 3- to align R&D&I the use of public funding towards R&D&I needs of the ICT industry is dubious.

In terms of policies for R&D&I, MICITT is the rector organization at the governmental level. However, the resources available to this organization do not give it much capacity to formulate policies in these areas. Furthermore, the law that created MICITT limits its scope of action for innovation. According to this law, innovation is a direct result of science and technology, and therefore, it does not recognize innovations that are not technology based.<sup>3</sup>

### **Creation of new companies**

For the creation of new companies, public and private universities in Costa Rica have generated in recent years linkages with the industry sector through i) the establishment of entrepreneurship courses, and ii) business incubators. The first ones are aimed at fostering the entrepreneurial spirit in the students, while the latter to develop new companies related to projects originated in the same universities. Through these two mechanisms, these academic organizations are trying to combine their educational purpose, with a mission to contribute to economic development (see ETZKOWITZ, (2008)).

The entrepreneurship courses are at the core of the academic component, whereas, incubators are located at the interface of the academic and industry sectors. It is important to note the existence of business incubators and accelerators, which operate completely from the industry sector.

Funding for new businesses can be obtained through the Development Banking System, and by private angel and venture capital funds. However, limitations for SMEs to access funding from the Development Banking System (see ANGULO (2004)) originated reforms to the law that created this system in 2014, yet there is still no evaluation of the impact of these changes. The Development Banking System is located at the interface between the industry and government components, because although the financing comes from financial institutions, policies guiding this system have been developed by government agencies.

On the other hand, COMEX and CINDE are actively seeking the attraction of multinational companies and provide assistance for their

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<sup>3</sup> See <http://www.mag.go.cr/informacion/FOMPRODUCE-Proyecto-Ley.pdf>

installation and operation in the country, as previously explained above. In particular, CINDE develops an activity that stands out worldwide (CIRAVEGNA, 2012) and operates at the interface between the government and industry sectors.

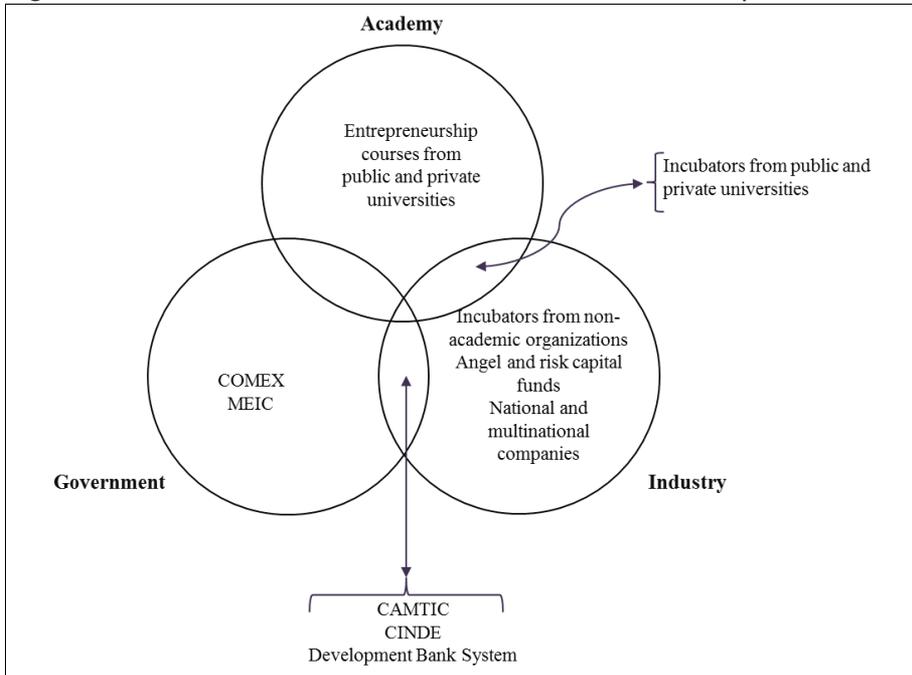
In a similar role, but in relation to the national companies, are MEIC and CAMTIC. CAMTIC has the CREAPYME project to create new ICT companies and has signed a collaboration agreement with MEIC in this regard, operating at the interface between the industry and government sector for this purpose (EL FINANCIERO, 2013b).

The previous actors are presented in Figure 4. As this figure shows, the absence of actors at the intersection of the three components is notorious, which creates serious questions about the effective coordination among actors in the three components of the sectoral ICT innovation system in Costa Rica for this activity. This lack of coordination affects basically the relationship between national and multinational companies, as explained in the next section.

## **Conclusions and recommendations**

A recurring theme in Ciravegna's work (2012) is the lack of coordination among actors related to the ICT sector in Costa Rica. This is evident in the three activities analyzed in this paper. In the case of human resource training, the difference between supply and demand can be attributed to the lack of coordination between the industry, government and academic sectors.

The involvement of the industry and the government should be improved for human resource training. A national commission on ICT human resources should be considered for this purpose -with participation from industry, government and academia- similar to the Commission on Incentives for Science and Technology. This new commission should also facilitate the articulation between the technical programs of MEP and INA and the university programs.

**Figure 4: Actors in the ICT sector in the creation of new companies**

Source: Own elaboration

In the case of R&D&I, there is also an inadequate coordination mechanism among actors in the three sectors of the triple helix. Moreover, since most of the R&D&I is funded by public universities, these activities are not necessarily aligned with the needs of the industry, but with the interests of the researchers -who tend to be more interested in writing academic articles than in developing marketable product. In this regard, it has been reported that 75% of the R&D&I initiatives are academic in nature -i.e., related to research projects and co-authored publications-, and only 10% are associated with activities related to companies, such as consultancies, R&D contracts or sale of services (PROGRAMA ESTADO DE LA NACIÓN, 2014).

Therefore, unless public universities succeed in establishing mechanisms that re-allocate a considerable amount of their R&D&I funds to projects aimed at commercial applications, this situation will continue. In order to achieve this transition, public universities are required to adopt an entrepreneurial business mission in support to the country's economic development (ETZKOWITZ, 2008). However, this could be considered as a sacrifice in autonomy about research by these universities (CEPAL/SEGIB, 2010). In addition, achieving practical research projects require the

development of an adequate intellectual protection regime, which is not yet well developed in the universities.

On the other hand, the demand of the R&D&I by the ICT companies is low, as much as for national and multinational companies. A possible explanation for this in the case of domestic firms could be attributed to their size and the few resources available for R&D&I. According to the latest Sectoral Survey of Digital Technologies, most ICT companies can be classified as SMEs and 52.8% of them sell less than US \$ 250,000 a year (CAMTIC and PROCOMER, 2015). In the case of ICT multinational companies, one possible explanation proposed by Ciravegna (2012) is that most of these companies have invested in the country looking for cheap labor (efficiency FDI), instead of looking for assets that provide strategic long-term advantage.

The limited demand for ICT R&D&I seems to go hand in hand with a limited supply of research for the ICT sector. In Costa Rica, R&D&I for Engineering and Technology ranked third for the year 2013 (21%), after Agricultural Sciences (24%) and Social Sciences (22%). This situation is complemented by the small number of ICT researchers in the country (196), from which only 9% have a doctorate and 22% a master's degree (MICITT, 2015).

Furthermore, it is difficult to align the R&D&I activities carried out by public universities if there is no real demand on the part of the companies. In this regard, the Science, Technology and Innovation Report 2014 states that "[t]he emptiness generated by scant private investment in R&D could be putting pressure on the country's science, technology and innovation system since it is not involved in the experimental development of new products and processes. The available data suggest that not only [these] tasks could be underperformed, but also basic research disregarded. Limitations on the quality of the existing information prevent knowing the magnitude of these effects" (PROGRAMA ESTADO DE LA NACIÓN, 2014, p.125).

The increase in I&D&I demand and supply should be accompanied by greater financing by industry or by government. In this regard, government can play an important role in coordinating ICT R&D&I in the country, particularly through competitive funds allowing to meet industry needs and universities to participate. The impact of this type of funds has been very limited to date, as noted before. However, government's participation in this regard should not only focus on increasing the amount of public funds available in a sustainable manner, but also on raising awareness about the need for more R&D&I by national and multinational ICT companies. CAMTIC,

in the case of national companies, and CINDE, in the case of multinational companies, can also play a role in this awareness-raising work.

The creation of new ICT companies in the country also faces coordination problems. Like the case of human resource training, no actors appear at the intersection of the triple helix for the creation of new companies, although there are organizations that operate at the interfaces of the government and industry sectors (e.g., CAMTIC and CINDE) and the academic and industrial (for example, business incubators from public and private universities).

In addition, the functions creating new national and multinational ICT companies are fragmented. In the first case, MEIC, CAMTIC, business incubators, the Development Banking System, and angel and venture capital funds participate. In the second case, COMEX and CINDE are found.

It is important to recognize that the export-oriented development strategy for non-traditional products and the policy of attracting FDI, implemented in response to the economic crisis of the 1980s, has had significant effects on national ICT companies. At the macro level, this policy undoubtedly strengthened the ICT sector, since FDI allows developing countries -as is the case of Costa Rica- to have companies with a high technological capacity, through knowledge spillovers that can promote the technological development of the country (PAUS, 2005). Furthermore, Klein, Aaron and Hadjimichael (2001) indicate that FDI can serve as a mechanism to transfer "best practices" among countries. These authors add that through FDI developing countries can "import" larger and more productive enterprises. In addition, FDI could allow the successful development of a technological cluster in Costa Rica since the majority of this investment comes from the United States (MARTÍNEZ and HERNÁNDEZ, 2012), and new technological clusters have to deal with technological dominance of the companies in that country (BRESNAHAN and GAMBARELLA, 2004b).

On the other hand, at the micro level, FDI can generate negative effects on national ICT companies, such as an increase in wages for workers in this sector and the creation of an unfavorable business climate for them (MATA and MATA MARIN, 2008). As Table 1 shows, sales per employee in ICT multinational companies was almost double than for national companies, allowing multinationals to pay more to their employees. In this regard, a report from the Organization for Economic Co-operation and Development (OECD) warns that "Costa Rica cannot risk developing a dual economy - where international companies will be sophisticated and technologically advanced, installed in state-of-the-art industrial parks, hiring the best people, and dedicated to export, while local businesses will be less

competitive, with limited access to resources, and focusing primarily on the local market” (OECD, 2012, p. 132).

The previous supports the need to create an agency that coordinates activities related to the creation of new ICT companies, both national and multinational. The proposal to create the National Agency for Productivity, Innovation and Value Added (FOMPRODUCE) could be part of the solution to this problem, although it is aimed at SMEs.<sup>4</sup> This agency aims to contribute to productive development, national economic growth and improvement in the competitiveness of the beneficiaries of this law. The law to create such agency has undoubtedly merits, but very likely it would face multiple obstacles to be approved in Congress (LIZANO, 2015).

The deficiencies found in the three activities studied should be the subject of public policies aimed at improving the effectiveness of the sectoral ICT innovation system. Such policies require considering new institutions, fostering greater and more effective participation of the actors in the industry, government and academic sectors, and also achieving a coordinated vision between actors.

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<sup>4</sup> See <http://www.mag.go.cr/informacion/FOMPRODUCE-Proyecto-Ley.pdf>.

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