INNOVATION, R&D INVESTMENT AND PRODUCTIVITY IN COSTA RICA AND NICARAGUA

RESEARCH PROPOSAL

Proposal presented by Fundación CAATEC to the Inter-American Development Bank in response to the Call for Research Proposals “Innovation, R&D Investment and Productivity in Latin American and Caribbean Firms”

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Introduction

The Costa Rican High Technology Advisory Commission (CAATEC) is a private, independent, impartial, non-profit, apolitical, and non-governmental organization that seeks to promote the economic development of the Central American and Caribbean region through the design and promotion of innovation and technology development policies.

We are responding to the Call for Research Proposals on Innovation, R&D Investment and Productivity in Latin American & Caribbean Firms of the Research Department of the Inter-American Development Bank. We share the belief of the authors of that document that an improved understanding of the determinants and impact of innovative behavior in firms in the region, and the application of this understanding to new policy formation, can lead to substantial positive impacts on the economies and societies of the region. We believe that we are ideally situated to be able to carry out the type of investigation that is being called for, and to provide highly informative results based on a well-structured analysis of an interesting selection of businesses in two countries.

In conformity with the specifications of the Call for Research Proposals, we propose for the case of Costa Rica an econometric analysis which makes substantial use of an unusually appropriate and rich source of innovation-related data that CAATEC researchers originally gathered in 2004 on a statistically representative sample of Costa Rican firms in multiple sectors, supplemented by further data collected in the present project and analyzed using a powerful model detailed below. We also propose a case study analysis based on another highly appropriate set of data gathered by CAATEC researchers in 2007 on a statistically representative sample of Costa Rican firms working in the Information and Communications Technologies (ICT) sector; the comparison of selected groups of firms that is required by the Call for Research proposals will in this case be accomplished by comparing groups of firms within the sample, an approach which, as we detail below, still preserves the analytical ability to gain interesting information by comparing and contrasting groups which the authors of the Call for Research Proposals so correctly emphasized.

After discussing the possibility with representatives of the IADB, and receiving their approval, we have also taken the step of proposing a separate but related study of firms in Nicaragua. It is separate in the sense that either of the country-level analyses proposed – for Costa Rica and Nicaragua – may be evaluated and accepted or rejected by IADB representatives without necessarily accepting or rejecting the other proposed study. It is related in the sense that both studies will be using the same econometric model, assuring that the results of econometric analyses will be fully comparable between countries, providing an exceptional opportunity for comparing and contrasting the results of high-level analysis between different countries – in this case, between a relatively more developed and diversified economy (Costa Rica) and a relatively less developed economy that depends very heavily on agriculture, textiles and apparel for growth and employment creation (Nicaragua). The details of case study analyses in each country will also be shaped by the results of their corresponding econometric analyses, extending the usefulness of comparative analysis of groups of firms operating in highly specific and well-defined contexts to a new level within and between countries.

In the case of Nicaragua, there are no pre-existing sources of firm-level data particularly relevant to innovation, and the investigators involved in the Nicaragua study must carry out more extensive efforts to collect primary data, as discussed in more detail in the main body of the proposal. The structure of the econometric analysis will be the same as that proposed for Costa Rica, and the case study focuses on the dairy products sector, which shows a range in variability of innovative sophistication that will also permit meaningful and productive comparison of two groups of companies within a single sector, as well as permitting us to make particularly interesting comparisons between innovation and innovative practices in a “traditional” natural resource-based sector (dairy products) and the “modern” ICT sector.
COSTA RICA

I. Description of the data to be used in the studies

The data collected for two studies previously carried out by CAATEC researchers, and the contacts made while carrying out those studies, provide excellent starting points for the econometric and case study investigations which we propose to carry out in Costa Rica.

Data for the econometric model

Monge, et al. (2004) presented the results of a study of innovation in 277 Costa Rican businesses which were especially likely to be benefitted by the transition of Costa Rica towards a Knowledge-Based Economy (KBE). The data for the study came from interviews with managers and owners of businesses that were distributed as follows:

- **Agriculture** – 100 businesses that had been consistent exporters of non-traditional agricultural products between 2000-2002.
- **Industry** – 101 businesses selected from sub-sectors (defined with reference to the International Standard Industrial Code) in which businesses operating in the U.S. were characterized between 1988 and 1998 by high investment in research and development, high exportation, and increasing salaries.
- **Services** – 76 businesses working in sectors that were strongly related to the provision of “Internet-Related Services” (services provided to clients by means of the Internet), including accounting, legal services, software development, financial services, consulting and public relations.

The businesses were randomly selected to constitute a statistically representative sample of the universe of Costa Rican businesses operating in the corresponding sectors (with margins of error of 9.8%, 9.8%, and 11.3%, respectively, at the 95% confidence level). Micro-businesses were excluded from consideration, and only 10% of the sample consisted of large (more than 100 employees) businesses.

The primary questionnaire used to gather data was based on the “Bogotá Manual” of Jaramillo, et al. (2001), a widely-known and widely-used guide to the study of innovation in the region (this and other questionnaires are included in digital format as addenda to this proposal). The use of this instrument generated data on types of innovative activities carried out in the businesses; barriers to and facilitators of innovation; organization related to innovation; association with investigative, research and development institutions; sources of financing; and the use of information and communications technologies (ICTs).

A second questionnaire applied to the same 277 firms placed particular emphasis on the characteristics of human resources, including training and education, abilities, ICT skills, and projected future demand for skilled employees. Due to time and resource limitations the data collected with this instrument was not analyzed in the initial study on innovation; together with the full range of data collected using the other questionnaire, this will constitute an invaluable base resource for the proposed research. Substantial portions of data from both questionnaires should lend themselves to comparison with data from other studies, especially in the case of responses to questions which were based on the contents of the Bogotá Manual, which has shaped a number of other studies in the region.

The data sources described above will need to be supplemented by other data for the purposes of the proposed econometric analysis. Among other things, we will need to obtain information for the
appropriate years for the businesses included in the original analysis concerning payroll, number of employees, total sales, and capital. This information can be obtained from the registry of the Costa Rican Finance Ministry (Ministerio de Hacienda) and the Social Security system (Caja Costarricense de Seguro Social); should it be necessary, due to lack of data from these sources for specific businesses, we will communicate with the contacts from those businesses from the initial innovation study to obtain the necessary data. The relatively limited and well-defined types of information that we need mean that it will not be necessary to design a questionnaire specifically for this part of the overall study. The role of this information in our proposed investigation is discussed in more detail in the section of this document presenting our plans for econometric analysis.

Data for the case study

As was the case with the data to be used in our econometric analysis, we already have a source of relevant data that can be as a foundation for the proposed case study. In this instance, data was gathered by Hewitt and Monge-González (2007) for a mapping of the Costa Rican ICT sector contracted by the Costa Rican Chamber of Information and Communications Technologies (CAMTIC) as a step in the execution of an IADB-funded program. The questionnaire used in collecting this data is also included in digital format as an addendum to our proposal.

The original data was collected through interviews with managers and owners of a randomly selected sample of 125 ICT businesses from an estimated total of 600 ICT companies in the country; results of analysis have a margin of error of 6.8% with a confidence level of 95%. As can be seen by a review of the questionnaire, the data gathered can be grouped into the areas of basic characteristics of the businesses, impact of environmental factors (legal framework, human resources, finance, access to markets, etc.) on business performance, international commerce, competition and competitors, and employee training.

Given our long-standing interest in innovation in the region, we were careful to include questions related to innovative activities (and activities associated with innovation such as patenting, use of international quality standards, etc.) in the questionnaire. The way in which these innovation-related questions were structured corresponds closely to some of the questions included in the 2004 study which forms the initial basis for econometric analysis, thus facilitating the comparison and linkage of selected results from the econometric analysis pertaining to the country as a whole with results of the case study analysis focused on the ICT sector.

The resulting innovation data was used in some portions of the original sector mapping analysis, as well as in a more in-depth analysis included for illustrative purposes in an overview study of the status of innovation in Costa Rica (Monge-González and Hewitt [2008]), but its utility has been far from fully explored, and we will make good use of the data in our proposed case study analysis.

The initial case study data discussed above will also have to be supplemented with additional data, including information about relationships with the national innovation system, innovation success factors, details of a firm’s intellectual property protection activities, and so forth. We will collect the necessary information through interviews guided by a short questionnaire (a preliminary version of which is included in digital format as an addendum to this proposal), with the 98 companies from the original 125 which waived their rights to anonymity and allowed their names and contact information to be included in the original database to facilitate further communication if more information was required for future analysis. Given that this portion of the analysis is focused on ICT companies, and that all of these companies – indeed, all the companies in the national ICT sector – are well-provided with computers and Internet connections, and completely accustomed to the use of e-mail and Web pages, we also bear in mind that we could easily use Web-based forms and e-mailed requests for information to be supplied.
through these forms to quickly gather other types of information that we may find to be useful as the analysis is carried out.

II. Summary of data availability

As implied in the last sentence of the previous section, we are aware that the quality of our final results in both the case study and the econometric analyses we are proposing may well be improved by the addition of information, or use of analytical techniques, that we have not yet considered, or whose utility is not fully obvious to us at this time. We are also aware that the final form of our analysis, and the data that it requires, may be affected by results of the upcoming conversations with staff of the IADB Research Department and other investigators which are mentioned in the schedule included in the Terms of Reference of the Call for Research Proposals for this project.

Nonetheless, we believe that the data that is already available for our use, and other types of information that we have specified in the previous section as being especially relevant for completing the studies we are proposing, will provide us with the great majority of what we need for a rigorous and fruitful analysis of innovation, R&D investment, and productivity in Costa Rican firms. Obviously, this optimism is only justified if the data we plan to use is actually available; in summary form, the availability of the data that we will be using in our proposed analysis is as follows:

**Econometric study**

Secondary (existing) data sources: Information on innovative activities and relevant environmental factors for 277 Costa Rican businesses for the year 2004; data already in hand in SPSS data files.

Primary (to be gathered) data sources: Supplementary information for these 277 companies on payroll, number of employees, total sales, and capital, provided by the Costa Rican Finance Ministry and Costa Rican Social Security system. We have already contacted these organizations and have been assured that the necessary information can and will be provided in a timely manner.

**Case study**

Secondary (existing) data sources: Information on innovative activities and relevant environmental factors for 125 Costa Rican ICT businesses for the year 2007; data already in hand in SPSS data files.

Primary (to be gathered) data sources: Supplementary information to be gathered from 98 of the original 125 ICT companies (see comments in the previous section) on relationships with the national innovation system, innovation success factors, details of a firm’s intellectual property protection activities, etc. Given our strong working relationship with the companies involved, we anticipate no problems in obtaining the required data in a timely manner.
III. Survey questionnaires

The following questionnaires are provided in digital (PDF) format as addenda to this proposal.

**Econometric study**

Secondary (existing) data sources: Two questionnaires (innovation and human resources) used in the original 2004 study of 277 Costa Rican businesses

Primary (to be gathered) data sources: [none required; information on payroll, number of employees, total sales, and capital for the appropriate years for the 277 businesses in the original survey will be obtained through formal requests to the Finance Ministry and Social Security system]

**Case study**

Secondary (existing) data sources: Questionnaire used in the original 2007 ICT-sector mapping study of 125 Costa Rican ICT companies

Primary (to be gathered) data sources: Preliminary version of the questionnaire to be used in gathering supplementary information on relationships with the national innovation system, innovation success factors, details of a firm’s intellectual property protection activities, etc., from 98 of the 125 ICT companies in the original ICT sector mapping study

IV. Plan for Quantitative Analysis

*Previous studies on Innovation in Costa Rica*

Lederman and Sáenz (2003) investigated efforts to promote innovation in Costa Rica, and found that not only is Costa Rica not yet experiencing take-off in innovation efforts such as those in leading innovator countries, but that it in fact is a below-average performer compared to other countries with the same levels of per capita income, workforce size, and value of goods export to the US since the 1960s, with erratic patenting behavior and a volume of scientific publications that is 50% below the average of the other countries in the study. However, this study also showed that Costa Rica and Venezuela are the only two Latin American and Caribbean (LAC) countries that, although not leading innovators, show an elasticity in R&D investment and patenting above the OECD average, due to the higher quality of research institutions and greater collaboration with private firms in Costa Rica than in the rest of the LAC.

In a study of innovation in Central America, Rodriguez-Clare (2003) found that Costa Rica’s rate of patent filings tripled from 1988-1992 to 1993-1997, reaching levels above those of México, Chile and Brazil in that period. However, the author also concludes, in agreement with the findings of Lederman and Saenz, that there is no particularly strong area of innovation in Costa Rica, and that the available data suggest that patenting is still an activity limited to a few individuals rather than the result of an advanced innovation system in the country.

Lederman and Maloney (2002) find that Costa Rican investment in R&D is very low not only with respect to that of leading countries in this field, but also relative to other countries with a similar level of development. It can be argued that these low rates of investment in R&D are not due to low returns associated with such activities, since these authors found that economic returns on R&D for countries
with income levels similar to that of Costa Rica are near 65%; based on this finding, the authors state that Costa Rica should invest between 2 and 8 times more in R&D than it did in the 1990s.

Hausmann and Rodrik (2002) argue that the reason why some Latin American countries’ investment in R&D is so low is that innovators from these countries learn what they are good at producing, rather than the traditional concept of producing new goods which can be patented. They also suggest that most of the innovations carried out by Costa Rican firms may be very simple adaptations such as those described by Evenson and Westphal (1995), and thus not suitable for protection such as patenting (although it is important to sound a note of caution here since patenting is costly, especially for small and medium-size firms).

However, some Costa Rican experts on intellectual property rights\(^1\) claim that most firms in the country are not aware of the different mechanisms they can use to protect their innovations. According to these experts, this is due to the lack of suitable local legislation and regulation consistent with international agreements (e.g., TRIPS), lack of awareness of how to protect each type of innovation by both local firms and authorities (public and private), and the lack of an appropriate institutional framework in the country. In short, they claim that in Costa Rica there is an innovative culture among some firms, but no innovation on how to protect the knowledge they generate.

There is only one study that evaluates participation of Costa Rican businesses in innovative activities at the firm level. Monge-González et al (2004) carried out a survey on a representative sample of 277 SMEs in the Costa Rican productive sector, and found that:

- The great majority (79%) of businesses in the non-traditional exporting agricultural sector have entered into innovative activities as a way to improve their competitiveness in international markets; the corresponding percentages are 68% in companies in the manufacturing sector, and 82% in firms in the service sector.

- Innovative activities carried out by Costa Rican businesses consist mainly of organizational or commercialization innovations, such as product improvements (65% in the agricultural sector, 63% in the industrial sector and 71% in the services sector), improvements in package design (60% in the agricultural sector), improvements in the production process (60% in the agricultural sector and 52% in the industrial sector), and changes in company organization (51% in the services sector). In the case of technological innovations, such as launching a new product or service, the percentages of businesses that report having made this type of innovation are lower (43% in the agricultural sector, 51% in the industrial sector and 59% in the services sector).

- Although large and medium businesses are leaders in innovation in the three productive sectors analyzed, almost two-thirds of small businesses also report that they carry out some type of innovative activity.

- Once Costa Rican businesses innovate – by launching a new product or service in the market, for instance – only a very few of them protect their innovation through patenting or licensing in other countries (less than 16% in any of the three productive sectors). This constitutes a serious obstacle for the future growth of this firms and the country as a whole.

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\(^1\) Pedro Suarez, expert on IPR and professor at the University of Costa Rica, Luis Jiménez, director of the Proinnova program at the University of Costa Rica, Federico Valerio, former member of the negotiating team on IPR for CAFTA and Luis Diego Castro, IPR advisor for the Chamber of Costa Rica Manufacturers
Microeconomic Analysis of Innovative Behavior in Firms and Linkages to Productivity

While this brief review shows that there are a number of studies which discuss innovation in Costa Rica at a relatively general level, and one study that does so at the firm level, there are no studies that have analyzed the topic of innovation and the relationship between innovation and productivity at the firm level using multivariable or econometric analyses. Our proposed analysis would therefore provide the first clear evidence for the nature of the relationship between innovation and productivity at the firm level in the country.

The study would be oriented towards the evaluation of a straightforward main hypothesis – that increases in innovative activities by businesses lead to increases in productivity at the firm level. Should this be shown to be the case, then efforts to promote innovation by Costa Rican firms should play a central role in creating economic growth in the country. Our data and the model we are proposing should also allow us to evaluate several other more specific propositions which we suspect to be true, but for which we do not yet have convincing evidence, including:

1. R&D outsourcing facilitates innovation by Costa Rican firms.
2. The returns associated with investment in R&D in Costa Rica are positive at the firm level.
3. Although the returns associated with investment in R&D are positive in Costa Rica, the investment rate in R&D by local firms is low compared to corresponding figures for other countries with similar per capita income.

To carry out our analysis, we will use a modified version of the model developed by Crépon et al. (1998) (CDM) that explains the productivity of firms in terms of innovation input (knowledge acquisition), and innovation output (new or improved products, services and production processes, organizational changes). The CDM model includes two equations related to R&D (innovation input), one innovation output equation and one equation defining the production function.

We will follow Masso and Vahter (2008), using a different set of variables. To describe research behavior, we use a generalized tobit model with two equations. The first equation models the firm’s latent (unobserved) propensity to innovate, $g_i^*$, as follows:

$$g_i^* = x_{0i}b_0 + u_{0i}$$

Here, $x_{0i}$ is a vector of variables that explain firm’s innovation effort, $b_0$ is the associated coefficient vector, and $u_{0i}$ is the error term. We define vector $x_{0i}$ as $x_{0i} = (l_i, FC_i, E_i, S_i, IRD_i, M_i)$, where $l_i$ is firm size (log of number of employees), $FC_i$ is the share of foreign capital in a firm’s ownership, $E_i$ is a variable that indicates whether the firm is mostly export oriented, $S_i$ is a dummy variable that equals 1 if the firm was established after 1998, $IRD_i$ is a variable that indicates whether the firm has an internal department for R&D activities and $M_i$ is a dummy variable that equals 1 if the firm belongs to the manufacturing sector (for a detailed description of variables, see Appendix A).

Let $g_i$ denote the observed indicator variable that equals 1 for innovation input reporting firms and 0 otherwise. A firm invests in knowledge producing activities (i.e. $g_i = 1$) if its propensity to innovate, $g_i^*$, is greater than a constant threshold level, $c$, while if $g_i^* \leq c$, the firm does not invest in any knowledge producing activity (i.e. $g_i = 0$). Thus, $g_i^*$ represents some decision criterion about whether or not to engage in innovation input activities. For example, $g_i^*$ could be a measure of the expected return on investment in research and development (Crépon et al. 2006).
Once a firm is engaged in innovative activities (i.e. \( g_i = 1 \)), we can observe the total innovation expenditure \( T_i \) of firm \( i \), denoted by \( r_i^* \). The variable \( r_i \) denotes the latent intensity of research for firm \( i \). If the firm is engaged in innovative activities, its observed total innovation expenditure should be equal to its latent innovation expenditure. Correspondingly, if the firm is not engaged in any innovative activities, its observed innovation expenditure equals zero. The relationship between \( r_i^* \) and \( r_i \) is expressed by the following equation:

\[
 r_i = \begin{cases} 
 r_i^* = x_{1i}b_1 + u_{1i} & \text{if } g_i = 1 \\
 0 & \text{if } g_i = 0 
\end{cases}
\]  

(2)

Where \( x_{1i} \) is a vector of explanatory variables, \( b_1 \) is the associated coefficient vector, and \( u_{1i} \) is the error term. We assume that the error terms in equations (1) and (2) have joint normal distribution with zero mean, where \( \sigma_0 \) and \( \sigma_1 \) are the standard errors of \( u_{0i} \) and \( u_{1i} \) respectively and \( \rho \) is their correlation coefficient. The standard error \( \sigma_0 \) is normalized to 1 to estimate the model. We define the vector \( x_{1i} \) as \( x_{1i} = (l_i, FC_i, E_i, S_i, IRD_i, M_i, IRD_j, P_i) \), where \( IRD_i \) is the share of employees of internal R&D department in a firm’s total employment and \( P_i \) indicates whether or not the firm contracts public institutions for outsourcing R&D, while the rest of the variables are defined as before.

Since the data from the Costa Rican Innovation Survey does not report the total innovation expenditure of firm \( i \), but does allow us to calculate the share of total expenditure that is used in outsourcing knowledge producing activities, we will use the latter as a proxy for observed total innovation expenditure in equation (2), since there could be a relatively small number of Costa Rican companies undertaking internal R&D.

Equation (3) shows the knowledge or innovation production function relating innovation output to innovation input and other variables:

\[
 t_i = \alpha_k r_i^* + x_{2i}b_2 + u_{2i}
\]

(3)

Where \( t_i \) is the innovation output variable, \( x_{2i} \) is a vector of explanatory variables, \( b_2 \) is the associated coefficient vector, and \( u_{2i} \) is the error term which is assumed to be normally distributed with zero mean and variance \( \sigma_2^2 \) and also assumed to be independent of \( u_{0i} \) and \( u_{1i} \). The vector of explanatory variables \( x_{2i} \) is defined as \( x_i = (l_i, E_i, M_i, B_i, IS_i, O_i, F_i) \), where \( B_i \) is a vector of obstacles to innovation variables, \( IS_i \) is a vector of information sources for innovation, \( O_i \) is a vector of innovation objectives, \( F_i \) is a dummy variable that indicates whether or not the firm finances innovation (output) with external resources and the rest of the variables are defined as before (see Appendix A for a full description of variables).

Note that the firm’s latent innovation expenditure appears as an explanatory variable in equation (3). Therefore, its predicted value from generalized tobit model (equations 1 and 2), will be used in order to correct for both the selectivity and endogeneity of \( r_i \) in equation (3).

Given the data from the Innovation Survey, we have two options to create a proxy the innovation output variable. The first one is to use both the product and process innovation indicators (dummy variables) and estimate equation (3) as a bivariate probit model. Alternatively, we can use percentage innovative sales and estimate equation (3) as an ordered probit model. Both alternatives have been used in previous studies (Benavente, 2005; Griffith et al, 2006; Masso and Vahter, 2008).

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2 The total expenditure on innovation activities consists of internal R&D, outsourcing R&D, acquisition of machinery, equipment and software and acquisition of other external knowledge. This variable has been used instead of R&D expenditure by some studies (Masso and Vahter, 2008; Chudnovsky, Lopez and Pupato 2006; Stoevsky 2005).

3 These explanatory variables have been used in some previous studies (Benavente, 2005; Masso and Vahter, 2008).
The last equation in the model is the productivity equation, assuming Cobb-Douglas technology, where in addition to labor and capital, the innovation output indicator is included (Crépon et al. 1998). Thus, we can write the productivity function as,

$$q_t = \alpha T_{1t} + b_3 x_{3t} + u_{3t}$$  \hspace{1cm} (4)

where variable $q_t$ is the log of sales per employee, $x_{3t}$ is a vector of standard explanatory variables in the productivity analysis (i.e. $x_{3t} = (l_{it}, k_{it}, HS_{it}, SS_{it}, M_{it})$, where $l_{it}$ is the log of number of employees, $k_{it}$ is the log of the capital-labor ratio, $HS_{it}$ is the share of employees with a degree in business administration, science and technology, $SS_{it}$ is the share of employees with a satisfactory level of soft skills and $M_{it}$ is defined as before). The error term $u_{3t}$ assumed to be normally distributed with zero mean and variance $\sigma^2_{u3}$. Predicted values of $T_{1t}$ from equation (3) will be used in estimating equation (4) in order to account for endogeneity.

By estimating equations 1 to 4, we will be able to analyze the determinants of innovation for Costa Rican firms. It will also allow us to measure the impact of innovation on productivity, through $\alpha$, the coefficient associated to the innovation output variable. The main objective is to see whether or not innovation improves productivity for Costa Rican firms.

In addition to this modified version of the CDM model, we will attempt to analyze firms’ assessment of barriers to innovation. To do so, we will follow D’Este et al. (2008), relating a firm’s probability of considering a barrier to innovation as highly important to a set of firm characteristics, including size, firm’s degree of engagement in innovative activities, whether the firm was established after 1998 and whether the firm is mostly export oriented (for a detailed description of variables, see Appendix A). We will also control for differences between innovators and non-innovators. The main difference between our analysis and the one presented in D’Este et al. (2008) is that we are not able to distinguish between groups of non-innovators. However, this analysis will shed some light on how firms assess barriers to innovation.

V. Plan for Case Study Analysis: The ICT Sector

The proposed case study for Costa Rican businesses will focus on the national ICT sector, and will include an analysis of variation in innovative activities between groups of businesses within the sector, the environmental and organizational factors which affect this variation, and the impact of that variation on the productivity of the ICT firms studied.

The ICT sector is noted for its high growth rates and the increasing globalization of the production and sales of hardware and software products and services, as well as of a range of “Internet-related services” such as international business process outsourcing (BPO) which are not necessarily of themselves directly related to ICT services and products, but whose delivery to clients is enabled by telecommunications and computer networks. It is an intensely competitive sector in which the need for innovation has been constantly emphasized for many years, and is considered to be an especially promising area for the development of emerging economies, not only because of increasing global demand and the existence of a number of “ICT success stories” from developing countries in Asia and Eastern Europe (and, increasingly, in Latin America), but also because of its relative independence from the necessity for for abundant local natural resources and industrial manufacturing (with correspondingly lower potential for negative environmental impacts), and relatively low start-up costs for software and services companies.

Costa Rica’s ICT sector is one of the most notable participants in the ICT marketplace at a regional level, and both private and public institutions place a strong emphasis on the development of the sector as a strategic comparative advantage to enhance national competitiveness. CAATEC investigators have carried out several of the most important recent studies of this sector and its environment (see previous
discussions of data); the case study analysis we propose would be able to take initial advantage of a substantial familiarity with the sector on the part of the investigators, and existing data sources that have been compiled while carrying out these investigations (as discussed in previous sections of this document), and would move forward to place the understanding of the determinants of improved competitiveness of companies in the sector through innovation on a firmer basis.

The final orientation and details of the ICT-sector case study analysis will of course be strongly influenced by the findings of our econometric analysis of the sample of 277 businesses representing businesses operating in a wide range of sectors within Costa Rica, since, as the project TORs state, one of the principal goals of the case study is to “substantiate the relationships uncovered by the econometric models”. However, we already have independent information indicating that some of the factors that will be included in the econometric analysis are especially relevant to the ICT sector case study, implying that there will be interesting synergies between the two studies.

The mapping of the ICT sector summarized in Hewitt and Monge-González (2007) highlighted several extremely important issues bearing on the growth and prosperity of the sector, including the following:

- Owners and managers of all types of ICT businesses expressed worries about the availability and cost of human resources in the near future.
- Analysis showed significant shortcomings in the availability of financing for ICT businesses. At the time they were profiled, only 12.8% of these businesses were using credits from public banks, and 16% were using credits from private banks, while less than 2% of businesses were operating with venture capital funding, and only 4% were using resources from a national fund aimed at promoting technology development, obtaining patents, technology transfer, development of human resources, and technological services.
- Although all businesses surveyed had carried out some type of innovative activity, there was relatively little effort made by these businesses to protect their intellectual property – slightly less than one-third (32.3%) of businesses had obtained patents in Costa Rica or other countries, and slightly less than one-half (48.8%) had formally registered intellectual property.

The section of Monge-González and Hewitt (2008) that analyzed the Costa Rican ICT sector focused explicitly on the subject of innovation. One of the most important results of this investigation – from the point of view of complying with the requirement to compare groups of firms in the proposed case study – is that it was shown to be possible to arrange companies in the sample in clearly defined groups that could be used to productively study the relationships between various environmental variables and innovation.

This strategy was used to perform a simple analysis of selected characteristics of those companies which carried out one of the most basic types of innovation – introducing a new product or service. The companies were divided into three groups based on whether or not they launched a new product or service during the survey period, and where they launched it. The groups that were established in this way included (1) 21 firms that improved the products or services they offered, but did not launch a new product or service in either the national or international markets (least innovative with respect to new products or services); (2) 59 firms that launched a new product or service, but only in the national market (more innovative); and (3) 44 firms that launched a new product or service in the international market, usually in addition to launching products or services in the national market (most innovative). Applying

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4 One company did not provide sufficient information on its innovative activities to be classified, and was excluded from this portion of the analysis.
these categories to a consideration of the same factors discussed in preceding paragraphs, the authors found:

- Owners and managers of the least innovative (product improvement only) businesses were notably more pessimistic about the future availability of human resources than were their counterparts in more innovative businesses.

- While all categories of firms depended primarily on their own resources for financing, the least innovative businesses obtained far less credit (almost none) from public and private banks than the businesses who introduced new products.

- While all categories of firms made little attempt to register intellectual property or obtain patents outside Costa Rica, the least innovative businesses registered intellectual property in Costa Rica substantially less often than more innovative businesses.

Other suggestive findings that emerged from these comparisons include:

- The percentages of those companies that invested in R&D, and of those companies that associated with academic or research centers, increased steadily and substantially from the least innovative to the most innovative groups.

- A disproportionately large number of small businesses did not introduce new products or services, while all medium-sized business and almost all large businesses did introduce a new product or service.

Other results of the analysis only assumed significance when they were compared to figures from other countries: for instance, although the percentage of IT-enabled services (ITES) companies that exported their services (28.6%) was not substantially different from the figure for software companies or companies that offer direct ICT services (consulting, training, support, systems integration, etc.), the fact that ITES subsectors in Asian and Eastern European countries are known for their energetic pursuit of international “offshoring” clients suggests the existence of some kinds of barriers to such international expansion in the Costa Rican case. A consistent element in our case study analysis methodology will be the comparison of the Costa Rican situation with relevant data from other countries.

This same categorization of firms (based on the presence or absence of new products and services for national or international markets) can be used for a number of other informative analyses, especially if the original data can be supplemented by returning to the companies in the original sample to request new information suggested by the findings of the econometric analysis or other sources. As was mentioned in the first section of this document describing the data to be used in our analyses, only 98 of the original 125 companies can be re-contacted, since the remaining 27 companies chose to remain anonymous; this leaves 17 companies in the least innovative category, 45 in the group that only introduced new products or services in the national market, and 36 companies that introduced new products or services in the international market.

This categorization is obviously not the only way to divide ICT companies to permit useful comparisons while studying factors that may facilitate or impede innovation, and we will always maintain an open mind in this regard. We also bear in mind that the results of our econometric analysis may make it useful to divide cases in different ways, but we will not know that this is true until that analysis begins to produce results. Methods for creating categories for comparative purposes will also have to ensure that the number of cases in each category will be adequate to permit meaningful comparisons, and to meet minimum requirements for tests of statistical significance whenever possible. At this time, we assume that
statistical analysis of the case study data will mostly involve non-parametric approaches and statistics, but we will investigate the use of more powerful methods whenever possible.

Given the relationship between the econometric and case study analyses, the primary question to be answered or hypothesis to be tested in the case study analysis is clearly whether more sophisticated innovation leads to increased productivity and growth in the specific case of Costa Rican ICT companies. Subsidiary questions to be investigated would include, but certainly not be limited to, the following (all questions below pertain to companies in the Costa Rican ICT sector):

- Does investment in R&D really lead to increased innovation?
- What are the effects of relationships with academic and research centers on firm innovation?
- What are the effects of limited access to financing on firm innovation?
- How sophisticated (how different from existing products, services, or processes) are innovations in the sector?
- Why do so few firms take steps to formally protect their intellectual property? (Lack of awareness? Lack of an institutional framework? Lack of sophistication of innovations?)
- Does the sector have a comparative advantage (using the approach of “Net export” developed by Leamer [1984])?
- Are the institutions formally in charge of promoting innovation in the country perceived as having a positive effect? Are they seen as coordinating well?

VI. Research team Curricula Vitae

The curriculum vitae of each member of the research team is submitted as an addendum to this proposal in digital (PDF) format, as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>CV File</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ricardo Monge</td>
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<td>Ricardo Monge.PDF</td>
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<tr>
<td>John Hewitt</td>
<td>Researcher</td>
<td>John Hewitt.PDF</td>
</tr>
<tr>
<td>Gabriela Soto</td>
<td>Researcher</td>
<td>Gabriela Soto.PDF</td>
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VII. Budget

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<td>Overhead</td>
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<td><strong>Total contribution IADB</strong></td>
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<td><strong>48.450</strong></td>
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</table>
NICARAGUA

I. Description of the data to be used in the studies

In addition to the accomplishing the goals specified in the “Call for Research Proposals” in the particular case of Nicaragua, this study is also intended to enable a powerful comparative analysis of innovation, R&D investment, and productivity between Costa Rica and Nicaragua. This will contribute significantly to attempt to understand particular features of productive sectors, institutional settings and business climates can explain differences in terms of productivity and economic performance. The comparison of two developing countries at different levels of advancement can shed light on how innovation affects the potential for growth and development, and how productivity is affected not only by innovative activities but by specific conditions in an economy.

To facilitate this level of comparison, the contents of the questionnaires used by CAATEC researchers to gather data for the Costa Rica econometric study will be used to guide data collection for the corresponding econometric analysis in Nicaragua. The Central Bank of Nicaragua (BCN) has also been asked to support our efforts with data already gathered for their Annual Business Survey (Encuesta Económica Anual). We will coordinate our own field work to gather additional econometric data with the Department of Economic Analysis at the BCN, and will integrate data resulting from our own activities with information from their databases to compile the information our study requires. In addition, for our case study we have also contacted the Ministry of Agriculture and Forestry (MAGFOR), and will coordinate our field work with its Department of Technology Policy.5

Data for the econometric model

The econometric model used will be identical to that used in the Costa Rican study. The questionnaire to be used is closely based on the innovation study questionnaire used in the Costa Rican study, with slight modifications to include questions about characteristics of human resources, including training and education, which were covered by a separate questionnaire in the earlier Costa Rican study. A copy of the questionnaire to be used is attached in digital format as an addendum to this proposal. Firms to be interviewed will be drawn from a list of companies from the agricultural, industry, services, commercial, and other sectors, whose managers and owners have been interviewed by the Central Bank of Nicaragua (CNB) for its Annual Business Survey. At least 150 firms6 will be selected from the CNB sample to be interviewed using the combined innovation and human resources questionnaire; combined with the data gathered by the CNB for their own purposes, this will provide all necessary information for econometric analysis

Data for the Case Study

For the case study of the Nicaraguan dairy industry, the main information source will be interviews with key actors (firms, business organizations, government agencies) to collect qualitative data. A preliminary version of the questionnaire used to interview representatives of dairy firms is attached in digital format as an addendum to this proposal. Other, secondary, information sources that will be used include data from the Annual Business Survey from the Central Bank of Nicaragua (CBN) on payroll, number of employees, total sales, and capital.

5 Of particular interest is work done by PRORUAL, a network of actors and projects dedicated to agricultural development; one of the seven key components is technological innovation. See www.magfor.gob.ni/agregado/prorural.htm
6 Subject to available resources and logistical support, the sample might be increased.
II. Summary of data availability

As is the case in the proposed Costa Rican study, we will need to use a combination of already-gathered data and data that we collect in the field specifically for this study. The sources of information that we will use, and their availability, can be summarized as follows:

**Econometric study**

Secondary (existing) data sources: Annual Business Survey from the Central Bank of Nicaragua (CBN); database available to our investigators in SPSS format. Agricultural survey (Central Bank of Nicaragua). Data availability verified.

Primary (to be gathered) data sources: Data to be gathered from interviews with owners and managers of at least 150 firms.

**Case study**

Secondary (existing) data sources: Annual Business Survey from the Central Bank of Nicaragua (CBN). Database available in SPSS format. Agricultural survey (Central Bank of Nicaragua). Project reports from MAGFOR and PRORURAL (Rural Development Program); particularly from the Technological Innovation component. Availability of all reports verified.

Primary (to be gathered) data sources: Data to be gathered from at least 30 interviews with key actors (25+ firms, business associations, government organizations), in accordance with the Oslo Manual Guidelines for Collecting and Interpreting Innovation Data.

III. Survey questionnaires

The following questionnaires are provided in digital (PDF) format as addenda to this proposal.

**Econometric study**

Secondary (existing) data sources: [none required]

Primary (to be gathered) data sources: Innovation and human resources questionnaire based on the original Costa Rican econometric study questionnaires.

**Case study**

Secondary (existing) data sources: [none required]

Primary (to be gathered) data sources: Preliminary version of the interview guide for dairy businesses
IV. Plan for Quantitative Analysis

*Previous studies on Innovation in Nicaragua*

Hartwich et al. (2006) provide an overview of the state of innovation in the agricultural sector of Nicaragua, and notes the absence of previous evaluations of this sort. The influence of principal actors and policies, sources of financing, and sources of innovation (like universities and research centers such as INTA, IDR, and INATEC) is assessed. The main conclusion is that key elements for innovation are cooperation among firms, imported technology inputs and, to a lesser extent, research institutes and universities. Innovation systems seem to be driven by international cooperation projects.

Guasch and Escribano’s (2005) study is aimed at developing a methodology to appropriately estimate, in a robust manner, the productivity impact of investment climate variables. To illustrate the use of this methodology, the report uses data collected for Investment Climate Assessments in three countries: Guatemala, Honduras and Nicaragua. There is an econometric analysis of production function inputs and investment climate variables, with a control function approach, based on individual firm information, and aggregating investment climate variables by industry and region. In the case of Nicaragua, four important categories of investment climate (IC) variables are identified: (a) red tape, corruption and crime, (b) infrastructure, (c) quality, innovation and labor skills, and (d) finance and corporate governance. In the case of point c, regression results show that the contribution to the country’s average productivity of the country’s average fraction of computer controlled machinery is 0.1%; second, the contribution to the average productivity of the average fraction of total staff in R&D activities is between 0.4% and 0.6% percent; third, the contribution to average productivity of the probability of the firms engaging in a process of ISO quality certification is between 0.1% and 0.2% percent; forth, the contribution to the country’s average productivity of the country’s average fraction of total staff with secondary education or more is between 0.2% and 0.5%; and fifth, the contribution to the average productivity of the probability of a firm engaging in a training program for their workers other than on the job training is between 0.7% and 1.2%.

The paper by Alange and Scheinberg (2005) attempts to identify key stakeholders engaged in innovation activities and their relationship with clusters, with emphasis on university’s role in innovation. The paper concludes that local innovation is weak and not related to universities; most efforts come from the private sector. In the case of research and its diffusion, advances are not systematically documented or presented in public forums in academic organizations.

Pietrobelli and Rabellotti (2005) document lessons learned about policies designed to support the competitiveness of small and medium enterprises (SMEs) in global markets. The study evaluated the particular case of dairy products in Nicaragua. The degree of competitive achievements are explained by efforts made by local industries to (a) diversify their production and enter the processing stage; and (b) export to ethnic markets in the United States or in El Salvador, improving positioning in the urban markets of local consumers with higher income.

Finally, López (2004) describes the agricultural innovation system in Nicaragua from the perspectives of farmers, grassroots organizations (NGOs) and research organizations such as universities and public agricultural vocational organizations, and attempts to map the capability of information and knowledge management of individuals and organizations in the sector. The study was based on three sub-studies and a final study that consolidates the results assist in improving mechanisms for strategic alliances that strengthen the national system of innovation. The main conclusion of the study is that research activities are important in the innovations identified, but that national research provider organizations are not the source or principal simulators of innovation. Information and knowledge come from advisory and foreign
consultants, professionals with graduate degrees obtained outside the country, farmer-to-farmer contacts, assistance from chemical and pesticide suppliers (for production activities), and the agro industry.

Microeconomic Analysis of Innovative Behavior in Firms and Linkages to Productivity

In the case of Nicaragua, the available studies on innovation are mainly qualitative, with descriptive information and case study analysis. With the exception of Guasch and Escribano (2005), no sound quantitative analysis has been identified. The majority of sources emphasize agricultural and agro-industrial activities from a cluster perspective. Although innovation and productivity issues are addressed in some studies, no systematic analysis of the determinants of innovation and their specific impact on productivity and business performance are available.

Our analysis will therefore contribute to fill the gap between existing case studies and sound quantitative analysis, offering a more detailed perspective based on microeconomic analysis of information from a representative sample of companies from multiple sectors on the relationships between innovation activities and productivity, and how Nicaraguan firms are pursuing more innovative product and process development. We will thereby contribute to a better understanding of innovation issues in the country, and we expect to identify new research areas that will increase empirical knowledge in the area.

The quantitative analysis will use the same methodology as that of the Costa Rican econometric study, testing the hypothesis that innovative activities by businesses lead to higher productivity at the firm level. As was the case in the Costa Rican analysis, the data to be collected and the model proposed should also allow us to evaluate other specific propositions that have not been assessed in the literature reviewed so far, but in the specific context of the Nicaraguan economy:

1. R&D outsourcing facilitates innovation by Nicaraguan firms.
2. The returns associated with investment in R&D in Nicaragua are positive at the firm level.
3. Although the returns associated with investment in R&D are positive in Nicaragua, the investment rate in R&D by local firms is low with respect other countries experience with similar per capita income.

As explained in the presentation of the Costa Rican econometric analysis, the model used is a modified version of the model developed by Crépon et al. (1998) (CDM) that explains the productivity of firms in terms of innovation input (knowledge acquisition), and innovation output (new or improved products, services and production processes, organizational changes). We also follow Masso and Vahter (2008) in describing research behavior. In addition to the modified version of the CDM model, we will attempt to analyze firms’ assessment of barriers to innovation, following D’Este et al (2008).7

V. Plan for Case Study Analysis: The Dairy Sector

Innovation in Nicaragua is very limited. According to RICYT, technology investments in the country account for only 0.2% of GDP, with less than 700 active researchers. In the case of the agricultural sector, Hartwich et al (2006) estimate that there are less than 250 professionals specialized in research and development. The recent ratification of the DR-CAFTA has been seen as a significant opportunity for agricultural business, but limited technological advances and productivity improvements impede more

7 The formal structure of the model is the same as that presented in the discussion of the econometric analysis for Costa Rica; see ppg. 7-9.
export growth and improved international positioning. In the private sector, obstacles to entrepreneurship and lack of coordination between companies and the few existing public research centers worsen the picture (Alänge and Scheinberg, 2005). It is also estimated than only 8.6% of firms comply with the technological standards required by foreign companies and markets (CPC, 2003).

The Nicaraguan agricultural sector represents more than a third of Gross Domestic Product and creates more than 40% of jobs. In the last decade, agriculture has grown 2.3% on average, less than total production (3.8%) and total population.\(^8\) Data from FAOSTAT indicate that agricultural productivity in Nicaragua is lower than in other Latin American countries.\(^9\)

In spite of these limitations, some agricultural activities have shown good performance in recent years, among them beans, coffee, sugar cane, shrimp farming, oilseeds and dairy products, and Hartwich et al. (2006) identified some of the innovation elements that are contributing to agricultural growth. Although still limited and with wide potential for improvement, innovative activities in primary production, harvesting, marketing and other stages of the value chain are helping companies in both traditional and non-traditional sectors to strengthen their businesses competitiveness (see Table 1).

### Table 1: Innovation in the Agricultural Sectors of Nicaragua

<table>
<thead>
<tr>
<th>Not an Innovator</th>
<th>Traditional</th>
<th>Intermediate</th>
<th>Non-Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine Meat</td>
<td>Cocoa</td>
<td>Melons</td>
<td></td>
</tr>
<tr>
<td>Bananas</td>
<td>Black Beans</td>
<td>Watermelons</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Citrus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovator in Primary Production</td>
<td>Red Beans</td>
<td>Plantains</td>
<td>Vegetables</td>
</tr>
<tr>
<td></td>
<td>Corn (White)</td>
<td></td>
<td>Cassava</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td></td>
<td>Onions</td>
</tr>
<tr>
<td></td>
<td>Rice</td>
<td></td>
<td>Tobacco</td>
</tr>
<tr>
<td></td>
<td>Potatoes</td>
<td></td>
<td>Marañón</td>
</tr>
<tr>
<td>Innovator in Post-harvest / Commercialization</td>
<td>Dairy Products</td>
<td>Wood Products</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pumpkins</td>
</tr>
<tr>
<td>Innovator in both Stages</td>
<td>Coffee</td>
<td>Peanuts</td>
<td>Shrimp Farming</td>
</tr>
<tr>
<td></td>
<td>Sugar Cane</td>
<td>Pork Meat</td>
<td>Fish Farming</td>
</tr>
<tr>
<td></td>
<td>Poultry</td>
<td>Seeds (Ajonjoli)</td>
<td>Tropical Fruits</td>
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<td></td>
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</tr>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Honey</td>
</tr>
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</table>

Source: Hartwich et al. (2006)

We have therefore chosen to focus our case study on firms in the agricultural sector, and within this sector, on the dairy sector, where the available evidence suggests that innovative activities have been concentrated in the processing and commercialization stages of the dairy value chain. In 2007, dairy products exports reached US$100 million, and between 2000 and 2007, they increased almost four times (Figure 1). Powdered milk and cheese account for 90% of dairy products exports, while fresh milk deliveries grew from 2.9 million liters to 12.5 million liters by 2007 (Figure 2).\(^{10}\)

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\(^8\) Data from the Central Bank of Nicaragua.
\(^9\) See [www.faostat.org](http://www.faostat.org)

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10
Competition in fresh milk production has increased in recent years, due importantly to the growth of processing companies, both national and foreign.\footnote{At the end of year 2007 Centrolac started operations, with the supply of a new milk brand. Other companies like Prolacsa, Parmalat and Eskimo, as well as numerous rural cooperatives, have been increasing production.} Stronger competition could incentive dairy farms to innovate. Pérez (2003) indicates that multinational companies contributed to the technological upgrading of their fresh milk suppliers, requesting better practices in terms of quality, sanitary standards and management. Recently, processing companies have been promoting closer linkages with primary producers through technical assistance and financing and extension services to ensure higher quality and more efficient procurement.\footnote{Because of a growing export demand, Eskimo (a foreign company) has been increasing its business coordination with dairy farms. Technical assistance and technology transfer to improve milk quality is a central part of the company’s relationship with its suppliers (La Prensa newspaper, January 24, 2007).}

Figure 1: Dairy Products Exports

Figure 2: Fresh Milk Delivery for Processing

Source: Central Bank of Nicaragua and Cetrex

Major innovations in the dairy sector are taking place in the processing stage of the value chain. New products like yogurt, flavored milk and specialty ice cream are expanding market supply. Packaging and product presentation is also changing as a result of growing import competition, as well as export orientation and incentives for innovation. Certification requirements to comply with quality standards in foreign markets (i.e. HACCP) are moving companies towards stronger collaboration with suppliers. Some value chains have been identified in Nicaragua, as, for instance, in the Boaco and Chontales region (Figure 3). Several national and foreign actors are involved, and a network of local and foreign small, medium and large producers, with different levels of sophistication and different market targets, are competing in the dairy sector market.

This wide range in levels of innovativeness will allow us to compare and contrast two groups of firms which, although they are within the same sector, display enough differences in their relative sophistication and other circumstances to make the comparison informative. We will interview between 30 and 50 firms that represent extremes in this spectrum – “high innovators” and “low innovators” – following the strategy set forth in the proposed Costa Rican study (discussed in the first section of the overall proposal) of comparing businesses within a single sector in the same country, and then comparing the firms between countries to increase the richness of the final results of analysis.
Notwithstanding the relative advances in the dairy sector of Nicaragua, there are important obstacles to overcome. According to the Ministry of Agriculture and Forestry (MAGFOR) in 2006 only 16.4% of the national fresh milk production was purchased and processed by the dairy industry. Average yield per animal is estimated at 4 liters per day, one of the lowest in the world. In addition, lack of paved roads and the low quality of electricity services in production zones limit the sector’s competitiveness. We will therefore pay particular attention to the barriers that impede higher growth and business modernization in the dairy sector based on innovation and technological upgrading.

Figure 3: Dairy Products Value Chains in Nicaragua

Based on this discussion, the case study will address the following points:

- Analysis of market structure, concentration and competition levels, competitive strengths and main actors.
- Assessment of market failures: self-discoveries, coordination failures, information asymmetries.
- Identification of innovation activities and technology transfer across the dairy products value chain.
- Identification of company strategies and their integration with innovation activities.
- Identification of innovation drivers: R&D investments, technology adaptation, human capital formation, etc.
- Identification of innovation outputs: new product development, new methods of production, new market penetration, etc.
- Identification of the main business obstacles for innovation.
- Identification of specific roles in the innovation chain of the sector and the country.
- Assessment of public support programs and the quality of the national innovation system (role of regulatory and business climate).

We will conduct between 30 and 50 interviews with firms, as well as other interview with key actors\textsuperscript{13} (firms, business associations, government organizations) in order to obtain first-hand information about innovation practices in companies, institutional characteristics of the business environment, and productivity performance, to be able to identify general characteristics of the innovation process in companies and assess the general innovation framework within which firms operate. The interviews will be structured by the Oslo Manual Guidelines for Collecting and Interpreting Innovation Data (OECD and Eurostat, 2005), and a preliminary version of the guide to be used in these interviews is included as an addendum to this proposal. Figure 5 shows the Oslo Manual framework; the main components of the framework are: a) innovation of the firm; b) linkages with other firms and public research institutions; c) the institutional framework in which firms operate; and d) the role of demand.

\textbf{Figure 5: The Innovation Measurement Framework}

\textsuperscript{13} Among others: a) Most relevant companies (Centrolac, Prolacsa, Parmalat and Eskimo, Camoapan, La Exquisita, Cenilac, Lactosam and Rural Cooperatives); b) business organizations (Unión Nicaragüense de Productores de Leche, Unileche; Asociación de Productores de Leche de Nicaragua, Aproleche; c) Ministry of Agriculture and Forestry (MAGFOR); d) universities and research centers.
The Science, Technology and Industry Scorecard 2007 (OECD, 2007) highlights the importance of two particular inputs to stimulate innovation, namely, investment in research and development (R&D) and continuing growth of human resources in science and technology (HRST). We will assess whether these two points are being internalized in the business strategies of leading companies of the dairy sector, and the perspectives for their incorporation in the business development process. In addition, we will clearly dimension the current level of innovation and how those (and other) inputs are influencing technological change.

VI. Research team Curricula Vitae

The curriculum vitae of each member of the research team is submitted as an addendum to this proposal in digital (PDF) format, as follows:

Ricardo Monge: Project director Ricardo Monge.PDF
Julio Rosales: Researcher Julio Rosales.PDF
Luis Rivera: Researcher Luis Rivera.PDF
Juan Carlos Vargas: Researcher Juan Carlos Vargas.PDF

VII. Budget

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<td>Secretary</td>
<td></td>
<td>1,500</td>
<td></td>
</tr>
<tr>
<td><strong>Total Contribution CAATEC</strong></td>
<td></td>
<td><strong>4,000</strong></td>
<td></td>
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<tr>
<td><strong>TOTAL COST OF PROJECT</strong></td>
<td></td>
<td><strong>49,000</strong></td>
<td></td>
</tr>
</tbody>
</table>
References


Hewitt, J. and R. Monge-González (2007) *Mapeo del Sector de las TICs de Costa Rica.* Report carried out by CAATEC and Unimer Research International for CAMTIC as a part of the Accelleration and Internationalization component of the Dynamic Entrepreneurship Program (Programa Link), financed by the Multilateral Investment Fund (FOMIN) of the Inter-American Development Bank


## Appendix A: Econometric Model Variables

(“ISCR” – Knowledge-Based Economy Innovation Survey-Costa Rica; a version of the same questionnaire will be used in Nicaragua)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Dependent Variable</th>
<th>Explanatory Variables</th>
<th>Variable Definition</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Firm’s propensity to innovate</strong></td>
<td>Innovation input</td>
<td></td>
<td>Observed indicator variable that equals 1 if the firm has engaged in at least one innovation input activity, 0 otherwise. Among innovation input activities, we consider: R+D, Licensed Patents, Training, Technical Assistance, Product or Process Design, Organizational Change, Inverse Engineering, Quality System.</td>
<td>Firms that responded “YES” to, at least, one innovation producing activity. Question 12, Knowledge-Based Economy Innovation Survey, Costa Rica (ISCR hereafter)</td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td>Log Mean of the number of employees for 2001-2003.</td>
<td>In Costa Rica, data comes from the Caja Costarricense del Seguro Social (CCSS). Number of firm's employees, 2001-2005; in Nicaragua, from the Banco Central de Nicaragua (BCN)</td>
</tr>
<tr>
<td>Foreign Capital</td>
<td></td>
<td></td>
<td>Share of foreign capital in the firm's ownership.</td>
<td>Question 8, ISCR.</td>
</tr>
<tr>
<td>Export</td>
<td></td>
<td></td>
<td>Option 1: Indicator variable that equals 1 if the firm is mostly export-oriented (export share on sales higher than 50%), 0 otherwise. Option 2: Share of exports on sales</td>
<td>Question 6, ISCR.</td>
</tr>
<tr>
<td>Start-up</td>
<td></td>
<td></td>
<td>Indicator variable that equals 1 if the firm is relatively new (was established after 1998), 0 otherwise.</td>
<td>Question 10, ISCR.</td>
</tr>
<tr>
<td>Internal R&amp;D</td>
<td></td>
<td></td>
<td>Indicator variable that equals 1 if the firm's innovation input activities are developed by people within the firm, 0 otherwise.</td>
<td>Firms that responded 1 or 3 to question 13, ISCR.</td>
</tr>
<tr>
<td>Industry Dummy</td>
<td></td>
<td></td>
<td>Indicator variable that equals 1 if firm belongs to manufacturing sector, 0 otherwise.</td>
<td>Firm's identification data. Page 2, ISCR.</td>
</tr>
<tr>
<td><strong>Firm’s intensity to investigate through outsourcing</strong></td>
<td>Outsourcing in R&amp;D</td>
<td></td>
<td>Percentage of firm's expenditure in innovation input activities in terms of its total expenditures (per worker)</td>
<td>Question 11 and question 16, ISCR.</td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td></td>
<td>Log Mean of the number of employees for 2001-2003.</td>
<td>In Costa Rica, data from Caja Costarricense del Seguro Social (CCSS). Number of firm's employees, 2001-2005; in Nicaragua, from the BCN</td>
</tr>
<tr>
<td>Equation</td>
<td>Dependent Variable</td>
<td>Explanatory Variables</td>
<td>Variable Definition</td>
<td>Data</td>
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</tr>
<tr>
<td></td>
<td>Foreign Capital</td>
<td>Share of foreign capital in the firm's ownership.</td>
<td>Question 8, ISCR.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Export</td>
<td>Option 1: Indicator variable that equals 1 if the firm is mostly export-oriented (export share on sales higher than 50%), 0 otherwise. Option 2: Share of exports on sales</td>
<td>Question 6, ISCR.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Start-up</td>
<td>Indicator variable that equals 1 if the firm is relatively new (it has less than 5 years since its establishment), 0 otherwise.</td>
<td>Question 10, ISCR.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal R&amp;D</td>
<td>Indicator variable that equals 1 if the firm's innovation input activities are developed by people within the firm, 0 otherwise.</td>
<td>Firms that responded 1 or 3 to question 13.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industry Dummy</td>
<td>D1 = 1 if firm belongs to manufacturing sector, 0 otherwise</td>
<td>Firm's identification data. Page 2, ISCR.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Size Internal R&amp;D</td>
<td>Share of employees in R&amp;D activities</td>
<td>Firm's identification data (page 2) and question 14, ISCR.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public Outsourcing</td>
<td>Indicator variable that equals 1 if the firm uses R&amp;D services from public institutions.</td>
<td>Firms that reply &quot;1&quot; in P15.</td>
<td></td>
</tr>
<tr>
<td>Innovation Output 1</td>
<td>Product</td>
<td>Indicator variable that equals 1 if the firm reports having introduced new or improved products or services</td>
<td>Question 17, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Innovation Output 2</td>
<td>Process</td>
<td>Indicator variable that equals 1 if the firm reports having introduced new or improved production process</td>
<td>Question 17, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Innovation Output 3</td>
<td>Organization</td>
<td>Indicator variable that equals 1 if the firm reports having introduced organizational innovations, including marketing</td>
<td>Question 17, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Innovation Output 4</td>
<td>Innovative sales</td>
<td>Share of innovations in total sales</td>
<td>Questions 2, 4 and 6, ISCR.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outsourcing in R&amp;D</td>
<td>Predicted value from the firm's intensity to investigate through outsourcing equation</td>
<td>Question 11 and question 16, ISCR.</td>
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</tr>
<tr>
<td></td>
<td>Size</td>
<td>Log Mean of the number of employees for 2001-2003.</td>
<td>In Costa Rica, data from the Caja Costarricense del Seguro Social (CCSS). Number of firm's employees, 2001-2005; in Nicaragua, from the BCN</td>
<td></td>
</tr>
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<td>Equation</td>
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<td>Explanatory Variables</td>
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</tr>
<tr>
<td>Export</td>
<td>Option 1: Indicator variable that equals 1 if the firm is mostly export-oriented (export share on sales higher than 50%), 0 otherwise. Option 2: Share of exports on sales</td>
<td></td>
<td></td>
<td>Question 6, ISCR.</td>
</tr>
<tr>
<td>Industry Dummy</td>
<td>Indicator variable that equals 1 if firm belongs to manufacturing sector, 0 otherwise.</td>
<td></td>
<td></td>
<td>Firm's identification data. Page 2, ISCR.</td>
</tr>
<tr>
<td>Market obstacle</td>
<td>Indicator variable that equals 1 if the firm considers that at least one market related obstacle is affecting its innovation capacity.</td>
<td></td>
<td></td>
<td>Question 31 (for all firms) or Questions 26 and 27 (just for innovative firms), ISCR.</td>
</tr>
<tr>
<td>Institutional obstacle</td>
<td>Indicator variable that equals 1 if the firm considers that at least one institution related obstacle is affecting its innovation capacity.</td>
<td></td>
<td></td>
<td>Question 31 (for all firms) or Questions 26 and 27 (just for innovative firms), ISCR.</td>
</tr>
<tr>
<td>Internal sources</td>
<td>Indicator variable that equals 1 if information from internal sources was the main information source for innovation.</td>
<td></td>
<td></td>
<td>Question 29 (just for innovative firms), ISCR.</td>
</tr>
<tr>
<td>External sources</td>
<td>Indicator variable that equals 1 if information from external sources was the main information source for innovation.</td>
<td></td>
<td></td>
<td>Question 29 (just for innovative firms), ISCR.</td>
</tr>
<tr>
<td>Costs Reduction</td>
<td>Indicator variable that equals 1 if firm's main innovation objective was &quot;costs reduction&quot;.</td>
<td></td>
<td></td>
<td>Question 28 (just for innovative firms), ISCR.</td>
</tr>
<tr>
<td>Increasing market share</td>
<td>Indicator variable that equals 1 if firm's main innovation objective was “increasing market share”.</td>
<td></td>
<td></td>
<td>Question 28 (just for innovative firms), ISCR.</td>
</tr>
<tr>
<td>Financing</td>
<td>Indicator variable that equals 1 if the firm finances innovation mostly with external resources, 0 otherwise.</td>
<td></td>
<td></td>
<td>Question 21, ISCR.</td>
</tr>
</tbody>
</table>

<p>| Productivity | Labor Productivity |  | Total Sales per worker |  | In Costa Rica, total sales will be obtained from Ministerio de Hacienda (MH) or directly from firms; in Nicaragua, from the BCN |
| Innovation output (1, 2, 3 or 4) | Predicted value from the firm's innovation output equation |  |  |  |
| Size | Log Mean of the number of employees for 2003. |  |  |  |</p>
<table>
<thead>
<tr>
<th>Equation</th>
<th>Dependent Variable</th>
<th>Explanatory Variables</th>
<th>Variable Definition</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Intensity</td>
<td>Log Capital/Labor Ratio</td>
<td></td>
<td>In Costa Rica, capital will be obtained from Ministerio de Hacienda (MH) or directly from firms; in Nicaragua, data will be obtained from the BCN</td>
<td></td>
</tr>
<tr>
<td>Hard skills</td>
<td>Share of employees with a degree in business administration, science and technology</td>
<td></td>
<td>Human Resources Questionnaire, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Soft skills</td>
<td>Share of employees with a satisfactory level of soft skills</td>
<td></td>
<td>Human Resources Questionnaire, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Industry Dummy</td>
<td>Indicator variable that equals 1 if firm belongs to manufacturing sector, 0 otherwise.</td>
<td></td>
<td>Firm's identification data. Page 2, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Barrier to innovation</td>
<td>Important barrier</td>
<td>Dicotomic variable that indicates whether the firm assesses at least one barrier as highly important.</td>
<td>Question 31, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Number of important barriers</td>
<td></td>
<td></td>
<td>Question 31, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Innovation active 1-3</td>
<td>Indicator variable that equals 1 if the firm has engaged in 1 to 3 innovation input activities.</td>
<td></td>
<td>Question 12, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Innovation active 4-9</td>
<td>Indicator variable that equals 1 if the firm has engaged in 4 to 9 innovation input activities.</td>
<td></td>
<td>Question 12, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>Log Mean of the number of employees for 2001-2003.</td>
<td></td>
<td>In Costa Rica, data will be obtained from Caja Costarricense del Seguro Social (CCSS). Number of firm's employees, 2001-2005; in Nicaragua, data will be obtained from the BCN</td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>Indicator variable that equals 1 if the firm is mostly export-oriented (export share on sales higher than 50%), 0 otherwise.</td>
<td></td>
<td>Question 6, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Start-up</td>
<td>Indicator variable that equals 1 if the firm is relatively new (less than 5 years), 0 otherwise.</td>
<td></td>
<td>Question 10, ISCR</td>
<td></td>
</tr>
<tr>
<td>Industry Dummy</td>
<td>Indicator variable that equals 1 if firm belongs to manufacturing sector, 0 otherwise.</td>
<td></td>
<td>Firm's identification data. Page 2, ISCR.</td>
<td></td>
</tr>
<tr>
<td>Innovators</td>
<td>Indicator variable that equals 1 if the firm has introduced at least one new or improved product, service or process</td>
<td></td>
<td>Question 17, ISCR.</td>
<td></td>
</tr>
</tbody>
</table>
Files included with the proposal

Costa Rica

Econometric analysis
Costa Rica – Original Data Econometric Analysis – Innovation.PDF
Costa Rica – Original Data Econometric Analysis – Human Resources.PDF

Case Study
Costa Rica – Original Data Case Study Analysis – ICT Sector Mapping.PDF
Costa Rica – New Data Case Study (Preliminary).PDF

CVs
Ricardo Monge.PDF
John Hewitt.PDF
Gabriela Soto.PDF

Nicaragua

Econometric analysis
Nicaragua - New Data Econometric Analysis– Innovation and Human Resources.PDF

Case Study
Nicaragua - New Data Case Study (Preliminary).PDF

CVs
[Ricardo Monge: see above]
Julio Rosales.PDF
Luis Rivera.PDF
Juan Carlos Vargas.PDF