

require 1,016 new ICT positions for the period 2014-2016, mostly demanding a bachelor's degree in CS.

5. Supply versus demand of human resources in CS at the university level in Costa Rica

When comparing the estimated supply of bachelor's in CS for the period 2014-2016 –using the linear regression equation presented in Table 4– with the demand computed from the companies participating in CAMTIC's survey –previously presented–, a surplus of 3,603 graduates is obtained (see Table 6). An estimated demand of 4,161 professionals for the period 2014-2016 can be extrapolated for the whole population –assuming the sample obtained was representative.⁶ Under this scenario, a surplus of 458 graduates would still exist. As the ICT sector is the most intensive in hiring CS professionals, it is not evident that other sectors not related to ICT would add such a difference to account to the 7,000-8,000 deficit reported by the media, and defended by CAMTIC on the basis of its own survey (see [9]).

Table 6. Expected Supply versus Demand of Occupations related to CS in Costa Rica (2014-2016)

	2014 - 2016
Supply	4,619
Demand	1,016
Supply minus demand	3,603

Sources: Supply data from CONARE and demand data from CAMTIC's survey

Discussing these results with CAMTIC's Board of Directors in November 2015, they claimed that their survey had two drawbacks. First, it was not possible to obtain information from several multinational companies in the country, which supposedly require a considerable number of ICT staff. Second, their database did not contain information about companies that are not formally registered in the country. According to them, there is evidence of a large degree of informality in the sector since many companies –particularly foreign– hire Costa Rican freelance programmers. In view of this situation, CAMTIC's officials alleged that their survey turned out not to be representative in terms of human resources. In this way, they contradicted the assertion presented in the publication of their own survey, in which they claim that it aims at providing a "characterization of the companies, ... including ... human capital" [23, p. 10].

⁶ This estimate was obtained for the 897 companies in CAMTIC's database using the rule of three.

6. Conclusions and recommendations

As explained in section 3, the supply of diplomas in CS during the period 2001-2013 increased 148% for all universities in Costa Rica. This growth is higher than the one observed for all diplomas obtained in these educational institutions (99%). Therefore, universities in Costa Rica are responding positively to the labor market related to ICT occupations.

Notwithstanding, this growth could have been higher, the same seems to be limited more by the preferences of the students in the country for social sciences and education programs, rather than by the capacity of the universities –particularly public–, as the similarity in the degree structures by public and private universities demonstrate.

Despite the lower unemployment rates in engineering and basic sciences, students in Costa Rica favor more social science and education programs, with greater such rates. Lower unemployment is a clear signal of greater demand in the labor market. Nevertheless, lack of interest in engineering and basic sciences from high school students, particularly women, may explain this situation, as previously explained. Therefore, policies are required to motivate more students to pursue technological programs and to reduce the gender gap in CS, which has been documented in Costa Rica (see [24]).

Furthermore, public universities shared a greater burden in supplying CS graduates, considering their smaller number.

These results undermine the criticism often made to public universities that they are not capable of responding to the needs of the labor market, since they are too bureaucratic.

On the other hand, the demand estimate obtained from CAMTIC's Digital Technologies Sector Survey does not provide evidence that a large deficit for ICT occupations –as announced by the local media and supported by CAMTIC– exist. Such figure arose from CINDE's estimate in 2007 (see [19]) and has not changed for at least nine years (see [9]). During this period, there has been an increase in the number of multinational ICT-related companies in the country, which would not have been possible with scarce human resources.

A word of caution, however, is needed. In studies of this nature, the estimation of demand is the most problematic part due to several reasons. First, a survey to estimate demand for human resources in ICT related occupations should necessarily consider every company/organizations in the country, due to the pervasive nature of ICT. This requires considering a very large population, which is difficult and costly to enumerate. Second, the response rate in studies of this kind is relatively low, as shown by the same survey carried out by

CAMTIC. This situation can bias the resulting sample, making it difficult to obtain results that can be considered representative. Third, estimates of future human resource demand may be affected by overconfidence on the part of the respondents about business growth or by the desire to count with an excess of supply to reduce labor costs. It is, therefore, important in this type of studies to complement the demand projections with data on the actual number of professionals that have not being recruited at a specific time due to lack of potential employees, as considered in the study conducted by Pinto et al. [15] and contemplated in our proposed demand survey. Therefore, the analysis of supply and demand in ICT requires more comprehensive – and therefore, more expensive– studies to address the above-mentioned problems.

However, supply and demand studies only provide an indication of the situation regarding human resources. Interaction between several actors determine the dynamics of CS labor market: public universities, private universities, ICT companies, and government agencies. Such process requires planning, monitoring, and decision-making, not facing a single of these actors the whole responsibility for securing an adequate supply and demand of human resources in CS in Costa Rica [25].

Therefore, paraphrasing Donne,⁷ we can say that:

None of these actors is an island,
every one of them is part of the
whole. Therefore, never send to
know for whom the bell tolls; it
tolls for all them.

Consequently, these actors must join efforts to carry out supply and demand studies of human resources for the ICT sector in the country. So far, related studies have been conducted without the active participation of all actors. Such participation would not only mitigate the limitations of such studies but also increase the awareness about the situation and facilitate action.

In this regard, Mata and Quesada [25] recommend the creation of a national commission on ICT human resources, with active participation of actors from the business, academic and governmental sectors.

Better studies are needed to develop policies and implement a concerted action plan to sustain the development of the ICT sector in Costa Rica.

7. References

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