The complementary role of universities and industries in technological learning: a developing country perspective

Watu Wamae
Professional Development Award – Independent Research
IPS Program Area

Acknowledgements

I am grateful to IDRC's Innovation, Policy and Science Programme for sponsoring this research. I am particularly thankful to Jean Woo for her consistent support during the entire process of the study. I am also very thankful to IDRC - ESARO for the facilities and help that were provided during my field work in Kenya. Special thanks go to François Gasengayire for the discussions and guidance that were useful in carrying out the survey.

I wish to express my gratitude to Mwangi Waweru, the Director of the Institute of Computer Science and Technology, Jomo Kenyatta University of Agriculture and Technology (JKUAT) and Edilberto Strauss, the Director of Computer Engineering and Informatics at the Escola Politécnica, Universidad Federal do Rio de Janeiro (UFRJ) for providing the necessary assistance for the surveys. I am also grateful to Helena Lastre and Jose Cassiolato, the co-ordinators of RedSist at the Economics Institute, UFRJ for hosting me during my fieldwork in Brazil.

Special gratitude goes to Judith Sutz and Rodrigo Arocena from the Universidad de la Republica, Uruguay, who were a great source of valuable inspiration in developing the study. I would also like to thank Banji Oyeyinka, UN HABITAT for his suggestions during the initial stages of the study.

I am greatly indebted to Martin Bell for extending an invitation to visit the Science and Technology Policy Research (SPRU) at the University of Sussex, and taking great interest in my work. I am particularly thankful for his instructive comments and constructive criticism during the write-up of the study. I would also like to thank the SPRU team for the facilities and help provided. In particular, I thank Ed Steinmueller, Pablo d'Este Cukierman and Rocio Alvarez Tinoco for the stimulating discussions and suggestions.

Finally, many thanks go to a number of anonymous contributors who provided valuable help.

Tables of contents

Tables

Appendix Tables

Figures

1 Introduction

1.1 Background

The broad aim of this research is to improve our understanding of the nature, extent and importance of opportunities for technological learning within the production sector as a complement to education and training in universities in developing countries. It addresses two questions: *(i) To what extent do basic technical abilities produced in formal education institutions benefit from technological learning opportunities in the production section? (ii) What are the implications of this for the development of innovative technological capabilities in the local economy?*

This research is concerned with tracing computer engineering graduates from Jomo Kenyatta University of Agriculture and Technology (JKUAT) in Kenya (and the Federal University of Rio de Janeiro (UFRJ) in Brazil to a lesser extent)[1]. It is based on primary data collected from a survey of computer engineering graduates conducted between September 2006 and January 2007. The aim of the survey was to obtain specific information on three primary aspects of computer engineering skills' development in the production sector: the patterns of complementary explicit training within industry; the learning opportunities provided within employment; and the possible outcomes in terms of developing innovative technological capabilities.

The analysis focuses on opportunities for transforming basic computer engineering abilities produced in formal institutions into technologically creative competences[2], which are important for technological capability building. The discussion is structured as follows. The rest of this section discusses the rationale for the study and presents the framework of analysis. Section two presents a brief overview of the survey context. The sample and tools for data collection as well as the response rates are presented in section three. Section four discusses the emerging trends and discusses the relationships. Section five presents a summary of the results.

[1] Due to data limitations, the Brazilian case has been left out of the main discussions, but some information is provided in the appendix 1.

[2] Technologically creative competences: this terminology is taken from Bell (1988) and implies the competences that are used to build the technological capability. See figure 1.1.

1.2 Rationale

Notwithstanding considerable efforts to develop indigenous technological capabilities, developing countries continue to face major constraints.[3] The level of innovation tends to be low; demand pull on research, which is expected to stem from the production sector in order to lead to effective innovation, is clearly absent in developing countries such as Kenya, Mwamadzingo (1996). Inadequate technological learning has been identified as one of the major challenges, Wangwe (1992). Two of the main elements that influence technological learning are: basic technical abilities produced by formal institutions such as universities, and technologically creative competences that are the outcome of innovative efforts within the production sector. The latter aspect is the primary issue of discussion with regard to the continuing challenge of building a basis for the development of indigenous technological capability.

There is a general consensus that a complementary role exists between technologically creative competence development and domestic innovative activities; technologically creative competences are required to support domestic innovative activities, and conversely, domestic innovation plays an important role in providing a milieu for improving the technologically creative competences. The central focus is the learning process within industry which leads to the generation and strengthening of technologically creative competences for the development of technological capabilities.[4] Basic technical abilities produced in formal training institutions must be transformed into technologically creative competences through this learning process within the production sector, in order to contribute to domestic innovative capabilities.

University-trained computer scientists entering the job market have only basic skills and require further training and skill development within industry; general knowledge that is acquired through formal education and training systems has to be complemented with industry-specific knowledge (in-firm training, specialised training outside the firm and work experience) in order to become productive. However, learning within industry is calibrated on the basis of the formal education available in the economy, Lall (1992). Firms tend to adjust the technology they employ to the level of skill capacity produced by the formal system. Needless to say, if the formal system produces a low skill capacity, industry will use technology that requires minimal innovation and opportunities for up-grading creative technological learning capabilities will be limited. In addition, if job mobility is high as is the case of computer science skills, firms' commitment to explicit training may also be limited. However, apart from the output of educational institutions, the size and composition of basic technical abilities is also determined by the rate of labour absorption, magnitude of retention and the impact of migration.

---

[3] Technological capabilities are defined as "the resources needed to generate and manage technical change, including knowledge, skills, experience and institutional structures and linkages, Bell and Pavitt (1993).

[4] Learning is defined as "any process by which the resources for generating and managing technical change (technological capabilities) are increased or strengthened, Bell and Pavitt (1993)

The development of innovative technological capabilities in countries like Kenya (and probably everywhere) involves a two-stage process consisting of two sets of necessarily complementary activities: the acquisition of basic technical skills and knowledge via tertiary education and training; and subsequent learning within productive employment that adds critically important complementary skills and understanding. It is important to emphasize that the acquisition of basic technical abilities from tertiary institutions does not automatically result in improved technological capabilities of an economy. The development of technological capabilities also requires a complex learning process that is linked to innovative efforts within the production sector. Over and above learning by doing, the complex learning process involves learning by explicit intra-firm training and by managed experience accumulation that make significant contributions, Bell and Pavitt (1993); Lall and Teubal (1998).

Subsequent learning within productive employment (in-firm learning) that results in technologically creative competences involves two critical elements: (i) explicit training, and (ii) learning-by-doing. In turn, each of these two critical elements takes two forms:

- explicit training
    - (i) specialised training outside the firm - relatively specialised training that can in principle be provided outside the firm by, for example, universities (though often only with intensive involvement by firms, at least in developing the content but often also in providing the capabilities to implement the training)
    - (ii) specialised training within the firm - more specialised forms of training that can only be provided within the firm

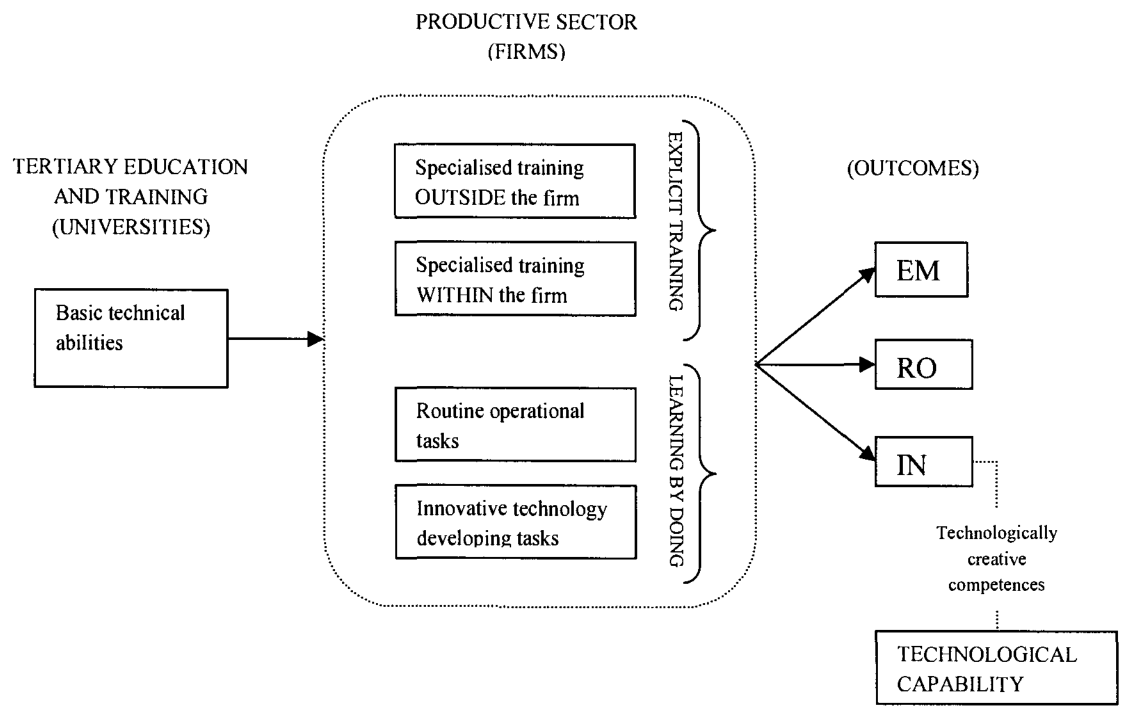
- learning-by-doing
    - (iii)learning-by-doing routine operational tasks - this typically adds little to the creative and innovative capability of individuals, Bell, (1984) and Lall and Teubal (1998)
    - (iv)learning-by-doing innovative technology-developing tasks - these are much more likely to add to innovative capabilities

The intensity and combination of these four aspects significantly influence the extent to which university education actually results in additions to domestic innovative capabilities. More specifically, one can envisage a university graduation cohort splitting into three groups:

EM – emigrants who join the international brain drain from developing countries
RO – graduates employed in the domestic economy, but on routine operational tasks
IN – graduates who come to constitute components of a domestic innovative capability

A summary of this framework is represented in the figure below[5]:

Figure 1. 1: Development of technologically creative competences



Source : author

The proportion of IN (graduates who eventually constitute components of a domestic innovative capability) in a cohort depends in particular on the intensity with which specialised training within the firm and innovative technology-developing tasks occur as complements to initial university education and training. Their basic technical abilities acquired in formal institutions are successfully transformed into technologically creative competences, which are used to build technological capabilities.

Insofar as the creation and development of the capability to absorb, improve and diffuse technology depends on a prior technical skills and knowledge, the importance of basic technical abilities for the creation, retention and development of technologically creative competences cannot be over-emphasised.[6] Basic technical abilities act as the foundation for the development of the indigenous technological capability in an economy, Cohen & Levinthal (1989). The suitability of basic technical abilities influence explicit training as well as learning by doing. In particular, specialised training outside the firm acts as an important conduit between basic technical abilities on the one hand, and specialised training within the

[5] I am grateful to Martin Bell for the discussions that lead to the development of this framework.

[6] Absorptive capacity, the ability to identify, assimilate and exploit external knowledge is largely a function of prior knowledge which at the most elementary level includes basic skills.

firm and learning by doing innovative-technology development tasks on the other: it contributes to overcoming the lacunae that emanate from formal institutions (particularly pervasive in developing countries) in the provision of basic technical abilities entering the productive sector, and it directly supports both specialised training within the firm and effective engagement in innovative technology developing tasks. In other words, the extent to which specialised training outside the firm is required to make up for the lacunae of basic technical abilities directly influences the intensity with which specialised training within the firm and learning by doing innovative-technology development tasks occur.[7] In turn, this influences the proportion of IN (graduates who constitute components of domestic innovative capability) and subsequently, the development of technological capability.

In developing countries, producing adequate basic technical abilities to boost innovation-led growth remains a major challenge. Universities are still grappling with the primary mission of training, and while research – a secondary mission - is gaining ground, it is still fairly weak. Joint university-industry research that leads to commercialisation – one of the extension university activities that constitute a third mission - has attracted a large amount of empirical and theoretical research. Studies on university interactions with industry are mainly carried out in an analysis of multiple sources of technology in developed countries, Laursen and Salter (2004); D'Este and Patel (2005). Other channels of university-industry knowledge exchange within this third university mission have been identified and include personnel mobility, consulting, spin-off companies, joint-research projects, informal contracts etc Arundel and Geuna (2004); D'Este and Patel (2005). However, the third university mission is mainly relevant to industrialised countries that have succeeded in not only achieving a substantial level of training and research, **but most importantly in creating an intricate connection between production of basic technical abilities and their development and up-grading within the production sector into technologically creative competences, which in turn creates the capacity for a demand pull on university research.**

Existing literature that focuses on complementarities between factors that lead to innovation-driven growth also tends to target various forms of complementarities that are particularly relevant to developed countries. These include internal R&D and external technology sourcing, Arora and Gambardella (1994) and government innovation policies concerned with R&D, patenting etc, Mohnen and Roller (2005). The complementarity between innovation and competences in developing countries requires an investigation that aims at unravelling the scope of developing, retaining and attracting technologically creative competences within the production sector.

From a developing country perspective it appears interesting to focus on basic technical abilities produced in universities and the scope of continuing technological learning within industry. Specifically, how the intensity and combination of explicit training and

[7] The intensity with which specialised training within the firm and learning by doing innovative technology-developing tasks is also influenced by other aspects such as infrastructure, policy etc.

learning by doing occur as complements to basic technical abilities. The transformation of basic technical abilities into technologically creative competences significantly influences the extent to which university education results in additions to domestic innovative capabilities. The main reasons for this are threefold: firstly, although innovative activities in developing countries revolve essentially around incremental technology, successful engagement in minor modifications does requires specialised skills and universities are mandated to produce basic technical skills for technological development; secondly, shortage of technologically creative competences is increasingly hampering innovation in developing countries, and in particular, progression from one technological stage to the next; thirdly, there is concern that research carried out in centralised institutions such as universities does not address the needs of the production sector and remains largely unutilised, which points to a potential problem of supply push of technological innovations from universities that is not matched by a demand pull on research by the production sector. In other words, universities have a central role in the production and further development of technological competences: they produce the required "raw" technical abilities; they may play a part in providing specialised training outside the firm through tailor-made courses and post-graduate research addressing specific problems of important industries; demand for research by the production sector via the various channels mentioned above, tends to depend on tight human skill relationships based on innovative capability that are developed between the two entities (university and industry).

A clear understanding of the process required to link creation of basic technical abilities produced in universities and continuous explicit training and engagement in technology-developing tasks targeting the creation of specific technologically creative expertise within the production sector is the issue here. The underlying idea is that over and above the competences that are required for *operating* production systems, there is a need to create distinct competences (technologically creative competences) that are capable of *changing* production systems. The learning process required to create these distinct change producing competences within a domestic innovation process, targets the expansion of technologically creative opportunities that determine the generation of indigenous technological capabilities.

A recent theoretical analysis on innovation-led growth revealed that in the absence of domestic innovation that provides a *mileu* for learning, efforts to improve basic technical abilities by raising the throughput does not automatically result in additions to the base for technological capabilities, Wamae (2006). Insufficient domestic innovation may act as a catalyst for emigration of the population with basic technical abilities. In other words, domestic innovation is necessary for providing technologically creative opportunities that involve *improving and modifying* production systems. The creation of indigenous technological capabilities that are required for innovation-led growth may otherwise be compromised.

Although, the feedback mechanism existing between basic technical abilities and domestic innovation is not well understood, creation of basic technical abilities in formal institutions needs to be matched with a corresponding innovation environment that develops technologically creative capabilities. It appears that focusing on the increment of basic technical abilities within formal institutions while paying little attention to the development of technologically creative competences through learning in the productive sector is not desirable; resources are expended in producing basic technical skills that will not get the opportunity to be transformed into technologically creative competences. While the importance of producing basic technical abilities in formal institutions that are attuned to basic industry entry requirements cannot be undermined, technologically creative competences acquired through learning in the productive sector are important for the expansion of technological capabilities, King (1984).

Efforts to steer developing economies to sectors of higher growth potential, despite the difficulties surrounding structural change, provide a sustainable solution for developing technologically creative competences. Innovation in sectors of high growth potential enhances, *a fortiori,* up-grading of basic technical abilities into technologically creative competences, and perhaps even more importantly, the retention of these competences that are essential for coping with the current environment of rapid technological transformations.[8] It is unlikely that shifting to sectors of high growth potential and moving up the technological ladder can be achieved without developing and sustaining technological capabilities, Figuieredo (1995). Undoubtedly, such efforts require government intervention to successfully implement a conscious policy in favour of technologically progressive sectors depending on the specificities of an economy.

The rest of the paper will examine a limited number of issues that emerge from this background. On the one hand, it will examine the scope of explicit training of computer science graduates within the productive sector. In particular, it will focus on specialised training outside the firm and its relationship to basic technical abilities from universities. On the other hand, it will examine the tasks carried out by graduates within employment with the aim of gaining insight into the extent of learning by doing innovative technology-developing tasks. The analysis will provide some information on the expected outcome with regard to technologically creative competences. More specifically, it will reveal whether university education is adequately complemented by learning within the productive sector and whether additions to domestic innovative capabilities can be expected.

The paper will argue that it is important to focus on how institutions of higher learning and industry relate to each other with respect to developing technologically creative competences.

[8] Retention of technologically creative competences is broadly defined to imply the capacity to obtain net benefits from them rather than imposing emigration restrictions. The underlying idea is that international mobility of these competences provides a source for continued technological learning that could afford benefits to the country of origin. However, it could also result in net loses if adequate long-term measures are not put in place to attract the improved competences back into the economy. This would essentially take the form of forging international linkages for technological capability building.

In particular, it will use data to determine the extent to which the two entities are engaged in strengthening the creation, development and retention of technologically creative competences in the production sector. The study will discuss how the split of the university graduate cohort into IN (graduates who constitute components of domestic innovative capabilities), RO (graduates in routine operational tasks) and EM (brain-drain emigrants) is likely to occur. The dynamism of the innovation process of an economy depends on its capacity to provide opportunities for developing and using technologically creative competences. Suitable technology learning opportunities reduce the proportion of RO in favour of IN and curb EM. The overall objective is to highlight the importance of providing a base that would lead to the creation of indigenous technological capabilities.

2 A brief overview of the survey context

This overview focuses on computer-related basic technical abilities in Kenya. The government's view with regard to computer-related competences in general, indicates that they represent a potential lever for strategically enhancing the capacity to deal with information, knowledge and innovation. Kenya's National ICT Policy (2006) and ICT Strategy for Economic Growth (2006), which are guided by the country's socio-economic development framework documents, reflect relatively well the country's approach to creating basic technical abilities: they place emphasis on the importance of developing computer-related competences in pursuing the goal of integrating into the knowledge economy. The documents emphasize the need to target the increase of both the demand for ICT products and services as well as the supply of locally produced innovative solutions through education and training. The two aspects are key to the development of indigenous technological capabilities, which require technologically creative competences to provide innovative solutions aimed at specific and existing demands. Some of the channels for enhancing the creation of technologically creative competences that are mentioned include: encouraging the most talented students to pursue higher education courses that contribute to building a research capability; promoting and supporting innovative capacity in industry, research institutions and universities for the development of products, processes and services.

The need to recruit, develop and retain technologically creative competences through, for example, encouraging the production sector to provide opportunities for technical skills' development is also highlighted. It is expected that this would, in addition to directly developing the technological capabilities of the economy, stem brain-drain and create a better interface to tap on Kenyan technological creative competences that are abroad. It is worth noting, however, that the need for education and training outlined in the documents places emphasis on the production of the "raw" technical abilities in formal institutions and include suggestions such as restructuring of curricula and expanding tertiary education. It appears, however, that no explicit approach is presented to tackle the issue of ensuring the provision of opportunities for technological learning within the production sector. In other words, the concept of innovation as a learning process does not seem to have a strong-hold on the government discussion on technology development.

In terms of creating specific basic technical abilities, various institutions of higher learning, including public universities, fall under the mandate of government technology development objectives. However, links between technology development and industry are consistently reported to be weak, Policy Framework for Education Training and Research, 2004. Jomo Kenyatta University of Agriculture and Technology (JKUAT) was established in 1994 through technical co-operation from the Japanese government with the aim of providing technicians in science and engineering for industry: its mission underscores the need to produce basic technical abilities for the development of innovative technologies. The university offers technology oriented training in its three faculties (agriculture, engineering, and science), one school and four institutes that include the Institute of Computer Science and Information Technology, which offers computer-related degrees. It also runs privately-sponsored programmes in three centres which include the Information Technology Centre that offers certificate and diploma courses in information technology and management as well as a Bachelor degree programme in information technology. While this research acknowledges the importance all ICT and associated competences, it focuses on computer science skills. The latter present a greater potential for the development of technologically creative competences in the production sector: the computer science programme structure includes courses that are intended to develop high-level abstract capabilities over and above the provision of basic skills in such areas as web design, system design and programming, which are generally offered in other basic computer-related courses.

3 Survey methodology

The survey was based on (i) a detailed survey questionnaire, (ii) in-depth interviews, and (iii) a limited number of key-informant interviews. A response rate of 92,7% was obtained. This section is divided into two parts: sub-section 3.1 which presents the sample and tools for data collection and sub-section 3.2 that looks at the structure of the questionnaire and the response rate.

3.1 Sample and tools for data collection

The survey sample is based on BSc. Computer engineering graduates from the Institute of Computer Science and Information Technology at JKUAT. Although it would have been ideal to include other traditional engineering disciplines such as mechanical and electrical engineering offered at the department of Engineering at JKUAT, this would have required a longer time frame for the survey. The choice of the computer engineering skills is based on three aspects: they fall within the category of basic technical abilities with a high potential for transformation into technologically creative competences; they are required for a general purpose set of technologies applicable to almost all economic sectors, and may be used to support different strategic areas of an economy (agriculture, manufacturing, infrastructure, public administration, finance, trade, distribution, marketing, education and health); they are very susceptible to the increased general demand worldwide, which has serious implications on efforts to develop a base for technological capabilities in developing countries.

The Institute of Computer Science and Information Technology at JKUAT offers degree programmes in computer science and computer technology. It issued Bachelor of Science in computer science degrees for the first time in 2003. It appeared more useful to base the survey on a sample of 2004 and 2005 graduates for two reasons: First, the 2003 graduates were somewhat of an exploratory attempt in the implementation process of the programme. Before the introduction of the degree, the students had been registered in the department of engineering and were attending the traditional engineering programmes. The BSc. degree in computer science is a four year programme and the 2004 graduates were the first group to attend it for the full four year. Second, with regard to 2006 graduates, it would have been difficult to obtain substantive information concerning their continued training in the production sector as most of them had only freshly been recruited.

Although the computer technology graduates are of potential interest for the analysis, the first group of the undergraduate students are currently in their third year of the four year degree programme. However, it is worth mentioning that admission of students into the computer technology programme is not as competitive as in the case of the computer science programme. All students at the undergraduate level are selected through the Joint Admission Board (that is responsible for coordinating admissions to public universities by merit). The admission criteria for the computer science programme are considerably higher than in the case of the computer technology programme. The computer science programme admits less that 25 of the very top students in the high school national examination (which generally has over 250,000 candidates of which about 65,000 qualify for university admission, but only about 15% are admitted to the seven public universities[9]) into the full-time government sponsored programme: they represent a high potential for the creation of technologically creative competences.

The survey tools for primary data collection of the 2004 and 2005 graduate sample were based on key-informant interviews, in-depth interviews of the graduates, and a questionnaire. The key-informants included practitioners in both the academia and industry concerned with computer engineering skills. The head of the Institute of Computer Science and Information Technology was interviewed and the main objective was to obtain information on the recruitment process of students into the institute, the nature of training offered to the computer

---

[9] Ministry of education: Government of Kenya - www.education.go.ke/

science students, the extent to which it responds to the demand for the computer engineering competences in the local industry, and the nature of local and international relationships with the institute. A local entrepreneur who offers services for technological infrastructure in the region and consistently recruits computer science graduates from JKUAT was also interviewed. The main questions centred on the key issues in terms of the basic technical abilities required for the company, views on the competences offered by JKUAT, opportunities for in-firm training, other sources sought for the computer engineering skills, other players who source for similar skills, explicit training collaboration with other players locally and internationally, sources for emerging technologies and issues on adaptation and improvement of technologies for the local market. The main aim of key-informant interviews was to inform the questionnaire design as well as to obtain views on the development of technologically creative competences in formal institutions and in the production sector.

Semi-structured in-depth interviews with the computer engineering graduates were carried out. The aim was to obtain general information that may have been useful to complement the questionnaire, and particularly to assist in data interpretation. The main questions centred around the evolution of the respondents views on opportunities for computer engineering skills, whether their employment expectations were matched by the production sector, the perceived obstacles for effective enhancement of their basic technical abilities, and suggestions of practical solutions that could be used to address the problems. The questionnaire - the main data collection tool – was pilot tested on 8 candidates outside the sample group, but who held at least one university degree. The structure of the questionnaire is provided below. The response rates are also presented.

3.2 Structure of the questionnaire and response rates

The questionnaire contained five sections:

- 1.0 General graduate information
- 2.0 Basic information on work environment and opportunities
- 3.0 Human resource development and mobility
- 4.0 Infrastructure and business environment
- 5.0 Networks with others in the field abroad

The first section sought data on current occupations and sector of employment, while the second section was intended to reveal general perceptions of work opportunities. Section three provided information on the nature of specific tasks undertaken, mobility, a record of additional technical training obtained during the period of employment and incentives to pursue such training. Information on infrastructure and business environment in section four was intended to provide views on the evolution of demand for technical skills. Section five provided information on how opportunities abroad were perceived in relation to existing opportunities in the domestic economy.

The total number of 2004 and 2005 graduates in Bachelor of Science in computer science was 41. The survey was able to obtain data on 92.7% of the graduates. A tight network amongst the graduates, which is probably partly as a result of the small size of classes and the emphasis on group project in the programme, highly contributed to the achievement of this result. The network also highly facilitated the oral interviews.

4 Main results

The main results of the survey are presented in this section in two parts. First, basic information about several individual characteristics of the JKUAT graduates is presented in section 4.1. Then in section 4.2 a broader discussion examines how these characteristics appear to be linked, suggesting that the learning environment into which graduates move after leaving the university does not act as a strongly positive complement to their university education, and probably reinforces other factors that raise the probability of emigration by these highly skilled human resources.

4.1 Emerging patterns from the survey

This section examines (i) a selected number of aspects of the learning environment that absorbs JKUAT graduates, (ii) the graduates' own views about the environment, (iii) details about selected issues raised in those views and (iv) the graduates' view about emigration as a possible response to the situation they face.

Section 4.1.1 outlines the distribution of graduates between types of industry in which they are employed in Kenya. This compares the distribution of graduates between industries with what might be considered the 'importance' of those industries in the Kenyan economy, and it also offers preliminary insight into the extent to which dynamic learning opportunities may be available to the graduates:

- features of industry employment reveal that sectors, which may be considered as 'important' to the Kenyan economy do not account for a significant number of the graduates

Section 4.1.2 examines the nature of those learning opportunities by focusing in more detail on the particular kinds of employment tasks that the graduates undertake in the various industries. It suggests that:

- only a very small proportion of the graduates are employed in tasks involving technology modification and improvement activities from which innovation-related learning might be derived. The overwhelming majority is employed in tasks involving relatively routine technology operation activities that seem likely to provide relatively limited learning opportunities

Section 4.1.3 more broadly reviews the graduates' perceptions about obstacles in their post-university environment to further complementary development of their competences. Their open-ended responses identify four main kinds of obstacles:

- (i) the limited training opportunities in local institutions; (ii) the limited availability of jobs that adequately offer innovation-related learning opportunities; (iii) infrastructure related problems for ICTs; (iv) the inadequate regulatory and policy framework

The first of these issues is then examined in more detail in section 4.1.4. It focuses on the nature and scope of explicit employment training undertaken by the respondents. The respondents' perceptions about start-up opportunities and the factors that affect them are reported in section 4.1.5. The results suggest that:

- the prospects for translating their university-derived basic technical abilities into technologically creative competences is limited
- although start-ups are viewed by respondents as an alternative way of developing technologically creative competences, this alley appears to be restricted by a non-conducive ICT start-up environment

Finally, section 4.1.6 examines the JKUAT graduates' views about emigration, particularly as a response to the constraints that their Kenyan employment environment imposes on their further capability development. This indicates that:

- the reported interest in emigration is very high and seems to stem from the desire to pursue explicit training for the development of technologically creative competences.

4.1.1 Classification by industry structure

The distribution of JKUAT graduates between industries is examined here with respect to three different industry classifications: (i) the standard industrial classification (ISIC); (ii) a re-classification of ISIC categories into a set of ICT-defined industry groups; and (iii) another re-classification that focuses more on the skill intensity of industries.[10]

(i) Employment by industry: the standard industrial classification (ISIC)

The distribution of JKUAT graduates by ISIC industry categories in shown in table 4.1. This provides a general background about their areas of employment, but also permits comment about the industry distribution of their employment relative to the 'importance' of different industries in the economy.

[10] Both (ii) and (iii) are based on the ISIC reclassification along specific dimensions developed to provide a descriptive analysis of relative industry performance, O'Mahony and van Ark (2003).

Table 4.1 shows that the JKUAT BSc. Computer Science graduates of 2004 and 2005 are distributed across 10 industries that fall within 8 ISIC sections. The 'computer related activities' industry under section K, which accounts for the largest proportion of graduates include the following activities: hardware consultancy; software publishing, consultancy and supply; data processing; database activities and online distribution of electronic content; maintenance and repair of office, accounting and computing machinery; and other computer-related activities.

Table 4. 1: ISIC Industry Classification of JKUAT BSc. Computer Science Graduates

ISIC sections	Industy (ISIC rev. 3)	no. of graduates	proportion of graduates (%)	contribution to GDP (%)
A	Agriculture, hunting and forestry	**1**	**2,6**	**24,2**
	(01) Agriculture and related activities	1		23,1
I	Transport, storage and communications	**2**	**5,3**	**10,9**
	(62) Air transport	1		n.a
	(642) Telecommunications	1		n.a
G	Wholesale and retail trade	**2**	**5,3**	**10,8**
	(52) Retail trade	2		n.a
D	Manufacturing	**1**	**2,6**	**10,5**
	(15) Food products and beverages	1		3,0
M	Education	**9**	**23,7**	**7,4**
	(80) Education	9		7,4
K	Real estate, renting and business activities	**17**	**44,7**	**5,6**
	(72) Computer and related activities	14		n.a
	(74) Other business activities	3		n.a
L	Public administration and defence	**3**	**7,9**	**4,5**
	(75) Public administration	3		n.a
J	Financial intermediation	**3**	**7,9**	**3,1**
	(65) Financial intermediation	3		3,1

source:Government of Kenya - contribution to GDP

An inverse relationship may be observed between the proportion of graduates in the industries and the industry contribution to GDP for the first six sections (A, I, G, D, M and K). Fairly low percentages of the graduates are employed in industries within the first four sections despite the large industry contributions to GDP. In particular, agriculture, which is an important industry of the economy accounts for only about 2,6% of the graduates. Although industry contribution to GDP may not be an adequate proxy for industry dynamism, a question may be raised concerning agriculture, which dominates the contribution to GDP (24,2%). Computer science graduates may contribute to enhancing its dynamism through technologically creative learning opportunities. Other industries that may raise similar questions include those under section I, G and D. The highest concentration of graduates is within sections M and K, although the GDP contributions are relatively low. Computer and related activities alone account for about 36,8% of the graduates followed by education (23,7%). The last two industries (under section L and J) present a different relationship: the proportion of graduates is about twice the GDP contribution of the industries. In the case of public administration, this may be related to its traditional role of hiring university graduates while the situation of financial intermediation may be related to its relatively high potential for growth.

(ii) Employment by industry: ICT-defined industry groups

This taxonomy distinguishes groups of industries depending on whether they (a) produce ICT goods and services, (b) intensively use ICT, and (c) are non-ICT intensive industries in manufacturing, services and other areas.

Table 4. 2: Industry Classification by ICT Taxonomy

industry structure	no. of graduates	%
ICT Producing - manufacturing	**0**	**0,0**
ICT Producing - services	**15**	**40,5**
telecommunications	1	
computer and related activities	14	
ICT Using - services	**8**	**21,6**
retail trade	2	
financial intermediation	3	
other business activities	3	
Non-ICT Manufacturing	**1**	**2,7**
food and beverages	1	
Non-ICT Services	**13**	**32,4**
air transport	1	
public administration	3	
education	9	
Non-ICT Other	**1**	**2,7**
agriculture	1	

taxonomy source: O'Mahony and van Ark (2003)

The industry classification by ICT taxonomy presented in Table 4.2 provides a different picture in terms of the distribution of JKUAT computer science graduates in the various industries. It may not be surprising that the "ICT Producing-services" and the "ICT Using-services" categories employ a fairly high percentage of the graduates; however, "Non ICT services" also attract a substantial percentage. A question arises whether these categories provide suitable opportunities for technologically creative learning.

(iii) Employment by industry: the skill intensity of industries

This taxonomy distinguishes four groups of industries based on the dominant level of skill intensity required in the industries: (a) high skilled, (b) high-intermediate skilled, (c) low-intermediate skilled, and (d) low skilled.

Given that the technical skills of computer science graduates are high skills by nature, the results in Table 4.3 are not unexpected; industries that require high skills account for an overwhelming proportion of the JKUAT graduates. However, this should not obscure the fact that other industries specialising in the use of different categories of skills could greatly benefit from these potentially technologically creative skills.

Table 4. 3: Classification by Skill Taxonomy

industry structure and taxonomies	no. of graduates	%
High skilled	**32**	**83,8**
financial intermediation	3	
computer and related activities	14	
other business activities	3	
public administration	3	
education	9	
High-intermediate skilled	**2**	**5,4**
air transport	1	
telecommunications	1	
Low-intermediate skilled	**2**	**5,4**
retail trade	2	
Low skilled	**2**	**5,4**
agriculture	1	
food and beverages	1	

taxonomy source: O'Mahony and van Ark (2003)

The industry classification of university trained computer scientists by these taxonomies provides some information on the distribution of the technical skills across industries. However, the taxonomies were developed to provide insight on the industry performance in industrialised countries; the situation may be different in developing countries. More specifically, industries requiring high skills in industrialised countries may require relatively low skills in developing countries if the skill inputs required are labour intensive rather than skill intensive. On the whole, the industry classifications tell us little about how the acquired basic technical abilities are used and up-graded in the production sector, and more importantly, the scope of providing technologically creative opportunities.

The next sub-section will closely examine the nature of employment tasks carried out by the JKUAT Computer Science graduates in their current occupations. Information concerning aspects of the nature of employment tasks was obtained using both the survey questionnaire as well as the in-depth interviews of the graduates. The questions were structured to capture information on the nature of training and skill development within industry, and the job mobility both within and across companies/institutions. The aim was to gain some information on the scope of developing technologically creative competences.

4.1.2 Graduates' employment tasks

The respondents were asked to describe the basic characteristics of the tasks they carried out in their employment positions. The information was drawn from the questionnaires and organised into four categories as shown in Table 4.4. They include: (a) "ICT development related activities" that relate to development and design activities, and from which innovation-related learning may be derived; (b) "ICT network/system support activities" relating to administration, management, support etc, which are likely to provide relatively limited learning opportunities; (c) "ICT training activities" that relate to teaching; and (d) "ICT un-related activities" that refer to areas such as medicine in which the core skills do not directly relate to ICTs. The information was checked against the firm/institution profiles to confirm the existence of the reported activities. It is worth noting that although the classification is based on the **main** tasks reported, the respondents are also involved in various ICT related tasks. Therefore, the interpretation of the results that emerge from the analysis requires a measure of caution. For example, given that the respondents in the category of "ICT development related activities" are also involved in "ICT support activities" such as implementation, maintenance and support, it would be particularly difficult to predict with precision whether they would eventually constitute components of a domestic innovative capability although the likelihood is high.

A summary of the main tasks carried out in the occupations of the respondents is presented in Table 4.4. In general, the tasks carried out in employment indicate that a very small proportion of the graduates is involved in technology modification and improvement activities while the overwhelming majority in technology operation activities. Almost three quarters of the graduates work in "ICT network/support activities" while less than one fifth are engaged in "ICT development related activities", which provide the best opportunities technologically creative learning. This suggests that there is an under-development of technologically creative competences, which may adversely affect the development of indigenous technological capability.

Table 4. 4: Classification of graduates by main tasks in employment positions

Task Categories	%
ICT development-related activities	18,4
system design/development	
network design/development	
security design	
software development	
website development	
ICT network/system support activities	73,7
system administration	
network management	
information systems audit	
e-banking support	
e-commerce support	
database administration	
ICT training activities	2,6
ICT unrelated activities	5,3

source: author

Table 4.5 crosstabulates the industry distributions of the respondents with the nature of tasks undertaken. One interesting observation is that all respondents engaged in "ICT development-related activities" fall into a single industry, computer and related activities. All other industries including agriculture offer employment only in "ICT network/system support activities", although "ICT development related activities" could in principle play an important role in improving the dynamism of these industries. The table also reveals that education does not offer any opportunities in "ICT development related activities"

Table 4.5 does not show the distribution across groups of graduates by task types. However, it is interesting to note that the data indicates that out of all the graduates working in computer and related activities, 50% are engaged in "ICT development-related activities" while the other 50% in "ICT network/system support activities".[11]

On the whole, the results in Table 4.5 confirm the observation made in Table 4.4: graduates with basic technical abilities leaving universities do not for the most part enter an employment path that is likely to offer learning opportunities that will translate their basic technical abilities into technologically creative competences.

[11] See appendix results A2.3

Table 4. 5: Classification by industry and group of main tasks in employment

ISIC sections	*Industry*	*Groups of graduates by task types* — *ICT development related activities*	*ICT network/system support activities*	*Other activities*	***Total by industry***
		%	%	%	%
A	Agriculture				2,6
	agriculture and related activities		3,6		
I	Transport, storage & communications				5,3
	air transport		3,6		
	telecommunications		3,6		
G	Wholesale & retail trade				5,3
	retail trade		7,1		
D	Manufacturing				2,6
	food products and beverages		3,6		
M	Education			100,0	23,7
	eduacation		21,4		
K	Real estate & business activities				44,7
	computer and related activities	100,0	25,0		
	other business activities		10,7		
L	Public administration & defence				7,9
	public administration		10,7		
J	Financial intermediation				7,9
	financial intermediation		10,7		
	Total percentage with group	100,0	100,0	100,0	100,0
	Percentage of total	18,4	73,7	7,9	100,0

source: author

Table 4.6 crosstabulates the type of employers within the various industries in relation to the nature of employment offered (development related or support activities). This provides an indication of where technological creativity is located. The distribution of graduates in Table 4.6 indicates that the public sector employs about one third of the graduates and engages them all in "ICT network/system support activities"; none are engaged in the "ICT development-related activities". Two of the private sector employers (joint-venture and foreign owned – other) are also in a similar situation. Locally-owned private firms account for almost all of the employment in "ICT development-related activities" (15,8%). The private (foreign owned – African) is the only other type of employer offering some "ICT development-related activities".

Table 4. 6: Classification of graduates by type of employer and type of employment (%)

Type of employer	*Groups of graduates by task types* ICT development related activities	ICT network/system support activities	ICT tutoring activities	ICT unrelated
private (locally owned)	15,8	7,9	2,6	
private (joint-venture)		7,9		
private (foreign owned - african)	2,6	5,3		
private (foreign owned - other)		21,1		
public		31,6		
other				5,3
Total	18,4	73,7	2,6	5,3

source: author

The information in Table 4.7 is a summary of the job satisfaction levels of the respondents in relation to the main tasks carried out in their occupations. The job satisfaction level is based of the perceptions of the respondents with regard to the suitability of work opportunities and dynamism of work environment.

Table 4. 7: Classification of graduates by perception of their work environment

	Groups of graduates by task types ICT development related activities	ICT network/system support activities	Other	**Total**
Suitability of work opportunities				
very poor				0,0
poor	14,3	7,1	66,7	13,2
good	57,1	78,6	33,3	71,1
very good	28,6	14,3		15,8
exellent				0,0
Dynamism of work environment				
very poor				0,0
poor		17,9	66,7	18,4
good	28,6	17,9	33,3	21,1
very good	42,9	50,0		44,7
exellent	28,6	14,3		15,8
Total by group	18,4	73,7	7,9	100

source: author

On average, the suitability of work opportunities was reported as "good", while the dynamism of the work environment as "very good". Nevertheless, there are two difficulties that arise with regard to Table 4.7: (a) the questions on the suitability of work opportunities and the dynamism of work environment were based on a likert scale. In such a scale respondents generally tend to choose the mid-point response as is clearly visible with regard to suitability of work opportunities; (b) the respondents are employed mainly in the top end of well performing firms/institutions within the economy, which may explain the fairly good response to the two aspects investigated. However, this does not imply that the opportunities offered by the employers to this particular set of basic technical abilities are very well suited for technologically creative learning.

Great caution is required in interpreting the information presented in the Table 4.7. However, it is illuminating to compare the responses of the categories (on the basis of the nature of tasks). Twice the number of respondents engaged in the "ICT development-related activities" indicated that the suitability of work opportunities was "very good" compared to respondents in "ICT support activities". However, twice as many respondents in the first group compared to the second group thought the suitability of work opportunities was "poor".

With regard to the dynamism of the work environment, twice as many respondents in "ICT development-related activities compared to those in "ICT support activities" reported that it was excellent. In addition, none in the first groups thought that the dynamism of the work environment was poor compared to 17,9% in the second group. These responses may be related to the availability of technology learning opportunities for the first group compared to the second.

More information on technological learning opportunities will be explored in the next sub-section, which presents information obtained from open-ended questions on obstacles facing respondents in enhancing their basic technical abilities.

4.1.3 Perceived obstacles for career development

The respondents were required to spontaneously raise any issues perceived as obstacles for their career development in the country. The responses have been grouped into four broad categories as follows: (i) training opportunities in local institutions; (ii) suitability of job opportunities for technical competence development; (iii) infrastructure related problems for ICT product and services demand and; (iv) regulatory/policy framework. Each of these categories are discussed briefly in this sub-section.

(i) Training opportunities in local institutions

This category includes all aspects that relate to the opportunities for professional studies. The respondents recognised the need to pursue complementary professional studies, but were faced with constraints in terms of costs to access professional training and the availability of good infrastructure for high level training. For example, these problems were expressed as *"prohibitive costs for further training"* and *"limited high-level training options, which are only available in developed countries"*.

Other comments raised with regard to training opportunities are of a broader nature and their interpretation could pose some ambiguity. Some of the examples are:

- *"university courses do little to equip us with industry relevant knowledge"*,

- *"training offered at universities is inadequate to meet industry requirement"* or
- *"training in universities and colleges should follow market trends as opposed to current general approach because IT is very dynamic"*

Training offered by university is usually general in nature the main aim being to provide a solid and broad base that would facilitate the accumulation of subsequent complementary job specific skills. In other words, the respondents, on entry into the job market, may have been faced for the first time with the reality that universities provide basic formal knowledge, but failed to realise that industry has a role in providing the complementary training. The basic formal knowledge serves as only "raw" knowledge to the industry and must be complemented to become productive. Nonetheless, this observation does not exclude the fact that universities could have a role in professional training opportunities, particularly as an instrument of flexibility that facilitates technologically creative learning. This idea will be explored further under the discussion section.

(ii) Suitability of job opportunities for technical competence development

Although the views expressed with regard to suitability of the job opportunities offered appeared to be favourable, further probing indicates a general dissatisfaction in the utilisation and enhancement of skills within the occupations of the respondents. This dissatisfaction is reflected in comments such as: *"limited opportunities by employer to develop talent"*, *"lack of appreciation of may talents"* and *"absence of dream jobs"*. The underpinning idea is that the respondents' creative potential remained under-developed and attempts to develop and use it were not met with appreciation. In-depth interviews indicated that the desire to develop technologically creative skills beyond the level required to carryout the allocated tasks was to some extent suppressed by the employer.

(iii) Infrastructure related problems for ICT product and service demand

These issues relate to the dynamism of local demand for ICT products and services. They refer to aspect of ICT infrastructure, ICT literacy and the rate of technology adoption. Examples of these aspects are captured in comments such as: *"high level of ICT illiteracy that results in an inadequate demand for ICTs"*, *"poor infrastructure, for example internet access"*, *"poor ICT business networks"* and *"slow pace of ICT advancement in the country"*. Adequate ICT infrastructure is important in the development of technological capabilities.

(iv) Regulatory and policy framework

The comments raised with regard to the regulatory and policy framework cover aspects of products and services as well as ICT training. With regard to products and services, this is encapsulated in one of the observations. It stated that there was *"lack of protective laws and standards"*, referring to inadequate measures to asses quality of products and an effective infrastructure to deal with issues of intellectual property rights such as piracy. The inadequacy of the regulatory framework in terms of dealing with ICT training was expressed as: *"institutional inefficiency in managing training and the business environment"*, *"poor regulatory framework – the sector is flooded with ICT quacks"*. The role of an effective regulatory framework in creating a trust environment conducive for business dynamism cannot be undermined.

These four categories of perceived obstacles are presented in Table 4.8 below that summarises the comments of the respondents. The table also indicates the ratings of the categories ($1 \rightarrow 4$), where 1 represents the group of obstacles to the development of technologically creative competences that were most frequently cited by the respondents and 4 the least cited. The table indicates that training in local institutions is the most frequently cited obstacle for continued learning, followed by suitability of job opportunities for career development, ICT infrastructure related problems and finally, regulatory and policy framework related problems. However, it is important to note that all categories of obstacles presented are of great concern, and are to some extent inter-related.

Table 4. 8: ICT demand and supply obstacles

	Demand	***Supply***
ICT Technical Skills	Training opportunities in local institutions Limited opportunities to utilise and enhance skills in occupations within industry (1)	Suitability of job opportunities for technical competence development Limited options (affordability & adequacy) for high level training in local training institutions (2)
ICT Products and Services	Infrastructure related problems for ICT product and service demand Limited ICT demand – slow pace of technology adoption (3)	Regulatory/policy framework Inadequate regulatory (IPR) and policy framework for ICT (4)

Source: author

Table 4.9 below shows that the two groups differ in the intensity with which they cite obstacles in their post-university environment to further complementary development of their basic technical abilities. Respondents working in "ICT development-related activities" cited the suitability of job opportunities, infrastructure related problems for ICT product and service and problems related to regulatory and policy framework with greater intensity than the respondents engaged in "ICT network/support activities". The scale range for "ICT development-related activities" group was 1-2 while that of the "ICT network/support activities" group ranged from 2-4. This suggests that the "ICT development-related activities" group are more disillusioned than the "ICT network/support activities" group with regard to the opportunities that are available for technological learning in the Kenyan environment.

Table 4. 9: Classification by main obstacles of competence development

	Skills		*Services and products*	
	demand infrastructure	*supply infrastructure*	*demand infrastructure*	*supply infrastructure*
Development-related activities	1	1	2	2
Network/system support activities	1	2	4	3
Rating by both groups	1	2	3	4

Source: author

It appears reasonable to assume that an effective solution would have to take the relationships amongst all the categories into account; such an analysis lies beyond the scope of this presentation. However, a closer look at the graduates' situation of acquiring complementary post-university skills and knowledge, the main focus of this research, will be carried out in the next sub-section.

4.1.4 Graduates' patterns of training

Given the short duration of employment since graduation (one to two years), it is expected that learning within industry so far is limited to "new entrants'" skills and knowledge complementation. However, an examination of the learning that occurs after graduation is useful in indicating whether there is a general pattern of developing technologically creative competences of a longer-term nature owing to the specific characteristics of the surveyed sample. The respondents were asked to indicate: whether the employer had offered any kind of training since employment; the nature of training offered; whether the training offered was in-house, in another firm locally, in another firm abroad or in a learning institutions; whether respondents had attended self-sponsored courses since graduation; and the nature of courses attended.

The desire to continuously develop skills within industry appears quite strong. Virtually all the respondents have undergone or are in the process of pursuing employer-sponsored course, self-sponsored coursed or both. 81,6% of the respondents indicated that they have or are in the process of pursuing self-sponsored courses. The enhancement of technical skills with a view to developing talent (technologically creative competences) was given as the main objective.

The situation of skill acquisition is depicted in Table 4.10 below, which indicates that three fifths of the respondents have benefited from employer-sponsored course.

Table 4. 10: Broad patterns of training

	Group of graduates by task types			
	ICT development related activities	*ICT network/system support activities*	*Other activities*	***Total***
employer-sponsored	%	%	%	%
yes	71,4	60,7		61,1
no	28,6	39,3	100,0	38,9
self-sponsored (completed)				
yes	57,1	57,1		55,6
no	42,9	42,9	100,0	44,4
self-sponsored (on-going)				
yes	71,4	50,0		57,9
no	28,6	50,0	100,0	42,1

source: author

Table 4.10 shows that within the group of "ICT development-related activities" 71,4% of the respondents have pursued employer-sponsored training outside the firm compared to 60,7% within the "ICT network/system support activities". A total of 61,1% have gained access to employer sponsored courses.

In terms of self-sponsored courses the proportions of completed and on-going courses are similar (55,6% and 57,9%). The proportion of graduates within the self-sponsored on-going courses includes: (i) graduates who may have previously completed a self-sponsored course since graduation and have proceeded to pursue other self-sponsored courses, and (ii) graduates who are pursuing the first self-sponsored course after graduation. Table 4.10 does not provide information on the overall proportion of graduates who have sponsored themselves at least once (regardless of whether the course has been completed on is on-going). Nonetheless, the data indicates that 81,6% of all the respondents have sponsored themselves at least once[12].

A comparison between employer-sponsored training (60,7%) and overall self-sponsored training (81,6%) indicates two things: first, the respondents are highly motivated and have a strong desire to improve their skills regardless of the sponsor; second, the employers require the skills obtained through self-sponsored courses, but are reluctant to invest in them.

Within the economy, tight competition for computer-related technical skills tends to restrict employer training to in-house specific skills and to consistently engage in technical skills "poaching" based on pay packages. This may have far reaching implications that may lead to a lock-in situation with regard to the development of technologically creative competences. Put differently, salary-package "wars" may encourage resignation of the respondents to less technologically creative tasks; the opportunities to engage in activities that spur technological

[12] See appendix results A2.11

creativity may be constrained. Indeed, an indication of this situation is portrayed by a comparison between the patterns of completed self-sponsored and on-going self sponsored training.

The completed self-sponsored courses are generally pursued as a strategy to access the most suitable ICT-related opportunities upon entry into the job market. It is useful to bear in mind that the sample consists of respondents who have been in the job market for a minimum period of one year and a maximum period of two years. A comparison of the percentages of those who have completed self-sponsored courses within the "ICT development-related activities" group and the "ICT network/system support activities" group are equal (57,1% - Table 4.10). This implies that initially the desire to access suitable job opportunities is similar between the two groups. However, a look at the on-going courses shows that 74,1% within the "ICT development-related activities" group are pursuing self-sponsored courses compared to only 44% within the "ICT network/system support activities" group. The pursuit of self-sponsored courses tends to grow significantly within the "ICT development-related activities" group and to dwindle with the "ICT network/system support related activities" group.

It is noteworthy that 71,5% of the respondents in the "ICT network/support activities" group are employed by "other" foreign owned companies and by the public sector (28,6% and respectively 42,9%). In terms of the entire sample, these two employers account for 53% of the employment. Both of these employers offer no employment at all that is ICT development-related. In other words, the lock-in situation with regard to development of technologically creative skills is likely to be embedded within the employment offered by these two types of employers.

The categorisation of sources of training into single and multiple sources in Table 4.11 is based on the underlying idea that multiple sources are more likely to offer a greater diversity, and hence, a better opportunity to develop creativity in the use of technical skills.

Table 4. 11: Source of employer-sponsored training

	Groups of graduates by task types			
	ICT development related activities	*ICT system support activities*	*Other services*	***Total***
	%	%	%	%
source				
single	28,6	35,7		36,1
multiple	42,9	25,0		36,1
none	28,6	39,3	100,0	27,8

source: author

Table 4.11 shows that in general, out of all those who benefited from employer-sponsored courses, half of them accessed courses offered by a single source while the other half from multiple sources. With regard to the different groups based on the tasks undertaken, 42,9% of the group in "ICT development-related activities" accessed courses from multiple sources compared to 25% in "ICT support activities" group. It appears that not only do employer-sponsored courses favour those within "ICT development-related activities" group, but also tend to provide them with greater access to multiple sources of training in contrast to the "ICT network/system support activities" group. It is also important to note that as indicated previously, 85,9% of those within the "ICT development-related activities" work in locally-owned private companies while the remaining 14,1% in African-owned private companies. In other words, locally owned private firms are more willing to engage basic technical abilities in a more technologically creative path compared to any other type of employer.

Information on the nature of courses pursued after graduation is used to assess the areas in which complementary training is sought. Three types of categories were identified: (a) computer-related courses, (b) management-related courses and (c) other courses whose core elements are unrelated to either (a) or (b). The information is summarised in Table 4.12 below with regard to self-sponsored courses.

Within the completed self-sponsored courses 64,9% were computer-related compared to 14,9% for management-related. With regard to the different groups 42,9% of the "ICT development-related activities" group pursued computer-related courses compared to 35,7% of the "ICT network/support activities" group. The proportions do not differ significantly. In terms of the on-going courses on the whole, the proportion of computer-related courses constitutes 72,7%. This is reflected by the increase within "ICT development-related activities" group to 57,1%. The proportion within the "ICT network/support activities" group falls slightly to 33,3%. The self-sponsored computer related courses are in almost all cases undertaken for the purpose of obtaining manufacturer certifications such as CISCO, IBM, ORACLE etc.

With regard to management-related courses, completed courses constitute 14,9% compared to only 4,5% on-going courses for the whole sample. A more interesting observation is offered by a comparison between the two groups. 14,3% of the "ICT development-related activities" group compared to 7,1% of the "ICT network/support activities" group have completed management-related courses. However, in terms on on-going management-related course the proportion remains stable for the "ICT development-related activities" group, but falls to zero for the "ICT network/support activities" group. Management-related courses seem to be an area of complementary knowledge and skills within productive employment, which is mainly sought by those working within the "ICT development related activities".

Although information on the nature of employer-sponsored courses was not requested in the questionnaire, the in-depth graduate interviews indicated that employer-sponsored courses mainly targeted computer related courses and in particular manufacturer certifications. Notwithstanding the possibility of improving basic technical abilities through certifications, this may raise concerns with regard to the ability of university computer science programmes to meet industry entry requirements for basic technical abilities.

Table 4. 12: Nature of self-sponsored training

	Groups of graduates by task types			
	ICT development related activities	*ICT system support activities*	*Other services*	***Total***
	%	%	%	%
nature of self-sponsored courses (completed)				
computer related	42,9	35,7	33,3	36,1
management related	14,3	7,1		8,3
other		14,3		11,1
none	42,9	42,9		44,4
nature of self-sponsored courses (on-going)				
computer related	57,1	39,3		42,1
management related	14,3	0,0		2,6
other	0,0	10,7	66,7	13,2
none	28,6	50,0		42,1

source: author

The pursuit of further training is one way of developing technologically creative competences. The respondents also perceive start-ups as an alternative way of acquiring critically important complementary skills and understanding. The next sub-section presents some features of the start-up environment.

4.1.5 Start-up environment

This section looks at two aspects with regard to creating start-ups: (i) the interest of respondents in creating start-ups, which seems strong particularly for graduates engaged in "ICT development- related activities" and (ii) perceived impediments for starting-up start-ups, which indicate that the Kenyan environment is not particularly favourable for start-ups.

(i) Interest in creating start-ups

As in the case of the desire to pursue self-sponsored training, the respondents cited talent (acquisition of technologically creative competences) development as one of the main reason behind the interests in start-ups. The respondents were asked to indicate their interests based on a likert scale.

Table 4.13 shows that the interest in start-up was very strong. 18,4% already have a start-up despite the relatively short period since graduation, while another 44,7% expressed a very strong desire in creating a start-up. A comparison between groups indicates that 42,9% of the group engaged in "ICT development-related activities" already have a start-up compared to only 10,7% within the "ICT network support activities" group. The remaining 57,1% of the

"ICT development-related activities" expressed a very strong desire for start-ups compared to 46,4% within the "ICT network support activities" group. Within the "ICT network support activities" group 17% were mildly interested in start-ups and 25% expressed some interest.

Table 4. 13: Interest in start-up

	Groups of graduates by task types			
	ICT development related activities	*ICT network/system support activities*	*Other activities*	***Total***
	%	%	%	%
never				
maybe		17	66,7	18,4
probably		25		18,4
it is my utlimate goal	57,1	46,4		44,7
i have a start-up	42,9	10,7	33,3	18,4
Group total	18,4	73,7	7,9	100

source: author

(ii) Perceived impediments for starting-up start-ups

In order to have an idea of the impediments to setting-up start-ups, the respondents were asked in an open-ended question, to state what they perceived as the main obstacles for start-ups. The cited obstacles clearly overlap with those stated above with regard to career development. They include:

- *"poor policy and regulatory framework"*
- *"lack of access to capital"*
- *"under-developed ICT infrastructure"*
- *"ready market/market opportunities"*
- *"technical expertise – need to subsidise professional training"*
- *"ICT business networks"*

A few selected issues are presented here. They include: (a) access to capital for start-ups, (b) suitability of the Kenyan environment for start-ups, (c) support for start-ups from various agents and (d) professional associations/network and trade union membership.

(a) Access to capital for start-ups

The overview of access to capital for start-ups presented in the Table 4.14 above shows that about three fifths of the respondents considered that it was a major problem.

Table 4. 14: Financial constraints

	Groups of graduates by task types			
	ICT development related activities	*ICT network/system support activities*	*Other activities*	***Total***
	%	%	%	%
major	42,9	60,7	100	58,3
moderate	57,1	35,7		38,3
minor		3,6		2,8

source: author

While 42,9% of those within the "ICT development-related activities" group indicated that is was a major problem, a larger percentage (60,7%) within the "ICT network/system support activities" group were of the same view. This difference may be attributed to the relatively stronger desire within the "ICT development-related activities" group to set-up a start-up owing perhaps to the lesser tendency of being tied down to occupations that do not encourage technological creativity. In addition, this may be confirmed by the fairly greater interest of the "ICT development-related activities" group to pursue self-sponsored courses in management as depicted in Table 4.12. In-depth interviews indicated that although constraints to capital tended to postpone the creation of start-ups, establishment of business networks and acquisition of relevant technologically creative experience while in employment were perceived as critical.

(b) Suitability of the Kenyan environment for start-ups

Table 4.15 below attempts to summarise the general views on physical and institutional infrastructure within the economy, which is relevant for creating start-ups. The top columns labelled 1 to 5 represents ratings. A rating of 1 represents the assessment *"very poor"* and 5 *"excellent"*. The last column labelled *"rank"* attempts to class the performance of various aspects by descending order. These ranks must nonetheless, be interpreted with caution. For example, in the quality of physical infrastructure, water supply has been ranked as the best whereas it is clear that its efficiency is fairly inadequate according to the ratings given by the respondents.

Table 4. 15: Suitability of environment for technical competence enhancement

	1	2	3	4	5	rank
Quality of physical infrastructure						
Water	0	21	46	33	0	**1**
Electricity	0	25	58	8	8	**2**
Telecommunications network	8	13	54	21	4	**2**
Public health facilities	21	17	50	13	0	**4**
Transport services	25	46	29	0	0	**5**
Quality of institutions						
University education	0	21	50	21	8	**1**
Technical training institutions	4	21	38	33	4	**2**
R&D institutions	25	21	25	29	0	**3**
Access to capita/credit	4	63	25	8	0	**4**
Legaly systems and judiciary	33	17	46	4	0	**5**
Co-ordination from basic government institutions	21	42	38	0	0	**6**
Benefits from interacting with institutions and agents						
Private institutions	0	4	46	29	21	**1**
Industry and business associations	8	4	21	46	21	**1**
Hardware and software suppliers	4	13	21	42	21	**3**
Consultants	4	21	17	42	17	**4**
Participants of local exhibitions & trade fairs	8	25	25	33	8	**5**
Universities and technical training institutions	8	13	50	13	17	**6**
Government institutions	25	33	17	17	8	**7**
Investment promoters	33	21	21	21	4	**8**

Source: author

On the whole, the respondents indicate that the quality of physical infrastructure and institutions are mediocre.

(c) Support for start-ups from various agents

Interactions with various institutions and agents, private institutions as well as industry and business associations appear to make the largest contribution to competence enhancement. Others include hardware and software suppliers as well as consultants. The contribution by government institutions and investment promoters appears rather appalling. Follow-up questions reveal that the respondents overwhelmingly favour private sources as the main technical support for start-up efforts. These results are presented in Table 4.16 below. Business associations and government institutions tag along well behind. This pattern of views does not seem to vary much between the "ICT development-related activities" group and the "ICT network/system support-related activities" group as shown in Table 4.17.

Table 4. 16: Reliance on various agents for technical support in start-up effort

	%	rank
private sources	77,8	1
business associations	11,1	2
government	8,3	3
NGOs	2,8	4

Source: author

Table 4. 17: Support for start-up from various agents

	Groups of graduates by task types			
	ICT development related activities	*ICT network/system support activities*	*Other activities*	***Total***
agents	%	%	%	%
government		10,7		8,3
business association	14,3	10,7		11,1
private sources	85,7	75	100	77,8
NGOs		3.6		2,8

source: author

(d) Professional associations/network and trade union membership.

In an attempt to probe the matter further, an investigation of membership to professional associations/networks and trade unions was carried out. The results in Table 4.18 show that 50% were members of a professional association/network while only 25% were members of a trade union.

Table 4. 18: Professional associations/networks and trade union membership

	Groups of graduates by task types			
	ICT development related activities	*ICT network/system support activities*	*Other activities*	***Total***
professional association	%	%	%	%
yes	71,4	46,4		50,0
no	28,6	53,6	100,0	50,0
trade union	%	%	%	%
yes	14,3	25,0	100,0	25,0
no	85,7	75,0		75,0

source: author

A relationship may exist between the strong reliance on private sources for business start-up and the average interest in belonging to professional associations/networks. It may be the case that ICT business market opportunities are at an under-developed stage and that ICT market dynamism is not strong enough to commandeer strong professional associations or networks. The strong reliance on private sources may be based on a strong presence of informal contacts. The next sub-section attempts to trace views of respondents on ICT opportunities in developed countries.

4.1.6 Graduates' interest in emigration

Personal contacts abroad are generally thought to be useful in encouraging emigration. This section presents some information on: (i) contacts abroad and the nature of activities in which they are engaged in, (ii) the respondents' interests in living abroad, and (iii) the emigration destination preferences.

(i) Contacts abroad and the nature of their activities

Table 4.19 indicates that on the whole, 77,8% of the respondents have personal contacts abroad. Out of this proportion 78,5% of the contacts were reported as being involved in a computer-related field (studying, working or both) while 21,5% in a computer-unrelated field. Although there is no direct way of relating contacts abroad and the desire to emigrate, this high level of contacts abroad could reflect a significant interest in emigration. In particular, the high proportion contacts engaged in a computer-related field could represent better opportunities for technological learning for the respondents.

Table 4. 19: Contacts abroad and nature of their activities

	nature of activities carried out by contacts			
	computer related field	*computer unrelated field*	*none*	***Total Contacts***
	%	%	%	%
yes	61,1	16,7		77,8
no			22,2	22,2

source: author

(ii) Respondents' interests in emigration

Table 4.20 below shows that 76,3% of the respondents expressed interest in living abroad. The main reasons advanced were to access better skills and knowledge through study and work experience.

Table 4. 20: Interest in living abroad

	Groups of graduates by task types			
	ICT development related activities	*ICT network/system support activities*	*Other activities*	***Total***
	%	%	%	%
yes	85,7	71,4	100	76,3
no	14,3	28,6		23,7

source: author

A comparison in Table 4.20 between the two groups shows that while on the whole both group are keen to have a foreign experience, the "ICT development-related activities" is more interested than the "ICT network/system support activities" (85,7% versus 71,4%). This seems to tie in well with other results presented above: First, the "ICT development-related activities" group is more interested in acquiring further training as well as in creating start-ups as a means of accessing to technologically creative opportunities than the "ICT network/system support activities" group. Experience abroad appears to be considered as a step towards achieving that goal. Second, the former group appears to find the obstacles to competence development presented in Table 4.11 more restrictive than the latter group. Again, experience abroad appears to be considered as a way of overcoming some of the obstacles. Thirdly, the "ICT network/system support activities" group appears more prone to settling down for competitive pay packages at the expense of developing technological creativity in contrast to the "ICT development-related activities" group as observed in Table 4.12.

(iii) Emigration destination preferences

Interest in living abroad was generally expressed with regard to industrialised countries. In Table 4.21 below, columns 1 to 5 represents ratings by order of interest where 1 represents *"highest preference"* and 5 *"lowest preference"*. The countries are ranked in the last column in ascending order from the most preferred to the least preferred.

Table 4. 21: Foreign country preferences

	1	*2*	*3*	*4*	*5*	***rank***
UK	42,9	25,0	0,0	21,4	10,7	1
Canada	10,7	57,1	14,3	14,3	3,6	2
USA	21,4	10,7	46,4	14,3	7,1	3
South Africa	21,4	0,0	21,4	25,0	32,1	4
Australia	3,6	7,1	17,9	21,4	50,0	5

source: author

The UK features as the most popular destination followed by Canada. It may be the case that the UK, besides being viewed as offering considerably better opportunities for competence enhancement compared to Kenya, may also be more attractive in terms of contacts based on historical relationships. Canada's ranking in the second position may be related to the fairly technical skills friendly foreign policy. The US comes third despite the relatively more dynamic ICT industry. It may be the case that its tighter foreign policy has some bearing. Although South Africa and Australia appear on the list, the interest is fairly less intense compared to the first three countries, particularly in the case of Australia. However, South Africa may be perceived as having relatively lower competence enhancement opportunities compared to the other four countries, but presents better opportunities than Kenya. Proximity probably makes it more favourable compared to Australia. Other spontaneous choices placed Japan in a high position, which may be attributed to its tight connection with JKUAT based on technical co-operation. Other spontaneous preferences included Norway and Belgium. It is interesting to note that Southern Sudan was pointed out as an interesting destination for the development of start-ups.

In the next section, the analysis of the information provided by the respondents will be used to make an assessment of the extent to which the job expectations of university trained computer scientists correspond to jobs undertaken once the graduates are in employment. The aim is to try to capture the scope of opportunities for technological learning. This analysis may also be used to determine possible trajectories of the computer science skills and their implication on government objectives of fostering innovation-led development through ICTs.

4.2 Discussion

The rationale for this study suggests that universities and industry could play complementary roles in the development technologically creative competences that contribute to the generation of indigenous technological capabilities. Section 4.2.1 discusses the findings, which suggests that subsequent learning within productive employment that adds critically important complementary skills and understanding to basic technical abilities acquired in universities remains a major challenge in Kenya. Section 4.2.2 briefly discusses the question of emigration. It seems that there is a very high likelihood that a significant proportion of the graduates will emigrate as a response to the inadequate technology learning opportunities in Kenya.

4.2.1 The complementary role of universities and industry in technical competence development

The results presented in the sub-section 4.1 indicate that in the case of Kenya, the complementary roles of universities and industry do not operate in a constructive way. Consequently, the proportion of graduates who would eventually constitute components of a domestic innovative capability may be relatively low (the fraction on IN - figure 1.1) and this may raise a concern. Four critical issues regarding this observation are discussed: (i) the quality of basic technical abilities produced in universities, (ii) the distribution of graduates between tasks involving technology modification activities from which innovation-related learning may be derived and tasks involving relatively routine technology operation that seem likely to provide relatively limited learning opportunities, (iii) the distribution of graduates across industries, and (iv) the general infrastructure in the Kenyan environment.

(i) Basic technical abilities entering the job market: The requirement to obtain manufacturer certifications upon entry into the job market may raise concerns with regard to the ability of university computer science programmes to meet industry entry requirements for basic technical abilities. The brief analysis of the Brazilian case provided in appendix 1 indicates that manufacture certifications are not an important requirement for the employment of UFRJ graduates.

(ii) The distribution of the graduates between "ICT development-related activities" and "ICT network/system support activities": Employers that engage graduates in "ICT development-related activities" present a lower risk of throttling the development of indigenous technological capability. Nevertheless, this category of employers attracts less than one fifth of the graduates and face stiff competition from poaching practices not only amongst themselves, which to some extent may be considered healthy, but also from employers who offer work opportunities in "ICT network/system support activities". Work involving relatively routine technology operations or "ICT network/system support activities" are likely to provide relatively limited technology learning opportunities. Nevertheless, employers offering this type of work opportunities are particularly adept at attracting and retaining the graduates. This situation may have far-reaching adverse effects on the expansion of technological learning opportunities. First, employer-sponsored training tends to be highly restricted to specific in-house requirements and attempts to offer minimum diversity for technological creativity. Second, technologically creative competences are not sufficiently developed particularly because the graduates are engaged in "ICT network/system support activities" where the desire to develop technological creativity tends to be snuffed.

(iii) The distribution of the graduates across industries: While it is expected that the computer and related activities industry should attract the majority of computer-related technical skills from the university, only half are engaged in "ICT development-related activities" while the other half in "ICT network/system support activities". In addition, important industries of the Kenyan economy such as agriculture, food and beverages and telecommunications do not seem successful in offering attractive opportunities as observed in Table 4.1. These important industries not only attract a very small minority of this category of basic technical abilities, but also offer no opportunities in "ICT development-related activities". The industries could, nonetheless, greatly benefit from employing computer science graduates and engaging them in improving competitiveness in the current fast changing technology-driven context. The telecommunications industry is critical in the provision of an effective overarching infrastructure for the development of indigenous technological capabilities. If specific innovation opportunities within the telecommunications industry are not sufficiently explored in order to provide a well articulated infrastructure for other industries, it may act as an obstacle rather than a catalyst for technological capability building. In Kenya, it seems that current efforts to create conditions and structures intended to strengthen the competitiveness of the industry hung on a tight rope.

(iv) The general infrastructure over and above telecommunications: This includes institutional aspects such as access to capital, regulatory institutions, other basic government institutions, business networks, professional training accessibility etc. The survey indicates that both the physical and institutional infrastructure are inadequate in facilitating technological learning. For example, a closer analysis of post-university training reveals that respondents are generally highly motivated in terms of obtaining improved technical skills with about 75% of them seeking self-sponsored courses not only in computer-related courses but also in management. This phenomenon is quite revealing of the desire for technological learning opportunities. However, opportunities seem to be limited at two levels: (a) access to further high quality training that also offers a whole panoply of options is limited in the local context. This is manifested in the strong desires (76,3%) to relocate to industrialised countries for the acquisition of complementary skills and knowledge; and (b) opportunities to develop and use technological creativity within occupations is to some extent restricted. This poses a serious problem in terms of expanding the scope of technological learning opportunities and ultimately the development of indigenous technological capabilities.

The question that may be raised from these points is: *How can universities and industry play a complementary role in a way that expands the scope of technological learning in the economy?* The findings indicate that there is a clear need to link technologically creative competences, entrepreneurship and innovation through a favourable mix of policies and institutions.

4.2.2 Emigration and technical competence development

While it is acknowledged that various concerns come into play, this sub-section will be limited to a brief discussion of emigration for the purpose of the scope of the discussion. It was observed that 76,3% of the 2004 and 2005 BSc. Computer Science graduates expressed interest in living abroad as a means of gaining access to high-level technical training and suitable work experience. Although this percentage represents *"expressed interest"* and not the *"actual"* relocation, it is reasonable to assume that it is a fairly good proxy for the emigration that may emanate from this category of basic technical abilities. Given the specific characteristics of the computer science graduates as well as the intellectual elite selective processes that offered them the limited formal training places at JKUAT, it appears very likely that the rule of the thumb, which indicates that 75% are expected to emigrate, would be respected. An assessment of the extent to which the emigration of the respondents would lead to a net brain-drain for the Kenyan economy lies beyond the scope of this research. Of great concern, however, is that the high interest in emigration reflects limited opportunities for technological learning, Arocena and Sutz (2006); this problem is of critical concern and requires attention regardless of the proportion that will ultimately emigrate. Furthermore, it may be safely assumed that these observations could be extended to other categories of technical skills that display similar characteristics, for example, graduates of other engineering sciences.

Despite the general indication by the survey that the respondents were interested in living abroad for only a limited duration that would allow them to enhance their competences, it is worth noting that the return of technical skills to the country of origin invariably depends on existing opportunities to use and develop the acquired skills. Countries that have been successful in recovering emigrated technical skills have aggressively worked towards strategically creating attractive opportunities. Notwithstanding the benefits that accrue from the improvement of basic technical abilities abroad, great caution is required in addressing the question of brain circulation – the ricochet effects may be limited to the economies that offer the most attractive opportunities. To the extent that the development of indigenous technological capability hinges on opportunities for transforming basic technical abilities into technologically creative competences, discussions suggesting that remittances from the Diaspora could mitigate a net brain loss are palliative. Focus should remain on the creation of suitable opportunities for technological learning that target the development of indigenous technological capabilities.

4.2.3 Other concerns

The purpose of this work was to shed some light on the importance of identifying strategies for developing technologically creative competences. It suggests that universities and industry could engage in complementary roles in a constructive way in order to expand the scope of suitable technological learning opportunities. Nonetheless, limitations abound. For example, this discussion does not attempt to tackle the question of brain-drain *per se*. Another major limitation of the research is that its failure to address the inter-relationships amongst the various obstacles to development technical abilities that were highlighted in Table 4.8. A further limitation is that the research does not attempt to elucidate how specialised training outside the firm interacts with (i) the other aspects that are important for technological learning within the production sector and (ii) basic technical abilities acquired in universities. A host of other aspects that also influence technological learning also lay beyond the scope of this research. For example, a set of complementary practices, such as incentive pay, team work, employment security, job flexibility, information sharing and labour relations, which determine the productivity of basic technical abilities, Ichniowski et al (1997). These aspects could be the object of further research that attempts to understand the process of technological learning.

5 Summary of results and implications

5.1 Summary of results

This research provides preliminary results of a survey that focused on JKUAT computer science graduates' views on the suitability of opportunities for technological learning within occupations in Kenya. The survey provides unique information on efforts to develop technologically creative competences as well as an evaluation of the importance of some factors that influence this process.

The key question addressed in the analysis is the extent to which opportunities for technological learning can be expanded and strengthened through a complementary role between universities and industry. The main findings of the research are as follows:

- Data on employment of computer science graduates reveal that only a small percentage of these basic technical abilities are in ICT development-related work
- The survey also indicates that ICT development-related opportunities are almost exclusively offered by locally-owned private firms
- The analysis shows that training practices of employers could lead to a low innovation lock-in situation that may restrict indigenous technological capability building
- The finding that there is a strong preference for private sources in start-up effort may be an indication of an insufficient conducive business environment
- Finally, the survey indicates that there is a strong desire to emigrate for purposes of enhancing basic technical abilities and acquiring relevant experience, which may reflect the unavailability of suitable technological learning opportunities

5.2 Implications

5.2.1 Further research

Drawing on the results of this bounded research, it appears that the complementary role of universities and industry in developing technologically creative competences in Kenya is constrained. The proportion of graduates who would constitute components of domestic innovative capability might be relatively low. Consequently, the process of building technological capability might be limited. However, it would be useful to carryout a wider study to provide more robust information on this probable problem.

There appears to be no previous work that provides comprehensive data and analysis of the technological learning process within the production sector in Kenya. This exploratory work has demonstrated the value and importance of targeting the transformation of basic technical abilities produced in education institutions into technologically creative competence that are necessary for the development of domestic innovative capabilities; basic technical abilities do not automatically lead to additions to the base of technological capabilities. Nevertheless, the research is bounded in various ways:

- It examines only one technical discipline (computer science). A more comprehensive study covering other science and engineering disciplines such as engineering, agriculture, food science and technology, biotechnology etc would be necessary for more robust results.
- It is based on only one university (JKUAT). A study involving a large proportion of all the local university would be relevant for policy implication.
- The tracer study looks at graduates with only a maximum of two years in employment. A longer time span would provide more reliable results.
- The research is somewhat speculative in terms of the outcomes (IN, EM and RO in figure 1.1) of the technological learning process within industry. The results are based on a sample of only 38 graduates and in addition, rely on an analysis that draws on subjective evaluations of the respondents.

Further work is, therefore, required to extend these boundaries and provide specific policy recommendations.

5.2.2 Policy implications

Policy implications based on the exploratory and bounded nature of this research can only at best be tentative.

(i) A general policy: a policy for science, technology and innovation (STI) needs to take into account the importance of developing technologically creative competences. It is important to emphasize that basic technical abilities emanating for formal education institutions do not automatically result in additions to technological capabilities. Technological learning opportunities within industry are key for the development of domestic innovative capabilities without which an economy cannot effectively benefit from technological changes.

(ii) A detailed policy: despite the exploratory and bounded nature of this research, a policy implication with a measure of detail may be provided. A starting point for a policy could be a focus on creating and strengthening "local champions" based on the locally-owned private firms that offer ICT development-related opportunities and the existing basic technical abilities acquired from local universities.

The demand for manufacturer certifications upon entry of the graduates into the job market may be an indication that computer science under-graduate programmes in Kenya are out of step with industry requirements for basic technical abilities. The locally-owned private firms could work with local universities to: (a) address this problem by providing focused contribution to the design of university under-graduate programmes, and (b) design and implement a pilot post-graduate programme that serves as an instrument of flexibility for enhancement of technical skills. Technology universities or specialised training institutes have been created by private firms to cater for the need to improve technical skills. This may not be an immediate option for the locally-owned private firms in Kenya and, hence the need to explore a solution in collaboration with an existing university.

An instrument of flexibility that facilitates technological learning could be developed between universities and industry with an important contribution from the government. This instrument of flexibility could take the form of "detachment" from employment. For example, just as industrial attachments in the undergraduate university training programmes in science and engineering disciplines are considered important, "detachment" from employment for further training at the post-graduate level, and once the candidates have had an industry experience for at least two years, could be useful in reviving the potential technologically creative competences that may either have been locked in limited technological learning opportunities such as "ICT network/system support activities" or that require sharpening up for improved technological learning within industry.

Although local universities may continue to face the challenge of providing high quality training and a wide range of options, a programme could be devised that links a local university to an industrialised country university with the required facilities. Essentially, the candidates would undertake a sandwich programme that would allow them to attend core courses in the industrialised country university for the required duration, but the research projects would be based at the local universities and would have to be relevant to local problems. The "detachment" from employment programme would not be one-sided. One of the roles of the industry would be a requirement by the government to encourage employees in this category (computer science graduates) to pursue the "detachment" from employment programme after serving the firm or institution for a minimum defined period through, for example, a leave of absence. A second role would be a requirement to facilitate the graduates' research projects in investigating the set problems. A third role of industry would be a requirement to offer a position to the graduates on completion of the programme should the latter be interested. This would provide a form of employment security that would introduce a measure of flexibility aimed at encouraging technical skills enhancement.

As concerns the graduates, they would have the option of going back to the previous employer or seek employment elsewhere. However, they would have the requirement of working within the economy for a minimum defined period of time after which they would be free to seek employment abroad. The idea is not to hold them prisoners. The government would presumably facilitate the "detachment" from employment programme through access to a favourable student loans facility targeting this category of basic technical abilities. The, the graduates would then have the responsibility of using their improved technical skills within the economy and to reimburse the loans over a period of time after completion of the programme. In other words, the main interest would be to encourage the graduates to employ the improved technical abilities for the benefit of the economy. Technically, the graduates of the programme who would prefer to leave the economy on completing the specially facilitated programme, but without using their abilities within the economy, would face more stringent reimbursement requirements. A core importance of the "detachment" from employment programme would be to involve the various agents (government, industry, universities and the graduates) in an intricate relationship and by so doing provide an opportunity to embrace and effectively own the development of technological capabilities.

This type of instrument could be extended to other categories, such as engineering sciences, that have similar characteristics to the computer science graduates. A study on the utilisation of professional engineering skills in Kenya revealed that their development into technologically creative competences was limited, particularly in the private sector, and that stronger university-industry links could be useful in addressing this problem, Bennel (1984). Kenya's main asset lies in its potential for learning as may be observed from the existing scientific, engineering and entrepreneurship skills. These may be used creatively to provide opportunities for stimulating technological learning that addresses local problems. This would contribute to developing and retaining the technologically creative competences as well as setting grounds for the generation of indigenous technological capability.

Mechanisms for achieving the desired results, in addition to training that is targeted at the innovative capability of firms, would include seed funding, risk capital, and integration of associative and networking capabilities in the exploitation, generation and diffusion of ICT solutions that meet local needs, and particularly those that are not addressed by the predominant off-the-shelf solutions. The overall aim would be to develop a process of strengthening the technological capability of innovative firms.

Appendix 1: a snapshot of the Brazilian case

The situation of Computer Engineering graduates from UFRJ is briefly presented in two sections.[13] Section 1.1 examines the distribution of UFRJ graduates across industries with respect to three different industry classifications: (i) the standard industrial classification (ISIC); (ii) a re-classification of ISIC categories into a set of ICT-defined industry groups; and (iii) a re-classification that focuses more on the skill intensity of industries.[14] Section 1.2 presents broad patterns of graduate training based on (i) studies pursued after graduation, (ii) nature of post-graduate courses, and (iii) post-graduate levels. No attempt is made to determine the nature of activities carried within occupation due to data limitations.

The data was collected from 2004 and 2005 graduates based on a short version of the original questionnaire. The questionnaire focused on two aspects: (a) current employment and (b) studies pursued after graduation. A 50% response rate was obtained.

1.1 Industry classifications

(i) Employment by industry: the standard industrial classification (ISIC)

Table A.1 presents information on the distribution of graduates across industries and the percentage contribution to GDP of the industries. Available data for industry contributions to GDP has been lumped together for some ISIC sections (LMNOP and JK). Nevertheless, the table reveals that the graduates are employed across a wider variety of industries (16) compared to Kenya (10). Although education attracts the largest proportion of graduates (31,8%), it is important to not that all the graduates within this industry are full-time post-graduate students with 66,7% enrolled in a Masters programme and 33,3% in Doctoral studies. This may be an indication that post-graduate studies are fairly accessible; opportunities to develop technologically creative learning within formal institutions may be available.

With regard to percentage contributions to GDP, community, social and personal services (ISIC sections LMNOP) account for the largest contribution (25,5%) and attracted almost a proportion of graduates that is twice as large (45,5%). Although manufacturing is almost an equally large contributor to GDP (22,1%) it attracted a proportion of only 12,1% of the graduates. ISIC sections JK (finance, real estate and business services) as well as section I (transport, storage and communications) attracted larger proportions of graduates than their contributions to GDP.

[13] The degrees awarded by UFRJ officially bear the title of "Electronic Engineering" although the programmes consists of core computer engineering courses and presented the closest match to the "Computer Science" degrees awarded by JKUAT.

[14] Both (ii) and (iii) are based on the ISIC reclassification along specific dimensions developed to provide a descriptive analysis of relative industry performance, O'Mahony and van Ark (2003).

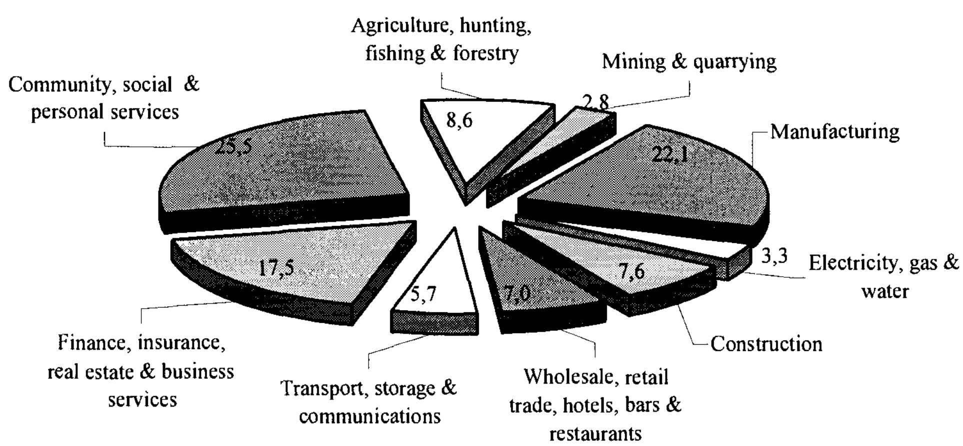
Table A. 1: ISIC Industry Classification – UFRJ BSc. Computer Engineering Graduates

ISIC section	industry	proportion of graduates (%)	contribution to GDP (%)
LMNOP	Community, social & personal services	**45,5**	**25,5**
	(75) Public administration & defence	7,6	
	(80) Education	31,8	
	(85) Health & social work	1,5	
	(92) Recreational activites (TV & news agency)	4,5	
D	Manufacturing	**12,1**	**22,1**
	(23) Petroleum products	3	
	(29) Machinery & equipment	1,5	
	(30) Computing machinery	3	
	(322) Telecommunication equipment	1,5	
	(351) Transport equipment	3	
JK	Finance, insurance, real estate & business services	**21,2**	**17,5**
	(65) Financial intermediation	3	
	(72) Computer related activities	12,1	
	(73) Research & development	4,5	
	(74) Other business activities	1,5	
I	Transport, storage & communications	**9,1**	**5,7**
	(639) Supporting & auxiliary transport activities	1,5	
	(642) Telecommunications	7,6	

source: ECLAC statistical year book, 2006 - contribution to GDP

Figure A.1 shows the GDP composition of all the sectors in 2005. Manufacturing (22,3%), community, social & personal services (25,6%), as well as finance & business services (17,4%) are by far the largest contributors.

Figure A. 1: Percentage composition of GDP by sector (2005)



source: ECLAC statistical year book for Latin America & the Caribbean, 2006 *(ii) Employment by industry: ICT-defined industry groups*

This taxonomy distinguishes groups of industries that broadly belong to two categories: (a) industries that produce ICT goods and services or intensively use ICT and (b) non-ICT industries in manufacturing, services and other areas.

One interesting observation in Table A.2 is that there seems to be a relatively even spread of graduates between (a) ICT industries that account for 36,3% and (b) non-ICT industries 34,8% with the exclusion of education (16,7%). Extraction of crude petroleum, an important industry in Brazil, which uses sophisticated technology accounts for a fair share of the graduates (12,1%). It is also notable that the "ICT Producing-manufacturing" industries attract graduates compared to the case of Kenya where the category accounted for none.

Table A. 2: Classification by ICT Taxonomy

Classification of UFRJ BSc. computer engineering graduates ICT Taxaonomy

industry structure and taxonomies	no. of graduates	%
ICT Producing - manufacturing		**4,5**
Computing machinery	2	
Telecommunication equipment	1	
ICT Producing - services		**19,7**
Telecommunications	5	
Computer related activities	8	
ICT Using - services		**12,1**
Machinery & equipment	1	
Transport equipment	2	
Financial intermediation	2	
Research & development	3	
Non-ICT Manufacturing		**3,0**
Petroleum products	2	
Non-ICT Services		**48,5**
Supporting & auxiliary transport activities	1	
Other business activities	1	
Public administration & defence	5	
Education	21	
Health & social work	1	
Recreational activites (TV & news agency)	3	
Non-ICT Other		**12,1**
Extraction of crude petroleum	8	

taxonomy source: O'Mahony and van Ark (2003) *(iii) Employment by industry: skill intensity of industries*

The skill taxonomy presented in Table A.3 distinguishes four groups of industries based on the dominant level of skill intensity required in the industries: (a) high skilled, (b) high-intermediate skilled, (c) low-intermediate skilled, and (d) low skilled.

The "low skilled" category presents an interesting result. It attracts 16,7% of the graduates. The sizeable number of graduates may be a reflection of increasing knowledge intensity within the "low skilled" industries. Brazil is a significant producer of both petroleum and recreational activities such as *soap operas*.

Table A. 3: Classification by Skill Taxonomy

industry structure and taxonomies	no. of graduates	%
High skilled		**68,2**
Petroleum products	2	
Computing machinery	2	
Telecommunication equipment	1	
Financial intermediation	2	
Computer related activities	8	
Research & development	3	
Other business activities	1	
Public administration & defence	5	
Education	21	
High-intermediate skilled		**13,6**
Transport equipment	2	
Supporting & auxiliary transport activities	1	
Telecommunications	5	
Health & social work	1	
Low-intermediate skilled		**1,5**
Machinery & equipment	1	
Low skilled		**16,7**
Extraction of crude petroleum	8	
Recreational activites (TV & news agency)	3	

taxonomy source:O'Mahony and van Ark (2003)

1.2 UFRJ graduates' patterns of training

The data of university trained computer scientists from UFRJ does not provide information on how the acquired skills are used and up-graded within the production sector; an analysis of the availability of technologically creative opportunities cannot be carried out. The data reveals that 75,8% are currently employed while the remaining 24,2% are full-time post-graduate students.

(i) Studies pursued after graduation

A brief examination of training within formal institutions of higher learning is presented in Table A.4 below. It reveals that 60,6% of the respondents have pursued or are pursuing further studies as. It is interesting to note that ICT certification courses (6%) do not appear critical for integration into the job market. In addition, a fairly large proportion (39,4%) does not pursue training from formal institutions, but are employed. This may be an indication that employers consider the basic technical abilities acquired at the degree level to be adequate. Another interesting observation is that 57,6% are in a post-graduate programme with only 4,5% reported to study outside the country. This may be attributed to the existing scholarship programme that favours domestic universities particularly at the Masters level.

Table A. 4: Studies pursued after graduation

	Year of graduation		***Total***
	2004	*2005*	
	%	%	%
none	12,1	27,3	39,4
certification	3,0		3,0
post-grad	28,8	25,8	54,6
both	1,5	1,5	3,0
Total	45,5	54,5	100,0

source: author

(ii) Nature of post-graduate courses

With regard to the nature of post-graduate courses pursued, the data presented in Table A.5 indicates that 40,9% are in engineering and physical sciences (EPS) while 16,7% in management related courses.

Table A. 5: Nature of post-graduate courses

	Year of graduation		***Total***
	2004	*2005*	
	%	%	%
none	15,2	27,3	42,4
other	4,5	12,1	16,7
EPS	25,8	15,2	40,9
Total	45,5	54,5	100,0

source: author

(iii) Post-graduate levels

Table A.6 below shows that progression from the Masters level to the PhD level is fairly fast – 12,1% of 2004 graduates are already enrolled in a PhD programme.

Table A. 6: Post-graduate levels

	Year of graduation		***Total***
	2004	*2005*	
	%	%	%
none	15,2	27,3	42,4
MSc.	18,2	27,3	45,5
PhD	12,1		12,1
Total	45,5	54,5	100,0

source: author

Appendix 2: χ^2 test results

χ^2 cross tabulation test results:

KENYA

A2.1 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
isic rev3 * year	38	76.0%	12	24.0%	50	100.0%

isic rev3 * year Crosstabulation

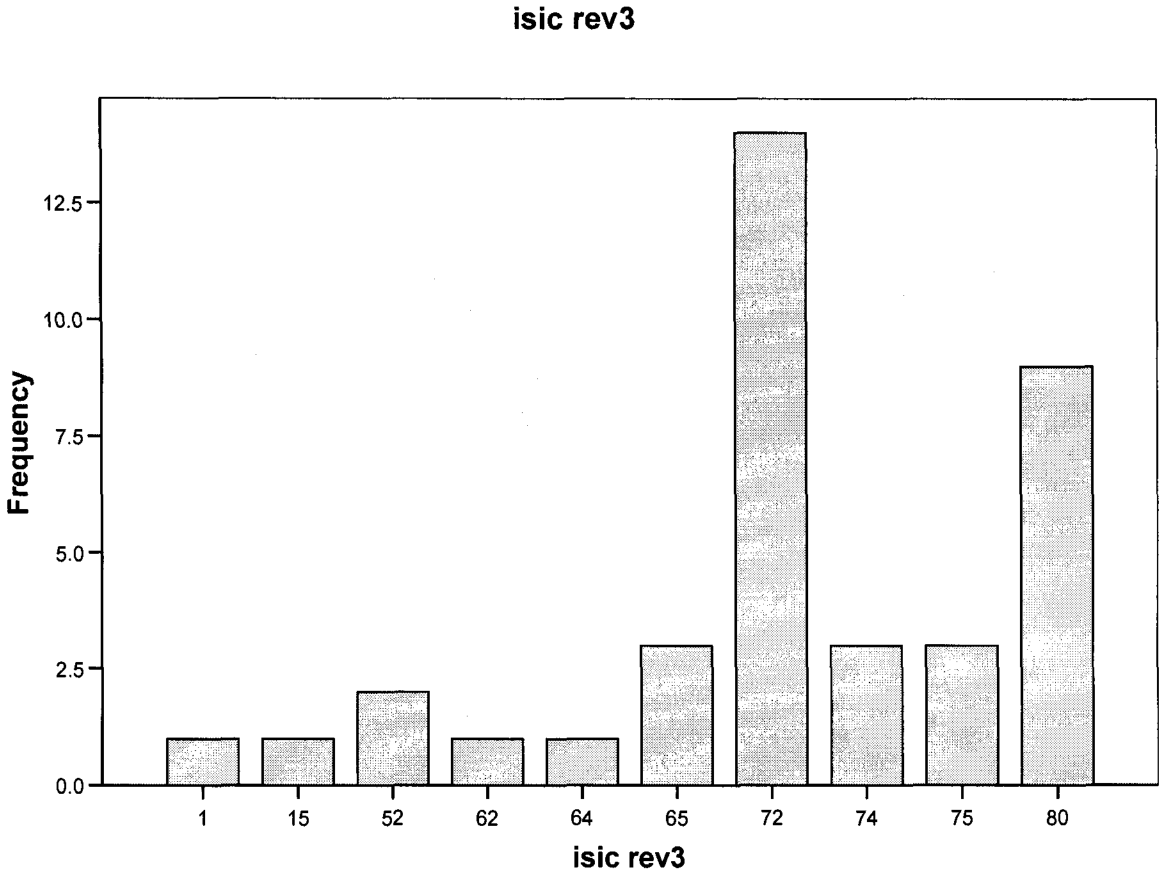
% of Total

		year		Total
		2004	2005	
isic rev3	1	2.6%		2.6%
	15		2.6%	2.6%
	52	2.6%	2.6%	5.3%
	62		2.6%	2.6%
	64	2.6%		2.6%
	65	5.3%	2.6%	7.9%
	72	13.2%	23.7%	36.8%
	74	5.3%	2.6%	7.9%
	75	7.9%		7.9%
	80	13.2%	10.5%	23.7%
Total		52.6%	47.4%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.840(a)	9	.452
Likelihood Ratio	11.549	9	.240
Linear-by-Linear Association	.004	1	.949
N of Valid Cases	38		

a 18 cells (90.0%) have expected count less than 5. The minimum expected count is .47.


isic rev3
Frequency
12.5
10.0
7.5
5.0
2.5
0.0
1
15
52
62
64
65
72
74
75
80
isic rev3

A2.2 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
industry * group	38	100.0%	0	.0%	38	100.0%

industry * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
industry	agriculture	% within group		3.6%		2.6%
		% of Total		2.6%		2.6%
	transport, storage & communications	% within group		7.1%		5.3%
		% of Total		5.3%		5.3%
	wholesale & retail trade	% within group		7.1%		5.3%
		% of Total		5.3%		5.3%
	manufacturing	% within group		3.6%		2.6%
		% of Total		2.6%		2.6%
	education	% within group		21.4%	100.0%	23.7%
		% of Total		15.8%	7.9%	23.7%
	real estate & business activities	% within group	100.0%	35.7%		44.7%
		% of Total	18.4%	26.3%		44.7%
	public administration & defence	% within group		10.7%		7.9%
		% of Total		7.9%		7.9%
	financial intermediation	% within group		10.7%		7.9%
		% of Total		7.9%		7.9%
Total		% within group	100.0%	100.0%	100.0%	100.0%
		% of Total	18.4%	73.7%	7.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.011(a)	14	.130
Likelihood Ratio	21.527	14	.089
Linear-by-Linear Association	1.147	1	.284
N of Valid Cases	38		

a 22 cells (91.7%) have expected count less than 5. The minimum expected count is .08.

A2.3 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
isiccode * group	38	100.0%	0	.0%	38	100.0%

isiccode * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
isiccode	1	% within isiccode		100.0%		100.0%
		% within group		3.6%		2.6%
	15	% within isiccode		100.0%		100.0%
		% within group		3.6%		2.6%
	52	% within isiccode		100.0%		100.0%
		% within group		7.1%		5.3%
	62	% within isiccode		100.0%		100.0%
		% within group		3.6%		2.6%
	64	% within isiccode		100.0%		100.0%
		% within group		3.6%		2.6%
	65	% within isiccode		100.0%		100.0%
		% within group		10.7%		7.9%
	72	% within isiccode	50.0%	50.0%		100.0%
		% within group	100.0%	25.0%		36.8%
	74	% within isiccode		100.0%		100.0%
		% within group		10.7%		7.9%
	75	% within isiccode		100.0%		100.0%
		% within group		10.7%		7.9%
	80	% within isiccode		66.7%	33.3%	100.0%
		% within group		21.4%	100.0%	23.7%
Total		% within isiccode	18.4%	73.7%	7.9%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.202(a)	18	.149
Likelihood Ratio	25.153	18	.121
Linear-by-Linear Association	.052	1	.820
N of Valid Cases	38		

a 28 cells (93.3%) have expected count less than 5. The minimum expected count is .08.

A2.4 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
industry classification * group	38	100.0%	0	.0%	38	100.0%

industry classification * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
industry classification	low skilled	% within industry classification		100.0%		100.0%
		% within group		7.1%		5.3%
	low intermediated skilled	% within industry classification		100.0%		100.0%
		% within group		7.1%		5.3%
	high intermediates skilled	% within industry classification		100.0%		100.0%
		% within group		7.1%		5.3%
	high skilled	% within industry classification	21.9%	68.8%	9.4%	100.0%
		% within group	100.0%	78.6%	100.0%	84.2%
Total		% within industry classification	18.4%	73.7%	7.9%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.545(a)	6	.863
Likelihood Ratio	4.052	6	.670
Linear-by-Linear Association	.255	1	.614
N of Valid Cases	38		

a 10 cells (83.3%) have expected count less than 5. The minimum expected count is .16.

A2.5 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
any training offered by employer * group	36	94.7%	2	5.3%	38	100.0%

any training offered by employer * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
any training offered by employer	no	% within any training offered by employer	14.3%	78.6%	7.1%	100.0%
		% within group	28.6%	39.3%	100.0%	38.9%
	yes	% within any training offered by employer	22.7%	77.3%		100.0%
		% within group	71.4%	60.7%		61.1%
Total		% within any training offered by employer	19.4%	77.8%	2.8%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.887(a)	2	.389
Likelihood Ratio	2.218	2	.330
Linear-by-Linear Association	1.039	1	.308
N of Valid Cases	36		

a 4 cells (66.7%) have expected count less than 5. The minimum expected count is .39.

A2.6

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
source of training * group	36	94.7%	2	5.3%	38	100.0%

source of training * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
source of training	single	% within source of training	15.4%	84.6%		100.0%
		% within group	28.6%	39.3%		36.1%
	multiple	% within source of training	23.1%	76.9%		100.0%
		% within group	42.9%	35.7%		36.1%
	none	% within source of training	20.0%	70.0%	10.0%	100.0%
		% within group	28.6%	25.0%	100.0%	27.8%
Total		% within source of training	19.4%	77.8%	2.8%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.957(a)	4	.565
Likelihood Ratio	2.923	4	.571
Linear-by-Linear Association	.055	1	.815
N of Valid Cases	36		

a 6 cells (66.7%) have expected count less than 5. The minimum expected count is .28.

A2.7 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
other courses attended at tertiary level * group	36	94.7%	2	5.3%	38	100.0%

other courses completed at tertiary level * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
other courses attended at tertiary level	no	% within other courses attended at tertiary level	18.8%	75.0%	6.3%	100.0%
		% within group	42.9%	42.9%	100.0%	44.4%
	yes	% within other courses attended at tertiary level	20.0%	80.0%		100.0%
		% within group	57.1%	57.1%		55.6%
Total		% within other courses attended at tertiary level	19.4%	77.8%	2.8%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.286(a)	2	.526
Likelihood Ratio	1.658	2	.437
Linear-by-Linear Association	.250	1	.617
N of Valid Cases	36		

a 4 cells (66.7%) have expected count less than 5. The minimum expected count is .44.

A2.8 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
nature of other courses attended * group	36	94.7%	2	5.3%	38	100.0%

nature of other courses completed * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
nature of other courses attended	computer related	% within nature of other courses attended	23.1%	76.9%		100.0%
		% within group	42.9%	35.7%		36.1%
	management related	% within nature of other courses attended	33.3%	66.7%		100.0%
		% within group	14.3%	7.1%		8.3%
	other	% within nature of other courses attended		100.0%		100.0%
		% within group		14.3%		11.1%
	none	% within nature of other courses attended	18.8%	75.0%	6.3%	100.0%
		% within group	42.9%	42.9%	100.0%	44.4%
Total		% within nature of other courses attended	19.4%	77.8%	2.8%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.736(a)	6	.841
Likelihood Ratio	3.809	6	.702
Linear-by-Linear Association	.605	1	.437
N of Valid Cases	36		

a 10 cells (83.3%) have expected count less than 5. The minimum expected count is .08.

A2.9 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
any on-going courses * group	38	100.0%	0	.0%	38	100.0%

any on-going courses * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
any on-going courses	no	% within any on-going courses	12.5%	87.5%		100.0%
		% within group	28.6%	50.0%		42.1%
		% of Total	5.3%	36.8%		42.1%
	yes	% within any on-going courses	22.7%	63.6%	13.6%	100.0%
		% within group	71.4%	50.0%	100.0%	57.9%
		% of Total	13.2%	36.8%	7.9%	57.9%
Total		% within any on-going courses	18.4%	73.7%	7.9%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%
		% of Total	18.4%	73.7%	7.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.424(a)	2	.181
Likelihood Ratio	4.536	2	.104
Linear-by-Linear Association	.042	1	.838
N of Valid Cases	38		

a 4 cells (66.7%) have expected count less than 5. The minimum expected count is 1.26.

A2.10 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
nature of on-going courses * group	38	100.0%	0	.0%	38	100.0%

nature of on-going courses * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
nature of on-going courses	computer related	% within nature of on-going courses	25.0%	68.8%	6.3%	100.0%
		% within group	57.1%	39.3%	33.3%	42.1%
		% of Total	10.5%	28.9%	2.6%	42.1%
	management related	% within nature of on-going courses	100.0%			100.0%
		% within group	14.3%			2.6%
		% of Total	2.6%			2.6%
	other	% within nature of on-going courses		60.0%	40.0%	100.0%
		% within group		10.7%	66.7%	13.2%
		% of Total		7.9%	5.3%	13.2%
	none	% within nature of on-going courses	12.5%	87.5%		100.0%
		% within group	28.6%	50.0%		42.1%
		% of Total	5.3%	36.8%		42.1%
Total		% within nature of on-going courses	18.4%	73.7%	7.9%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%
		% of Total	18.4%	73.7%	7.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.471(a)	6	.025
Likelihood Ratio	12.353	6	.055
Linear-by-Linear Association	.542	1	.461
N of Valid Cases	38		

a 10 cells (83.3%) have expected count less than 5. The minimum expected count is .08.

A2.11 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
tertiary * group	38	97.4%	1	2.6%	39	100.0%

Self-sponsored courses * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
tertiary	no	% within tertiary	14.3%	85.7%		100.0%
		% within group	14.3%	21.4%		18.4%
		% of Total	2.6%	15.8%		18.4%
	yes	% within tertiary	19.4%	71.0%	9.7%	100.0%
		% within group	85.7%	78.6%	100.0%	81.6%
		% of Total	15.8%	57.9%	7.9%	81.6%
Total		% within tertiary	18.4%	73.7%	7.9%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%
		% of Total	18.4%	73.7%	7.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.926(a)	2	.630
Likelihood Ratio	1.468	2	.480
Linear-by-Linear Association	.047	1	.829
N of Valid Cases	38		

a 3 cells (50.0%) have expected count less than 5. The minimum expected count is .55.

A2.12 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
interest in start-up * group	38	100.0%	0	.0%	38	100.0%

interest in start-up * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
interest in start-up	maybe	% within interest in start-up		71.4%	28.6%	100.0%
		% within group		17.9%	66.7%	18.4%
	probably	% within interest in start-up		100.0%		100.0%
		% within group		25.0%		18.4%
	it is my ultimate goal	% within interest in start-up	23.5%	76.5%		100.0%
		% within group	57.1%	46.4%		44.7%
	i already have a start-up	% within interest in start-up	42.9%	42.9%	14.3%	100.0%
		% within group	42.9%	10.7%	33.3%	18.4%
Total		% within interest in start-up	18.4%	73.7%	7.9%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.720(a)	6	.048
Likelihood Ratio	15.033	6	.020
Linear-by-Linear Association	5.856	1	.016
N of Valid Cases	38		

a 8 cells (66.7%) have expected count less than 5. The minimum expected count is .55.

A2.13 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
main supporter for start-up * group	36	94.7%	2	5.3%	38	100.0%

main supporter for start-up * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
main supporter for start-up	government	% within main supporter for start-up		100.0%		100.
		% within group		10.7%		8.
	business associations	% within main supporter for start-up	25.0%	75.0%		100.
		% within group	14.3%	10.7%		11.1
	private sources	% within main supporter for start-up	21.4%	75.0%	3.6%	100.
		% within group	85.7%	75.0%	100.0%	77.
	NGOs	% within main supporter for start-up		100.0%		100.
		% within group		3.6%		2.
Total		% within main supporter for start-up	19.4%	77.8%	2.8%	100.
		% within group	100.0%	100.0%	100.0%	100.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.469(a)	6	.962
Likelihood Ratio	2.436	6	.876
Linear-by-Linear Association	.085	1	.771
N of Valid Cases	36		

a 10 cells (83.3%) have expected count less than 5. The minimum expected count is .03.

A2.14 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
member of professional association * group	36	94.7%	2	5.3%	38	100.0%

member of professional association/network * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
member of professional association	no	% within member of professional association	11.1%	83.3%	5.6%	100.0%
		% within group	28.6%	53.6%	100.0%	50.0%
	yes	% within member of professional association	27.8%	72.2%		100.0%
		% within group	71.4%	46.4%		50.0%
Total		% within member of professional association	19.4%	77.8%	2.8%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.429(a)	2	.297
Likelihood Ratio	2.858	2	.240
Linear-by-Linear Association	2.222	1	.136
N of Valid Cases	36		

a 4 cells (66.7%) have expected count less than 5. The minimum expected count is .50.

A2.15 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
member of trade union * group	36	94.7%	2	5.3%	38	100.0%

member of trade union * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
member of trade union	no	% within member of trade union	22.2%	77.8%		100.0%
		% within group	85.7%	75.0%		75.0%
	yes	% within member of trade union	11.1%	77.8%	11.1%	100.0%
		% within group	14.3%	25.0%	100.0%	25.0%
Total		% within member of trade union	19.4%	77.8%	2.8%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.429(a)	2	.180
Likelihood Ratio	3.256	2	.196
Linear-by-Linear Association	1.667	1	.197
N of Valid Cases	36		

a 3 cells (50.0%) have expected count less than 5. The minimum expected count is .25.

A2.16 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
interest in living abroad * group	38	100.0%	0	.0%	38	100.0%

interest in living abroad * group Crosstabulation

			group			Total
			development related activities	support related activities	other	
interest in living abroad	no	% within interest in living abroad	11.1%	88.9%		100.0%
		% within group	14.3%	28.6%		23.7%
	yes	% within interest in living abroad	20.7%	69.0%	10.3%	100.0%
		% within group	85.7%	71.4%	100.0%	76.3%
Total		% within interest in living abroad	18.4%	73.7%	7.9%	100.0%
		% within group	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.643(a)	2	.440
Likelihood Ratio	2.359	2	.307
Linear-by-Linear Association	.002	1	.969
N of Valid Cases	38		

a 3 cells (50.0%) have expected count less than 5. The minimum expected count is .71.

BRAZIL

A2.17

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
isic rev3 * year	66	100.0%	0	.0%	66	100.0%

isic rev3 * year Crosstabulation

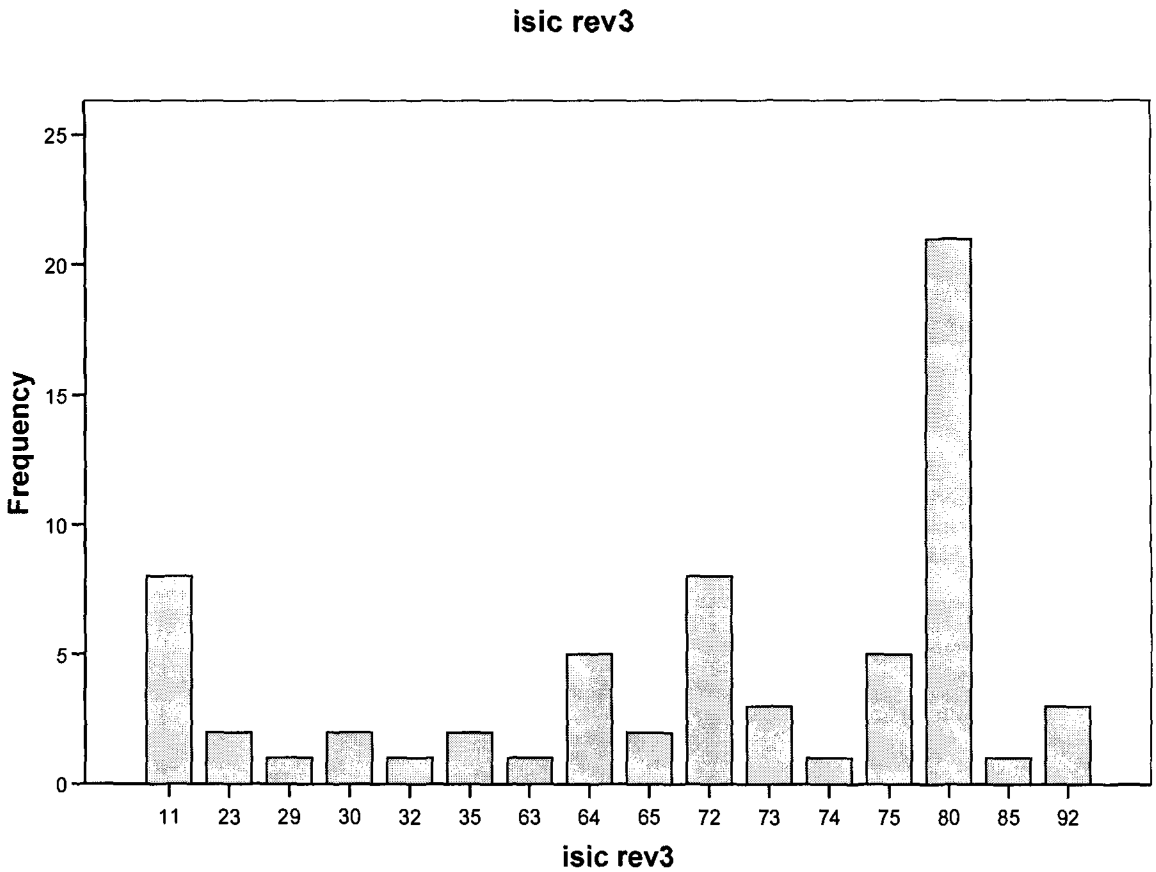
% of Total

		year 1	year 2	Total
isic rev3	11	7.6%	4.5%	12.1%
	23	3.0%		3.0%
	29		1.5%	1.5%
	30		3.0%	3.0%
	32	1.5%		1.5%
	35		3.0%	3.0%
	63		1.5%	1.5%
	64	4.5%	3.0%	7.6%
	65		3.0%	3.0%
	72	3.0%	9.1%	12.1%
	73	1.5%	3.0%	4.5%
	74	1.5%		1.5%
	75	1.5%	6.1%	7.6%
	80	18.2%	13.6%	31.8%
	85		1.5%	1.5%
	92	3.0%	1.5%	4.5%
Total		45.5%	54.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	18.200(a)	15	.252
Likelihood Ratio	23.312	15	.078
Linear-by-Linear Association	.146	1	.702
N of Valid Cases	66		

a 30 cells (93.8%) have expected count less than 5. The minimum expected count is .45.


isic rev3
Frequency
25
20
15
10
5
0
11
23
29
30
32
35
63
64
65
72
73
74
75
80
85
92
isic rev3

A2.18 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
other studies pursued * year of graduation	66	100.0%	0	.0%	66	100.0%

other studies pursued * year of graduation Crosstabulation

% of Total

		year of graduation		Total
		2004	2005	
other studies pursued	no	12.1%	27.3%	39.4%
	yes	33.3%	27.3%	60.6%
Total		45.5%	54.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.732(b)	1	.053		
Continuity Correction(a)	2.818	1	.093		
Likelihood Ratio	3.802	1	.051		
Fisher's Exact Test				.077	.046
Linear-by-Linear Association	3.675	1	.055		
N of Valid Cases	66				

a Computed only for a 2x2 table

b 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.82.

A2.19 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
type of studies * year of graduation	66	100.0%	0	.0%	66	100.0%

type of studies * year of graduation Crosstabulation

% of Total

		year of graduation		Total
		2004	2005	
type of studies	none	12.1%	27.3%	39.4%
	certification	3.0%		3.0%
	post-grad	28.8%	25.8%	54.5%
	both	1.5%	1.5%	3.0%
Total		45.5%	54.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.457(a)	3	.141
Likelihood Ratio	6.285	3	.099
Linear-by-Linear Association	2.610	1	.106
N of Valid Cases	66		

a 4 cells (50.0%) have expected count less than 5. The minimum expected count is .91.

A2.20 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
nature of post-grad courses * year of graduation	66	100.0%	0	.0%	66	100.0%

nature of post-grad courses * year of graduation Crosstabulation

% of Total

		year of graduation		Total
		2004	2005	
nature of post-grad courses	none	15.2%	27.3%	42.4%
	other	4.5%	12.1%	16.7%
	EPS	25.8%	15.2%	40.9%
Total		45.5%	54.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.876(a)	2	.053
Likelihood Ratio	5.966	2	.051
Linear-by-Linear Association	4.015	1	.045
N of Valid Cases	66		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.00.

A2.21 Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
post-grad * year of graduation	66	100.0%	0	.0%	66	100.0%

post-grad * year of graduation Crosstabulation

% of Total

		year of graduation		Total
		2004	2005	
post-grad	none	15.2%	27.3%	42.4%
	full-time	18.2%	12.1%	30.3%
	other	12.1%	15.2%	27.3%
Total		45.5%	54.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.786(a)	2	.248
Likelihood Ratio	2.800	2	.247
Linear-by-Linear Association	.579	1	.447
N of Valid Cases	66		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.18.

A2.22 **Case Processing Summary**

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
msc/phd * year of graduation	66	100.0%	0	.0%	66	100.0%

msc/phd * year of graduation Crosstabulation

% of Total

		year of graduation		Total
		2004	2005	
msc/phd	none	15.2%	27.3%	42.4%
	msc	18.2%	27.3%	45.5%
	phd	12.1%		12.1%
Total		45.5%	54.5%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.031(a)	2	.004
Likelihood Ratio	14.070	2	.001
Linear-by-Linear Association	6.671	1	.010
N of Valid Cases	66		

a 2 cells (33.3%) have expected count less than 5. The minimum expected count is 3.64.

References

Arocena, R. and Sutz, J. (2006) “Brain Drain and Innovation Systems in the South”, *International Journal on Multicultural Societies,* vol. 8, no. 1, pp. 43-60

Arora, A. and Gambardella, A. (1994) “Evaluating Technological Innovation and Utilizing it: scientific knowledge, technological capability, and external linkages in biotechnology”, *Journal of Economic Behaviour and Organization,* vol. 24, issue 1, pp. 91-114

Arundel, A. and Geuna, A. (2004) “Proximity and the use of public science by innovative European firms”, *Economics of Innovation and New Technology,* 13 (6): 559-580

Bell, M. (1984) “Learning and the Accumulation of Technological Capacity in Developing Countries, in Fransman and King (eds.), *Technological Capability in the Third World,* Macmillan

Bell, M. (1988) “The Development of Scientific and Technological Institutions in Africa: some past patterns and future needs”,

Bell, M. and Pavitt, K. (1993) “Technological Accumulation and Industrial Growth: contrasts between developed and developing countries”, *Industrial and Corporate Change,* vol. 2, no. 2, pp. 157-211

Bennell, P. (1984) “The Utilisation of Professional Engineering Skills in Kenya”, in Fransman and King (eds.), *Technology Capability in the Third World,* Macmillan

Cohen, W. and Levinthal, D. (1989) “Innovation and Learning: the two faces of R&D”, *Economic Journal,* no. 99, pp. 569-596

D’Este, P. and Patel, P, (2005) “University-Industry Linkages in the UK: what are the factors determining the variety of interactions with industry?” *Triple Helix Conference: The Capitalisation of Knowledge*

Figeuiredo, P. (2002) “Does Technological Learning Pay-off? Inter-firm differences in technological capability accumulation paths and operational performance improvement”, *Research Policy,* vol. 31, pp. 73-94

Government of Kenya (2006) “ICT Strategy for Economic Growth”, *Ministry of Information and Communications*

Government of Kenya (2006) "National Information, Communications and Technology (ICT) Policy, *Ministry of Information and Communications*

Government of Kenya (2006) "Statistical Abstract" *Ministry of Planning and National Development,* Central Bureau of Statistics

Ichniowski, C., Shaw, K. and Prennushi, G. (1997) "The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines", *The American Economic Review,* vol. 78, no. 3, pp. 291-313

King, K. (1984) "Science, Technology and Education in the Development of Indigenous Technological Capability", in Fransman and King (eds.), *Technology Capability in the Third World,* Macmillan

Lall, S. (1992) "Technological Capabilities and Industrialisation" *World Development,* vol. 20, no. 2, pp. 165-186

Lall, S and Teubal, M. (1998) "Market Stimulating Technology Policies in Developing Countries: a framework with examples from East Asia, *World Development,* vol. 26, no. 8, pp. 1369-1385

Laursen, K. and Salter, A. (2004) "Searching High and Low: what type of firms use universities as a source of innovation?", *Research Policy,* vol. 33, issue 8, pp. 1201-1215

Mohnen, P. and Roller, L.H. (2005) "Complementarities in Innovation Policy: an international comparative analysis", *European Economic Review,* vol. 49, issue 6, pp. 1431-1450

Mwamadzingo, M. (1996) "The Interaction of Universities and Industry in Science and Technology in Kenya", *DPhil thesis,* SPRU, University of Sussex

O'Mahony, M. and van Ark, B. (eds.) (2003) "EU Productivity and Competitiveness: an industry perspective can Europe resume the catching-up process?, *European Union,* Luxembourg http://www.ggdc.net/dseries/iga.html

Wamae, W. (2006) "Why Technological Spillovers elude Developing Countries", *DRUID working paper series,* no. 2

Wangwe, S. (1992) "Building Indigenous Technological Capacity in African Industry: An overview", in Stewart, F., Lall, S. and Wangwe, S. (eds.), *Alternative Development Strategies in Sub-Saharan Africa*, Macmillan