A SURVEY OF UNIVERSITY–INDUSTRY INTERACTIONS AMONG SELECTED BIO-SECTOR FIRMS IN UGANDA

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ABSTRACT

The Uganda situation is characterised by a low level of economic development, which is reflected in its dualistic economy between the 'modern' sector and the 'traditional/a subsistence' sector, resulting in a big gap between the incomes of the urban-based economic and political elite and the vast majority of the people in the country-side. Beside this dualism between the urban and the rural, there is also a wide gap between the foreign operated (multinational) companies and the Ugandan owned small enterprises that find it difficult to survive the competition from the big foreign firms.

Uganda has also been characterised by an unstable political environment, especially in the period 1962-1986. The result is that there has been a constant disruption of its educational institutions, including its well-known Makerere University, which has failed to emerge as an institution of higher learning providing high level manpower focused on the development of the country. Government policy in the teaching of science in the country was also affected and Uganda has moved a long a path of development that has been extremely reliant on its peasant-based agricultural sector.

The interaction between firms, especially Ugandan small firms, although it exists is rather informal in nature. There are no formal arrangements between the University and firms. The university primarily involved in the arrangement is Makerere University and the Ministry of Health Directorate under the Natural Chemotherapeutics Research Laboratory. The emergent trend in the linkages is that they appear to be forced on the firms. There is little conscious effort by the firms to link with the public research institutes and the university as a result of the bio-sector programme. This suggests the need for a more coordinated national policy framework that can consciously develop the Universities as developmental institutions that seek to link and interact with firms in the development of a national system of innovation.

Keywords: University-firm interactions, small-sized firms, Uganda, Universities, firms, developmental university, survey.

BACKGROUND

There is a widening learning divide in the global economy and challenges arising from transforming resource-intensive activities into knowledge intensive assets. The differences that manifest themselves across countries and sectors and its implications for situating the potential of, and extent to which universities and public funded research spurs innovation capability in the industries is the focus of this survey.

The International Development Research Centre (IDRC) through the Human Sciences Research Council of South Africa funded this survey entitled **"Knowledge for Development: University Firm Interactions in Sub-Saharan Africa"**. The survey focuses on three African countries at differing levels of development- South Africa, Nigeria and Uganda. Each country focuses on a particular sector, Nigeria on agro-food processing, South Africa biotechnology and for Uganda's case indigenous knowledge.

Uganda is classified in some literature as belonging to the cluster of "catch-up" economies, characterized by under developed knowledge economy and technology. The development of these synergies, it is argued, can best be achieved through university industry linkages- public funded research closely cooperating with industry to develop products for the market. Yet despite their apparent promise research about these linkages and collaborations is still scanty and lacking an integrated perspective. Equally arid is survey data on the attitudes, experiences and lessons of firms on their innovative capabilities. As has been observed, "research on innovative behaviour at the firm level is largely missing for developing countries and especially for Africa. The absence of survey data providing information on innovation on learning in firms lies at the origin of this problem".[1]

The survey is made up of two components. The first, designed to inform the firm level survey, sought to describe and analyze Uganda's national strategic policy framework and steering mechanism pertinent to innovation in general and the bio-sector in particular. It also sought to provide an overview of current research and technology development activity in Uganda in general and the bio-sector in particular. The second component is the firm level survey.

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[1] Goedhuys, Micheline (2005) Learning, product innovation and firm heterogeneity in Tanzania. UNU-MERIT Discussion Paper 2005-7. Maatricht: United Nations University.

Methodology

Data was gathered from a survey among 50 managers who deal with research and development or technology or product development in their firms. The survey instrument was an HSRC-designed questionnaire, which was an adaptation of one used in similar surveys in the USA (1995, 2002), South Africa (2003) and Brazil (2005). The adapted survey instrument asked a set of 19 questions divided into six sections namely: innovative and research and development activities; sources of information and knowledge; science and engineering fields; collaboration with universities and public research institutes and role of universities.

The concept of innovation that informs the survey holds that any new or improved technological product, process and form of organization produced by the firm in the past three years regardless of whether it is new to the world, the country or the industrial sector in question is acceptable.

It was planned to distribute the questionnaire to 50 bio-sector related firms on the basis of random sampling from the Registry of Companies. Subsequently, databases of the Uganda National Chamber of Commerce and Industry, the Uganda Bureau of Statistics, Natural Chemotherapeutics Research Laboratory (a directorate in the Ministry of Health) and the Uganda Export Promotion Board were also consulted. The target was to cover 20 small and medium sized firms-SMEs (of which 10 would be indigenous knowledge-based) and 30 large enterprises. The final categorization of a firm was left to returns about workforce size from the questionnaire responses.

Methodological challenges

The determination of who to survey initially relied on the Registry of Companies but this turned out to be less helpful than expected. The records at the Registry of Companies do not capture adequately the field of specialization- indigenous knowledge. The prospective respondents were instead identified using data from the Natural Chemotherapeutics Research Laboratory and Uganda Export Promotion Board.

Difficulty was also encountered in locating the physical addresses as some had either changed or were in distant places with poor access roads. There was apparent suspicion and mistrust from the

respondents considering the nature of their sector, indigenous knowledge. This may explain in part the low response to the questionnaires sent out.

As for the remaining 10 small scale and 30 medium and large size enterprises, the Registry of Companies proved defective as a population framework for random sampling. Consequently the random sampling had to be replaced by purposive physical sampling through some five industrial zones of Kampala namely; Ntinda, Bweyogerere, Kawempe and Namuwongo-Bugolobi and Nalukolongo. The Registry and related databases turned out to be hopelessly out of date or carried inadequate information. For example some of the companies had wound up (collapsed); others were inaccessible because they had changed addresses or the nature of business; still others appeared never to have existed beyond the Registry and other databases.

Secondly even when one succeeded to track down the firms, they remained reluctant and suspicious mistaking the exercise to be somehow connected with tax authorities. Many respondents found the questionnaire 'too long' and 'time consuming' 'tedious' and difficult to follow in some parts. Some, for example, could not tell whether routine quality control counted among research and development activities; others had no idea what intellectual property issues' or a firm being a 'spin-off' of a university for public research institute or 'prototypes' meant.

It is was not uncommon for a respondent to indicate under "General information" that the firm had no workers with post-graduate degrees only to assert under question 11, that recently hired graduates with advanced degrees were one of the firm's sources of information. Others declared that their firms are owned by a public institute or a university when that is obviously not the case. In other instances, some respondents would answer that universities and public research institutions were important information sources for innovation and then at the same time proceed to answer question 9 which was meant for those who had answered in the negative.

Such 'misinterpretation' could be put down to a certain attitude of perfunctoriness associated with doing a tedious task. But is could also be due to the caliber of the respondents. We found out that several firms have designated public relations official or front desk managers-cum-office security to handle all inquiries including questionnaires apparently. Some officials would insist on knowing first

whether and how government stood to benefit from our survey, whether government, etc had cleared the survey. In the event some retained the questionnaire or kept on postponing to fill in the hope that the researcher would give up. The most notorious in this regard were the firms owned by investors from the Indian sub-continent.

A total of 14 questionnaires were hand delivered to prospective respondents engaged in Indigenous Knowledge but only four (4) responded namely: **Tropical Aloe Lands Foundation, Theta, Adam & Eve, Natural Health Care Consultants (NAHECO).** Those that did not respond were: **Mant Herb Oil, Human Energy Ltd., Genapo, Kato Aromatic, Praunus Rwenzori, Flona Commodities, Buddu Enterprises, Black Herbals on the Nile, Prometra, East African Botanicals Uganda Ltd.**

To ensure an adequate response rate among the rest of the small scale industries as well as the medium and large sized ones, concerted effort was made to follow up those who seemed to be taking inordinate time to complete questionnaire it or were simply finding it hard to follow by themselves. In this way, 32 returns out of 40 were obtained.

For purposes of comparison the data is analyzed using the descriptive (exploratory) approach; it is summarized and presented in the form of frequency distribution and weighted average index tables. The weighted average index (WAI) measure has been applied to Likert verbal-numerical scale responses. The differential weights attached to the responses facilitate the multiplication of response frequencies with their denoted values, which are then added up and divided by the summation of the response frequencies.

FINDINGS OF THE STUDY

The survey produced 36 firms with responses adequate for analytical purposes. Section (a) carries an integrated analysis for the 36 firms as a whole as well as a disaggregated analysis for the 14 small-scale firms. Thus tables present findings for both the 36 firms taken together and the small-scale firms whose findings appear in parentheses alongside the aggregate data. Since indigenous knowledge was the focal technology platform of the Ugandan survey, section (b) presents yet another disaggregated analysis for the bio-pharmaceutical (herbal) sub-sector.

(A) INTEGRATED ANALYSIS AND SMALL-SCALE FIRMS

Table 1 gives a breakdown of the surveyed firms by sub-sector. The majority (11) are in agro-processing (coffee, sugar, seed multiplication and tobacco), followed by food processing (7) (grain milling, baking and confectionary) bio-pharmaceutical-herbal processing (4), floriculture (3), poultry breeding and animal nutrition (3), fish processing (2), wine and beverages (2), and one each from dairy, chemical, paper, and agro-machinery industries.

Table 1: Classification of firms surveyed by sub-sector

Sub-sector	Frequency
Sugar	4
Coffee	4
Bio-pharmaceutical (Herbal)	4
Grain milling	4
Bakery and confectionery	3
Poultry breeding and animal nutrition	3
Floriculture	3
Seed multiplication (cereals and agro-forestry)	2
Wines and beverages	2
Fish processing	2
Tobacco	1
Dairy processing	1
Paper manufacturing	1
Bio-chemical (cosmetics)	1
Agro-machinery	1
Total	**36**

(i) Age and firm size

The relationship between the age and size of a firm and its innovative capabilities was not an issue of specific investigation in this survey. However, previous forays into this issue by Rasiah and Tamale for example, found that age conferred only marginal influence on experiential and tacit knowledge.[2] This survey produced sixteen firms falling between 10 and 19 years; eight between 20 – 29; seven between 1 and 9, one between 30 and 39 and two over 50 years. A majority of the firms are small-scale enterprises.

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[2] Rasiah, Rajah and Henry Tamale (2004), Productivity, Exports, Skills and Technological capabilities; A Study of Foreign and Local Manufacturing Firms n Uganda UNU-INTECH Discussion Paper 2004 – 1,Maarshtricht: United Nations University.

Table 2: Categorization of firms by workforce size

Category	Frequency	Percent
Small-scale (1 - 50)	14	39.0
Medium – scale (51 – 200)	11	30.5
Large – scale (> 200)	11	30.5
Total	**36**	**100**

Table 2 shows that 14 firms (39%) fall in the small-scale category. Eleven firms employ between 51 and 200 workers and are considered medium size. Another eleven firms employ over 200 workers and are treated as large scale. Actually, the sugar and tobacco firms being plantation-based employ well over 1000 workers each. Some 12 firms claim to employ between 30 and 50 workers on research and development activities, the rest have less than 10. Eight firms have no R & D staff with post-graduate qualifications and the rest have mostly one, two or three.

(ii) Innovative and Research and Development activities

The findings suggest that most of the innovative activities are rooted in experiential learning within the firms. In Table 3, 23 firms concentrate their innovative work on improvement of existing products and processes. 13 and 12 firms respectively considered that their product and process improvements were new for the firms but not for the country. On the other hand, 10 and 8 firms respectively consider their innovative product and process activities to be new for the country but not for the world. A similar trend is witnessed for the small-scale firms. However, it is among the small-scale firms that 2 of them stake a claim to having brought forth products and processes that are new to the world. Perhaps not surprisingly, the two firms are indigenous knowledge-based.

Table 3: Innovative and R & D activities

Products and Processes	New or significantly improved product *		New or significantly improved process *	
Nothing new	6	(1)	5	(2)
Improvement of an existing product or process	23	(10)	23	(8)
New for the firm but not country	13	(3)	12	(4)
New for country but not for the world	10	(6)	8	(4)
New to the world	2	(2)	2	(2)

Total	**31**	**28**

* **Values in parentheses are a disaggregation for small-scale firms**

(iii) Investment in R & D activities

In Table 4, nearly half the respondents (48.5%) report that their average R & D expenditure over the past three years did not exceed 5%. The integrated analysis shows that 10 firms invested on average, revenues ranging between 10 - 45 percent. Firms that have apparently invested heavily in quality control such as the fish processors claim such highs. However, on disaggregation it turns out that 8 of those 10 firms are actually small scale. This too should not be surprising because from experience small-scale firms engage in a lot of product experimentation, value addition and commercialization as part of their 'learning by doing' ethos and partly as a response to aggressive market competition have also heavily invested in research and development.

Table 4: Revenue invested in R & D activities

Estimated percent of revenue invested	Number of firms *	Percent*
Not provided	3 (1)	- (-)
0	3 (-)	9.1 (-)
0 – 5.00	16 (5)	48.5 (38.5)
5.01 – 10.00	4 (-)	12.1 (-)
10.01 – 15.00	1 (1)	3.0 (7.7)
15.01-20.00	2 (2)	6.1 (15.4)
20.01-25.00	1 (-)	3.0 (-)
25.01 – 30.00	2 (2)	6.1 (15.4)
31.00 – 35.00	1 (-)	3.0 (-)
35.00 – 40.00	2 (2)	6.1 (15.4)
>45	1 (1)	3.0 (7.7)
N	**36 (14)**	

* Values in parentheses are for small-scale firms.

(iv) Organization of R & D activities

In table 5, the integrated findings show that 56% of the firms organize their R & D on a regular basis. However, only 31% do so in a centralized manner while 25% decentralized their R & D activities.

57.2% of small-scale firms on the others hand carryout their R & D work on occasional basis; a majority of them (35.8%) work in a decentralized way and 21.4% have centralized operations.

Table 5: Regularity and organization of R & D

Manner of Organization	Percent of Reporting Firms *
Regular (continuous) and centralized	31 (21.4)
Regular (continuous) and decentralized	25 (21.4)
Occasional (non-continuous) and centralized	25 (21.4)
Occasional (non-continuous) and decentralized	19 (35.8)
Total	**100**

* Figures in parentheses are for small-scale firms.

(v) Reasons for not investing in R & D activities

The number of firms implicated is only 7(19%). The most important reason for small firms not investing in R & D is cost (WA13.0) followed by reservations about market size affording an attractive return on the investment (WAI2.8). Furthermore and perhaps not surprisingly – the firms hold the view that external sources (2.6) pretty well suffice for meeting their innovation needs. The composite picture presently strikingly similar reasons save that external sources (2.5) are put slightly ahead of cost (2.3) and the appropriatability of R & D results (2.3) is introduced as a new factor.

Table 6: Why firms do not invest in R & D

Reasons	Weighted Average Index *
Firm does not innovate	2.0 (1.6)
Small market size does not allow recovering R & D investments	2.1 (2.8)
R & D investments is too risky	1.6 (1.3)
R & D is too costly for the firm	2.3 (3.0)
Lack of access to credit	1.8 (2.2)
Difficulties to appropriate R & D results	2.3 (2.2)
Lack of public support	2.2 (2.0)
R & D is not necessary for the firm's innovation	2.1 (1.7)
External sources of information are sufficient for innovation	2.5 (2.6)
Universities substitute for firm's R & D	2.0 (2.2)
PRIs substitute for firm's R & D	1.9 (2.3)

* Values in parentheses for small-scale firms.

But irrespective of the size of the firm, table 6 shows that all of them attach the least consideration to riskness of R & D investments as factor for not committing financially to R & D.

(vi) Sources of information and knowledge

Table 7 shows that internal capabilities of the innovation system possessed by customers, indigenous knowledge experts and the firms own manufacturing operations hold sway as the main sources of information for suggesting new projects for 22 (64%) and 20 (55%) respondents respectively. These are supplemented by technical reports and publications but these again presuppose an internal (to the firm, that is) technical absorptive and processing capability. Even with small scale firms, it is the same picture because here again more firms reported that it is indigenous knowledge, technical publications and reports, and own manufacturing operations in that order which play the critical role in the suggestion of new projects.

Table 7: Sources of information and knowledge for firms.

Sources of Information	Suggested new projects *		Completion of existing projects. *	
Firms manufacturing operations	18	(8)	23	(9)
Affiliated suppliers	15	(4)	11	(5)
Independent suppliers	12	(5)	14	(4)
Customers	22	(8)	16	(5)
Universities	13	(5)	8	(5)
PRIs	10	(4)	12	(4)
Competitors	14	(3)	10	(2)
Coop/Joint Ventures	10	(3)	12	(2)
Consulting/Contracting R & D Firms	17	(6)	18	(7)
Fairs and Expositions	15	(5)	10	(4)
Tech. Publication and reports	20	(9)	14	(6)
Internet	15	(6)	15	(4)
IKS	20	(9)	18	(8)
Others	5	(4)	4	(4)

* Values in parentheses are for small-scale firms.

63% of all firms (23) and 64% (9) of small firms report that the completion of existing projects also relies heavily on the knowledge accumulated by firms in the course of their routine operations. But

once again indigenous knowledge is attributed by 50% of all small firms (8) to be the next important sources of information and knowledge. This is followed by consulting and contracting R & D firms and customers. The role of universities and PRIs is only slightly better than average.

(vii) Reasons for universities lagging as sources of information

As can be gleaned from the previous table 7, less than a third of the respondents ranked universities and public research institutes and generators of information and knowledge for either germinating or completing their projects. The weighted average indexes is table 8 suggest both perceptual and institutional barriers to productive interaction between universities and firms. The aggregated data for all firms gives a WAI 2.6 for the perceptual handicap that universities are seen as being concerned with **big science**. This is exacerbated by yet another perceptual (although it could very well be borne of true experience) contention that: universities/PRIs lack understanding of the firms' respective lines of business (WAI 2.5). A third but moderately important reason is that universities and PRIs are difficult to strike contracts with (2.2).

Table 8: Why universities and PRIs are not important as information sources for innovation

Reasons for universities/PRI not being Info Sources	Weighted Average Index *
Our firm's R & D enough to innovate	1.9 (1.1)
Universities have no understanding of our line of business	2.4 (2.4)
PRIs have no understanding of our line of business	2.5 (2.4)
Contractual agreements are difficult	2.2 (2.1)
Lack of trust	1.6 (2.9)
Quality of research is low	1.8 (2.1)
University concerned only with big science	2.6 (2.9)
Geographic distance	1.4 (1.3)
Difficulties in dialogue	1.8 (1.5)
Intellectual property issues.	1.9 (2.6)

* Values in parentheses are for small-scale firms.

Both the floriculturalists and sugar firms were particularly emphatic about the issue of universities and PRIs lacking understanding of their line of business. But, bearing in mind that sugar and flower plantations are important and long standing sites of field study for university agriculture faculty staff and students, it seems there is need for further research to establish whether the problem is actually

lack of understanding or lack of interest. If it is indeed the latter, then it world be worthwhile exploring the dynamics that shape which "interests" public universities and research centers engage with.

The conclusions already generated from in the study of policy and current research agendas do implicate donor pressures and institutional barriers. This might perhaps explain the finding here that, to the extent that firms gain form universities, they do so overwhelmingly through consulting with individual researchers, informal information exchange, public conferences and meetings and temporary personnel exchange. In other words the channels and level of interaction are more ad hoc than formal and institutionalized.

The perspectives of small-scale firms are very much in consonance with the general trend but they introduce a telling new factor – lack of trust. To put this in context one has to see that while intellectual property issues are only slightly important in the aggregate WAI (1.9), they rank second (2.6) among the reasons advanced by small scale firms hence the information and knowledge distance, at least for some of the firms might be more calculated than enforced.

(viii) Access R & D activities of other firms

The external sources already highlighted in table 6 are instances of innovative contributions inherent firm-to-firm interactions. The findings presented in table 9 suggest that the main channels for accessing information about the R & D activities of other firms are not structural formal. The aggregate and small-scale firm WALs indicated that information is accessed by way of public conferences and meetings (3.2 and 3.7) informal information exchange (3.2 and 3.7). Publications and reports (3.1) and fairs and expositions (2.9) also avail a moderately important amount of information for the 36 firms as a whole.

Table 9: channels of information about the R & D activities of other firms.

Channels	Weighted Average Index *	
Patents	1.9	(2.1)
Publications and reports	3.1	(2.3)
Public conferences and meetings	3.2	(3.7)
Informal information exchange	3.2	(3.7)
Recently hired technical personnel	2.6	(3.5)
Licensed technology	2.3	(2.9)

Joint or cooperative R & D projects	2.8	(2.5)
Contract research with other firms	2.5	(2.4)
Products (for example by reverse engineering)	2.5	(2.8)
Trade associations	2.7	(3.0)
Fair and expositions	2.9	(2.5)

* Values in parentheses are for small-scale firms.

But these are not that important for the small-scale firms. Instead for them it is the hiring of technical personnel (3.5) and membership in trade associations (3.0) which feature as critical information sources. Actually both the last two channels are closely interrelated in the experience of small-scale firms in Uganda. Membership bodies such as the Uganda-scale Industries Association came into being specifically to promote firm-to-firm sharing of knowledge and expertise and also to procure technical personnel at shared cost who then goes on renders a shared service such as passing on R & D information.

(ix) Information channels, interaction modes for accessing research outputs of universities/PRIs.

Table 10 underpins once again lack the of formalized channels and modes for bringing firms and academia into structured collaboration. The activities and findings are mostly accessed through public conferences and meetings (2.8), informal information exchange (2.7), consultations with individual researchers (2.7) and publications and reports (2.6). True contracting research with universities and PRIs (2.5) as well as participating in networks that involve them (2.4) also feature but their contribution is more marginal than central to the process.

Table 10: Channel of information and modes of interaction about research activities or findings of universities and PRIs

Channels/Modes	**Weighted Average Index ***			
	University		**PRIs**	
Patents	1.5	(1.7)	1.8	(1.9)
Publications and reports	2.6	(2.5)	2.9	(3.1)
Public conferences and meetings	2.8	(3.3)	3.1	(3.3)
Informal information exchange	2.7	(3.5)	2.1	(3.3)
Recently hire graduates with advanced degrees	2.2	(2.3)	2.1	(2.3)

Licensed technology	1.9	(1.9)	2.0	(2.2)
Consulting with individual researchers	2.7	(3.2)	2.6	(3.5)
Contracting research with universities/PRIs	2.5	(3.2)	2.3	(2.8)
Joint or cooperative R & D projects	2.3	(2.8)	2.4	(2.5)
Participating in networks that involve universities/PRIs	2.4	(3.2	2.4	(3.2)
Temporary personnel exchanges	1.9	(2.5)	1.9	(2.5)
Incubators	1.5	(1.9)	1.7	(1.9)
Science and/or technology parks	1.9	(2.3)	2.0	(2.3)
Firm is owned by a university or PRI	1.4	(1.5)	1.6	(1.7)
Firm is a spin-off of a university or PRI	1.5	(1.8)	1.5	(1.9)

* Values in parentheses are for small-scale firms.

The same trend applies to small-scale industries. It is also worth observing that the kind or level of knowledge collaboration and diffusion of knowledge infrastructure based on patents, incubators, firm spin-offs and science/technology parks scores very low either because it is non-existent or still in infancy. Patents, for example, are still confined to a few, affiliate firms, a fact that was also point doubt in a recent World Bank study.[3]

Table 11: Importance of universities/PRI outputs and resources for firm innovative activities.

Output/Resources	Weighted Average Index *	
Research findings	2.8	(3.3)
Prototypes	2.0	(2.1)
New techniques and instruments	3.0	(3.2)
Laboratories and metrology	2.7	(2.3)

* Values in parentheses are for small-scale firms.

Table 11 above indicates that firms that seek out the research outputs of universities for their own innovation, which could support their own innovative activities, are mostly intent on new techniques and instruments (WAI 3.0) research findings (2.8) and laboratory faculties (2.7). Scale-scale firms put research findings (3.3) slightly ahead of new techniques/instruments (3.2). Much like the aggregate trend, the use of research laboratories is given third priority. Both category of WAIS suggest that bringing forth or testing prototypes has hardly been an engaging research output for interaction

[3] Oyelelaran-Oyeyika, B and P. Gehl Sampath (2007) Innovation in African Development, case studies of Uganda, Tanzania and Kenya. Washington, D.C., World Bank.

between firms and universities although the agro-processing technology until in Makerere's Faculty of Agriculture as well as the departments of mechanical engineering in both Makerere and Kyambogo public universities have been active with them.

(x) Contribution of university/PRI science and engineering fields to firm innovative activities.

Kyambogo University, Makerere University, the National Bureau of Standards and the National Chemotherapeutics and Research Laboratory are named by most respondents as the key institutions of science and engineering which have made the most contribution to the innovative activities of firms. In table 12 the fields of agronomy (2.9 and 3.1) and food science and technology (2.8 and 3.1) are at the forefront of the interactions between universities and industry. Both fields are closely connected with the bio-sector. Small-scale firms add biology (3.1) chemistry (2.7) and computer science (2.8).

Table 12: Contribution of university and PRI science/ engineering fields to firm innovative activities

Field	Weighted Average Index *	
Agronomy	2.9	(3.1)
Computer Science	2.4	(2.8)
Food Science & Technology	2.8	(3.1)
Biology	2.3	(3.1)
Industrial Design	2.3	(2.5)
Civil Engineering	2.0	(2.2)
Materials Engineering/Metallurgy	1.9	(2.2)
Mining Engineering	1.1	(1.6)
Electrical Engineering	2.5	(2.6)
Mechanical engineering	2.6	(2.9)
Chemical engineering	2.0	(2.4)
Physics	1.7	(2.3)
Geosciences	1.0	(2.3)
Mathematics	2.2	(2.3)
Medicine	1.9	(2.4)
Veterinary science	2.3	(2.4)
Chemistry	2.1	(2.7)

* Values in parentheses are for small-scale firms.

Other fields prominently mentioned were mechanical and electrical engineering. Most of staff occupying positions in R & D, technology and product development actually graduated over the past 10 years. Some are now back at their former institutions as part time post-graduate students. Hence what appears like a contribution of the university is actually down to the personal initiatives and research interactions of these staff as they pursue their higher degrees. This is more of tacit than explicit contribution by the universities. However, the contribution of both the National Bureau of Standards and the National Chemotherapeutics and Research Laboratory have been more explicit as they are concerned with quality and efficacy. This could also account for the moderately marked role of the fields of computer science and chemistry.

(xi) **Collaboration with Universities and Public Research Institutes**

The point made above about quality control is collaborated by the findings presented in table 13. The main objectives of collaboration are to perform tests necessary for the firm's products and processes (3.4) as well as seek help in quality control (3.3). The other equally significant objectives relate to product and process improvements through using university resources and public laboratories (3.3) and obtaining technological and consulting advice (3.1). The trend is the same for small-scale firms although it must be noted that for them the key objective is to contract research by universities and PRI labs that is helpful to their innovative activities (3.6).

Table 13: Reasons for collaboration between firms and universities/PRIS

Objectives of collaboration	**Weighted Average Index ***	
Technology transfer from the University	2.7	(2.8)
Technological/consulting advice to solve production-related problems	3.1	(3.3)
Augment firm's limited ability to find and absorb technological information	2.3	(2.6)
Get information about engineers/scientists/trends in R & D	2.4	(2.4)
Contract complementary research by universities and public labs helpful to firm's innovative activities	2.6	(3.6)
Contract research that firm can't perform	2.8	(3.1)
Value earlier contact with excellent university students for future recruiting	2.4	(2.6)
Use resources available at universities and public labs	3.3	(3.2)
Perform tests necessary for firm's products/processes	3.4	(3.4)
Help in quality control.	3.3	(3.4)

* Values in parentheses are for small-scale firms.

Although collaboration is not yet as extensive as would be desired, at least for those involved, the evaluation is positive about the outcomes. A majority of respondents (52% and 59%) report in Table 14 below that the collaboration is on going; nevertheless they are hopeful about the future. For the rest (41% and 33%) the outcomes are rated successful so far.

Table 14: Evaluation of collaboration outcomes

Rating	Percent *
Successful, so far	41 (33)
Not been successful	7 (8)
Still going on but trust will meet objectives	52 (59)
Not been competed but not expected to meet objectives	Nil (Nil)

* Values in parentheses are for small-scale firms.

The period of collaboration for the majority of respondents (54%) among small-scale firms is less than 5 years whereas only 47% of the aggregate figures fall in category. In fact, (38%) of the firms report collaboration stretching over 5 years but less than 10 years.

Table 15: Length of collaboration

Length	Percent *
Not important so far	Nil
Less than a year	Nil
Less than two years	14 (23)
Less than five years	33 (31)
Less than ten years	38 (15)
More than ten years	14 (23)

* Values in parentheses are for small-scale firms.

Remarkably Table 15 shows that (23%) of small-scale firms, which is higher than the aggregate figure (14%) boast more than 10 years of collaboration. Those that fault the collaboration attribute this development to a mismatch between the knowledge that the university has to offer and what the firm needed for its innovative activities.

(xii) WHY COLLABORATION HAS FAILED TO MEET EXPECTED OBJECTIVES

The key reasons given in table 16 by the 36 firms as a whole as well as small-scale firms is knowledge mismatch and the perceived low appreciation by universities of the needs and demands of firms. When this is coupled by perceived differences in points of view as well as appropriability of results, the point made earlier about mistrust is reinforced.

Table 16: Reasons why collaboration with universities/PRIS failed to meet expected objectives.

Reasons	Weighted Average Index *	
Knowledge mismatch	3.3	(3.7)
Differences in timing	2.2	(2.5)
Differences in points of view/objectives	2.0	(3.0)
Researchers too "science-oriented"	2.5	(3.0)
Researchers not "science-oriented" enough	1.6	(2.0)
Low sensitivity of universities to firm demands	3.0	(3.7)
Differences over appropriability of results	2.4	(3.0)
Lack of preparation of firm's personnel to deal with university	2.0	(2.0)
Other (universities/PRIs not interested in our field of work	1.0	(4.0)

* Values in parentheses are for small-scale firms.

(XIII) ROLE OF UNIVERSITIES

The most important role envisaged for universities is research, and then teaching followed by entrepreneurship and social engagement. The fact that the entrepreneurial and research roles are accorded such prominence dovetails well with the argument that the integration of the university in the national innovation process will entail bringing together some aspects of STI, DUI and Indigenous Technical Knowledge

Table 17: Role of universities

Role	Weighted Average index *	
Teaching	3.0	(2.7)
Research	3.0	(3.2)
Social	2.3	(2.3)
Entrepreneurial	2.5	(2.2)

* Values in parentheses are for small-scale firms.

(B) INDIGENOUS KNOWLEDGE-BASED FIRMS

(i) **THETA** is engaged in provision of health services drawing heavily on traditional medicine. It has a total of 18 full time employees with 5 of them dedicated to R&D activities of which 2 have post-graduate qualifications. 20% of its revenue is ploughed back to research.

The firm has been in collaboration with university and public research institutes for over 10 years. The collaboration has been instrumental in suggesting new products and completion of existing projects. On a scale of 1-4, the role of the university and public research institutes is rated at 4 in the fields of medicine and chemistry.

The use of university and public research contribution in the last 3 years was rated 4 for research findings, 2 for prototypes, new techniques and 3 for instruments and laboratories at 2. The university and public research institute was found to be very important in consulting advice in solving production related problems, complementary research, use of laboratories in performing tests and quality control. This was the best respondent.

(ii) **Natural Health Care Consultants (NAHECO)** are herbal processors with a total of 7 staff of who two are dedicated to R&D with post-graduate qualifications at PhD level. 10% of revenue is ploughed into research. The firm has collaborated with university and public research institutes for over 5 years.

The importance of the collaboration was scored at 4, involving technology transfer, consulting advice, getting trends in R&D, use of public laboratories, performing tests and quality control. The university was rated at 4 for its importance in collaboration.

(iii) **Tropical Aloe Lands Foundation**, a herbal supplements firm with 24 employees with 2 of them dedicated to R&D none with graduate qualifications. 40% o the revenue is invested in R&D.

The firm is heavily reliant on Indigenous Knowledge. The firm views university as being concerned with big science. Contracting research with public research institutes on the other

hand, is regarded as moderately important. The firm does get technological/consulting advice from public research institutes in solving production related problems and use university and public research institutes laboratories for tests and quality control are rated as very important. The collaboration has been on for less than 2 years. The firm rated the role of the university as very important in teaching, research, social and entrepreneurial.

(iv) **Adam & Eve** founded in 1987 by a graduate of naturopathic medicine from Nanjing University, China invests 30% of its revenue in R& D. The source of the firm's innovative operations are public research institutes, university and indigenous knowledge in suggesting new projects and contribution to existing projects. It does contract research with university. Makerere University and the Natural Chemotherapeutics Research Laboratory were scored as very important to the firm's innovative activities in agronomy, food science and technology, medicine and veterinary. University and public laboratories resources in their use for processes/products and control were evaluated as very important. Collaboration with University and public research institutes has been on for over 10 years.

Emerging Issues

Uganda has made concerted efforts to link universities closely with the private sector. The Uganda National Council of Science and Technology, a statutory body established in 1990 a successor to the National Research Council of 1970 whose mandate is to coordinate all science related research activities has with funding from the World Bank designed a strategy to develop the further application of Indigenous Knowledge in conjunction with universities. At a broader level the Private Sector Foundation, Uganda Manufacturers Association and the Uganda Export Promotion Board under its bio-trade programme have sought to promote forms of indigenous knowledge that lend themselves to commercialization with the active participation of the Natural Chemotherapeutics Research Laboratory, Faculty of Forestry and Nature Conservation and the Faculty of Science under the Department of Ethno-botany all of Makerere University. For example, the Uganda Export Promotion Board organizes these firms and directly links them with the research institutes and further opens up internal and export markets through regular trade fairs and keeping a data bank of the firms' activities.

From the firms surveys conducted herein, it does emerge that there are indeed university firm interactions occurring though at an informal level. No formal arrangements were found to be in place. The university principally involved in the arrangement is Makerere and the Ministry of Health Directorate under the Natural Chemotherapeutics Research Laboratory.

The emergent trend in the linkages is that they appear forced on the firms rather than a conscious effort by the firms to link with the public research institute and the university as a result of the bio-sector programme at the Uganda Export Promotion Board which requires strict measures for chemical and quality control, thus the involvement of the Natural Chemotherapeutic Research Laboratory.

PROFILE OF BIO-SECTOR FIRMS SURVEYED IN UGANDA

Firm name	Industrial category	Foundation year	Address	Location	No of employees	No of R & D Staff	No of R & D with Post Grad	Origin of capital	Respondents' Category
BATU	Agro Processing	1927	Box 7100 K'La	K'La	350	35	0	Shares	Product development
Kakira Sugar Works (1985) Ltd	Agro Processing	1930	Box 121 Jinja	Kakira, Jinja	3600	30	2	Shares/loans	Product development
Kinyara Sugar Ltd	Agro Processing	1993	Box 179 Masindi	Masindi	90	36	1	Shares/ gov't grants & loans	Product development
SCOUL	Agro Processing	1985	Box 1 Lugazi	Lugazi	2100	10	0	Shares/loans	R & D (crop science)
Victoria Seeds Ltd	Agro Processing	2004	Box 11913 K'La	K'La	41	Not provided	Not provided	Not provided	Product development
Agro Enterprises E.A. Ltd	Agro Processing	2002	Box 303 K'La	K'La	90	10	2	Shares	Accounting
Ugacof Ltd	Agro Processing	1994	Box 7355 K'La	Bweyogerere	640	3	0	Shares	Logistics
Great Lakes Coffee Co. Ltd	Agro Processing	1999	Box 27198 K'La	K'La	100	Not provided	Not provided	Not provided	Quality Control
Kyagalanyi Coffee Factory	Agro Processing	1992	Box 3181 K'La	K'La	90	Not provided	Not provided	Not provided	Finance/Accounting
Union Export	Agro Processing	1995	Box 7455	K'La Ntinda	12	Not provided	Not provided	Not provided	Quality Control

Services			K'La						
Delight U Ltd	Food Processing	1986	Box 1765 K'La	K'La Kawempe	128	4	2	Individual capital	Marketing
Britania Allied Industries	Food Processing	1993	Box 17518 K'La	K'La Ntinda	1000	20	8	Shares	Quality Control
Hot Loaf Bakery Ltd	Food Processing	1986	Box 2283 K'La	K'La Lugogo	130	10	3	Individual capital	Product development
Unga Millers (U) Ltd	Food Processing	2003	Box 7795 K'La	K'La Ntinda	23	4	0	Shares	Product development
E.A Basic Foods	Food Processing	1987	Box 8199 K'La	K'La Ggaba	50	7	4	Not provided	Quality Control
Sameer Agriculture &Livestock Ltd.	Dairy Processing	Not provided	Box 7078 K'La	K'La Bugolobi	21	5	1	Not provided	Product development
Uganda Fish Packers Ltd.	Fish Processing	1991	Box 7409 K'La	K'La Ntinda	350	15	3	Shares	Quality control
Hwan Sung	Fish Processing	1992	Box 7628 K'La	K'La Ntinda	250	4	2	Individual capital	Product development
Oscar Industries Ltd	Paper Manufacturing	1987	Box 1229 K'La	K'La Ntinda	400	10	0	Not provided	Human resources
Kajjansi Roses	Floriculture	1997	Box 6361 K'La	Kajjanzi	180	10	7	Shares/ loans	Product development
Melissa Flowers	Floriculture	1997	Box 210710 K'La	Entebbe	320	4	3	Shares	Product development
SCOUL Roses Uganda Hortech	Floriculture	1993	Box 1 Lugazi	Lugazi	269	3	0	Shares	Product development
Maganjo Grain Millers	Food Processing	1984	Box 6738 K'La	Kawempe Maganjo	180	3	1	Company funds	Technology (Agricultural engineering)
Ntake Bakery and Company Ltd	Food Processing	2002	Box 15207 K'La	Nalukolongo	80	5	2	-	Human resource management
Kagodo Farmers Ltd	Animal Nutrition/ Poultry breeding	1990	Box 10257 K'La	Kibuye	68	10	5	Personal earnings	Product development
Kayebe Sauce Packers	Food Processing	1978	Box 19124 K'La	Gayaza	21	2	2	Norwegian gov't	Product development
NFA Tree Seed Centre	Agro Forestry	2004	Box K'La	Namanve	17	7	Not provided	Member contributi	Technology/ Product

								ons & grants	improvement
ECUIFA	Agro and Food Processing	1987	Box 70770 K'La	Mengo Kisenyi	42	10	0	Personal savings	Technology/ Product development
MBS Fruit Agencies	Wine Production	1990	Box 7.1258 K'La	Nalukolongo	30	5	3	Personal savings	Research and development
Tonnet Agro-Engineering Co. Ltd	Agro Technology	1995	Box 35048 K'La	Kyanja	11	2	0	Personal savings	Technology
Samona Proeducts (U) Ltd	Chemical (Cosmetics)	-	Box 70447 K'La	K'La Busega	15	Not provided	4	Directors equity	Product development
Ugachick Poultry Breeders Ltd	Poultry breeding & Animal Nutrition	1992	Box 12337 K'La	Magigye Namulonge	220	10	5	Family Loans & joint venture	Product development
Adam and Eve	Pharmaceutical (Herbal)	1987	Box 29108 K'La	Naguru	6	2	1	Personal savings	Product development
Theta	Pharmaceutical (Herbal)	1992	Box 21175 K'La	K'La	18	5	2	Donations	Public health
NAHECCO	Pharmaceutical (Herbal)	1994	Box 2004 K'La	K'La	7	3	2	Savings	Product development
Tropical Aleelands Foundations	Pharmaceutical (Herbal)	2000	Box 70646 K'La	K'La	24	2	0	Self	Medical chemistry