Interactions between Public Research Organizations and SMEs: A Case of Uganda Industrial Research Institute

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ABSTRACT
Knowledge Translation (KT) is important to understand how knowledge is transformed to economic value. This paper seeks to scrutinize the synthesis, dissemination, exchange and application of knowledge produced by Uganda Industrial Research Institute (UIRI). Theoretically, the study relates to the area of public research organizations (PRO) – industry linkages with regard to knowledge uptake by the SMEs in LDCs. Through a case study approach, this paper contributes to the field of KT by discussing how interactions affect the usefulness of knowledge produced by research organizations. The study is based on original data collected through interviews carried out with UIRI researchers between November 2012 and January 2013. Knowledge Translation Indices were developed for sample projects. The findings revealed that both Mode 1 and Mode 2 types of knowledge generation existed, with the former leading to underutilization of knowledge or wasted results. Generally, KT is complex and cannot be achieved through linear relationships, thus, the study concludes that more interactions with the indigenous agro-processing SMEs will lead to industrial development.

Keywords: Interactions, Knowledge Translation, Mode 2, Public Research Organizations, Uganda

1.0 INTRODUCTION

1.1 Background

Public Research Organizations (PRO) have a key role in the creation and diffusion of knowledge with more specific focus on solving problems and attending to social needs (Etzkowitz and Leydesdorff, 2000). The need to match research outputs with customer needs and with market and processing opportunities dictates that research institutes build closer links with private sector and advisory service providers in ways that will increase both research efficiency and effectiveness. The conventional argument for linkages is that by working together, these actors stand better chances for establishing the institutional relationships that can facilitate access to technology, information, capital and marketing arrangements (Kimenye, 2006).

Most of the existing literature on PRO–industry linkages was produced in the context of developed countries. The particular characteristics adopted by PRO–industry interactions in developing countries justify the need of specific research based on the experience of these countries (Arza & Lopez, 2011). Uganda's agro-processing industry is still highly lacking in competitiveness in the regional and international markets. Agro-processing refers to the activities that transform agricultural commodities into different forms that improve handling, increase shelf-life and add value to the product (Mhazo, Mvumi, Nyakudya & Nazare, 2012). In Uganda, there are hardly any academic studies available related to the process of knowledge creation and diffusion in PRO.

Therefore, the aim of this paper is to discuss knowledge creation and diffusion between UIRI and SMEs, and thereafter, develop strategies for KT. Uganda Industrial Research Institute, established to spearhead industrialization of Uganda, is a Centre of value addition, business incubation, innovation, product and process design and technology transfer. It also offers outreach services for creation of agro-industry facilities (UIRI Strategic Plan 2007-2012). It is important to know how interactions between the PRO and industry might affect the possibilities of achieving industrial development. The research question that this paper answers is: how is UIRI interacting with agro-processing industries from creation of knowledge to its application? The research hypothesis is that greater UIRI – Industry interactions will lead to industrial development in Uganda.

For purposes of this paper, KT is defined as a dynamic and iterative process that includes synthesis, dissemination, exchange and ethically sound application of knowledge within a complex system of interactions between researchers and users. KT is broader in scope than technology transfer and this operational definition encompasses the steps necessary to move knowledge into action (Sibley, Straus, Webster & Jaglal, 2011).

The paper is structured as follows. The following subsection reviews the existing literature on KT. Section 2 describes the methodology used to carry out this study. Section 3 presents the main findings. Section 4 discusses the empirical results with interpretations and Section 5 provides the concluding remarks.

1.2 Theoretical Framework

Different conceptual frameworks have emerged in the literature aiming at understanding the way scientific and technological knowledge should be produced and supported (Arza & Lopez, 2011). The concept used as a basis for this study is "Mode 2" Production of Scientific Knowledge (Nowotny, Scott & Gibbons, 2003; Gibbons, 1997). This framework proposes change from Mode 1 thinking (production of knowledge governed by the academic interests of a disciplinary community), to a broader social and economic context of application of knowledge, which intends to be useful and usually involves more than one discipline and more than one community (Mode 2). Figure 1 below represents the conceptual framework used guide
this study.

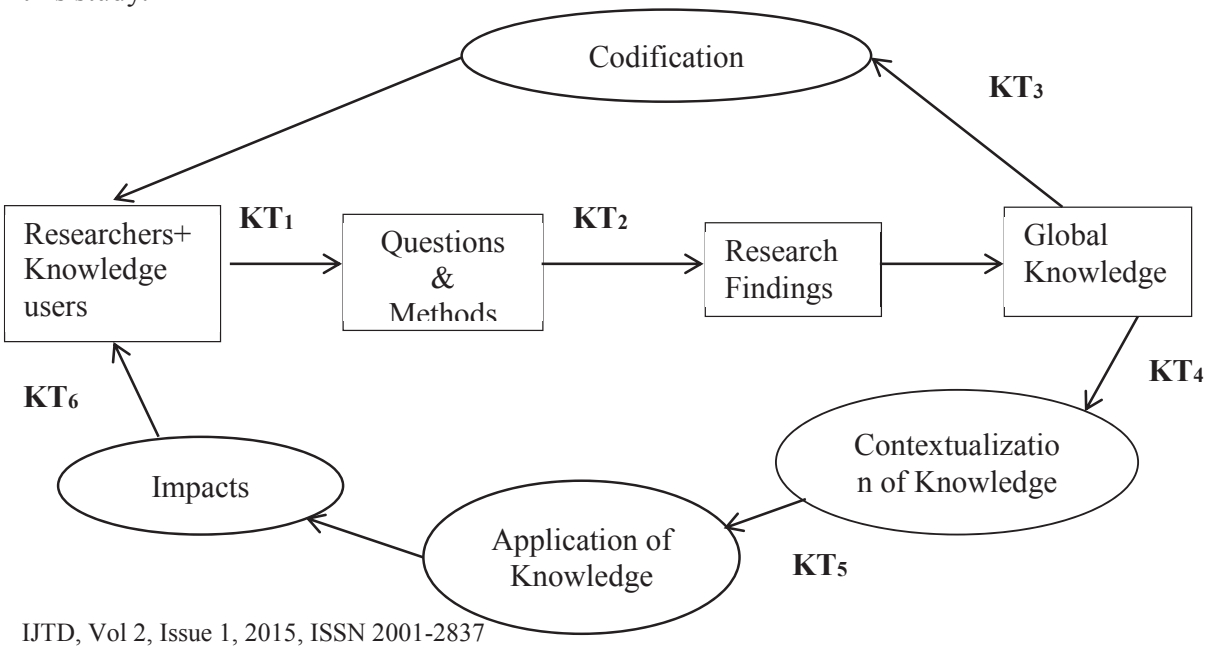

Figure 1: Important KT Stages in Research Cycle

Source: adopted from www.cihr-irsc.gc.ca with modification

KT_1: defining research questions and methodologies
KT_2: conducting research (as in the case of participatory action research)
KT_3: publishing research findings in plain language and accessible formats
KT_4: adapt knowledge to local context by addressing related barriers and facilitators to knowledge use
KT_5: making decisions and taking actions informed by research findings
KT_6: influencing subsequent rounds of research based on impacts of knowledge use

The framework holds similar view points with the KT theory and the Triple Helix perspective (Etzkowitz and Leydesdorff, 2000), which highlights the benefits associated to a more direct interaction and contribution to the industry. The focus of KT is to improve the dissemination and uptake of knowledge in decision-making. The audience of KT includes various decision makers such as entrepreneurs, intrapreneurs, consumers, researchers, policy makers, educators and the general public (Sibley et al., 2011). According to one of the major models of KT, the Knowledge-to-Action framework by Graham and Tetroe (as reprinted in Sibley et al., 2011), first, a gap must be identified between current practice and the evidence. Subsequently, to address the identified gap, the evidence must be adapted to the local environment while simultaneously addressing related barriers and facilitators to using the evidence in that particular situation. Strategic interventions (targeted to the barriers and facilitators) are required to facilitate uptake of the knowledge, followed by ongoing monitoring and evaluation to assess the impact of knowledge use and ensure knowledge use is sustained.

Dissemination and exchange are critical components of KT. Gagnon (2011) defines dissemination (also known as Knowledge Transfer or End-of-project KT) as targeting research findings to specific audiences. According to Acworth (2008), Cambridge Massachusetts Institute (CMI) defines knowledge exchange as a two-way flow of information, primarily between academia and industry, in which problems and market needs of the latter are the basis for defining the goals of research for the former. The fruits of this research are fed back in the form of solutions that can be implemented for the benefit of industry and the economy in general. Gagnon, (2011) further defines knowledge exchange, as involving active collaboration and simultaneous exchange between researchers and knowledge users throughout the research process from identifying and shaping the research questions to collecting data and interpreting findings and disseminating and applying the results.

2.0 METHODOLOGY

2.1 Research Design

This was a single case study involving analysis of UIRI's interactions with the agro-processing SMEs.

2.2 Research Approach

Basing on the questions that the study aimed to answer, the research approach was qualitative. The rationale for this was the need for detailed information and an in-depth understanding of the specific case.

2.3 Description of Population

This study established the nature of interactions by examining how stakeholders were involved in the UIRI project cycle. The population of projects from which samples were selected comprised agro-industry activities undertaken by UIRI since 2005.

2.4 Sampling Strategy

Purposive sampling method was used in this study. The categories of agro-industry projects which UIRI had carried out include production of foods and beverages, paper and wood products, and textiles. Food and beverage processing projects were selected because the largest number of projects done by UIRI was in this category. The sample included 10 UIRI food processing projects.

2.5 Data Collection Methods

Primary data was collected through face-to-face interviews and field notes on observations. Secondary data sources included reports, policy documents and the UIRI website (www.uiri.org). An interview guide for UIRI researchers was developed based on KT literature to build information on the nature of the interactions between UIRI and the agro-processing industry. Questions on what led to initiation of projects, how dissemination was done and existence of criteria to assess project outcomes were analyzed. The end was to scrutinize dissemination and check for the important stages of KT in the research cycle. The data was collected between November 2012 and January 2013.

2.6 Data Analysis

The empirical material from interviews was summarized and analyzed according to how the different issues asked and answered were interrelated.

3.0 FINDINGS

This section summarizes the findings of the study.

3.1 Agro-processing projects

The projects studied are described in table 1 below.

Table 1: Description of UIRI agro-processing projects

	Project	Reason for Initiation	Financial Support
1.	Food fortification 2007-2011	To reduce micronutrient malnutrition in the East, Central and Southern African region and improve child and maternal health, with various stakeholders.	(Academy for Educational Development (A2Z), US Agency for International Development (USAID)
2.	Development of value-added meat products	motivated by the UIRI business incubation programme	Government of Uganda (GOU) + Millennium Science Initiative (MSI)
3.	Dairy processing	motivated by the UIRI business incubation programme	GOU + MSI

4.	Fruits and vegetable processing	motivated by the UIRI business incubation programme	GOU + MSI
5.	Design and construction of hybrid solar drier	Food preservation. Equipment using solar energy and biogas to dry food	GOU
6.	Design and construction of manually driven threshers/shellers	Increase productivity. Extraction of maize grains, coffee beans, groundnuts seeds	GOU
7.	Design and construction graders	Increase productivity. Sorting coffee, groundnuts, maize	GOU
8.	Design and construction of Ewing III	Value addition. Producing groundnut paste	GOU
9.	Design and construction of maize mill	Value addition. Hammer mill to produce maize flour	GOU
10.	Construction of manual and motorized cassava graters	Value addition. To tear the cassava flesh into pulp for subsequent processing	GOU (pool from National Agricultural Advisory Services (NAADS) and UIRI)

3.2 Channels of Interaction

Uganda Industrial Research Institute interacted with industry through a variety of channels. Table 2 below describes the common channels.

Table 2: Channels used for UIRI-SME interaction

Interaction Channel	Description
SME incubators/creation of physical facilities	The incubators were all addressing local economic development related problems that aim to improve the entrepreneurial competence including training in production, business development, ICT skills, marketing, among others.
Training	Interested persons applied and some of them were offered training in different areas of food processing depending on their interest. Students from universities and other tertiary institutions were also offered industrial training in different areas.
Trade shows/exhibitions	Products developed were exhibited at trade shows for public awareness.
Networking	Entrepreneurs also made valuable contacts with suppliers, market, etc., through UIRI
Joint research projects	This involved research undertaken by both parties
Conferences/workshops/seminars	Information was diffused by bringing stakeholders together.
Consultancy work	This refers to work commissioned by industry which did not involve original research e.g. conducting routine tests (analytical testing) or providing advice to industry.

3.3 KT and the Research Cycle

Knowledge Translation is based on involvement of users in the research process (interactions). To construct the measure of the *involvement of knowledge users*, focus was on the 6 KT stages relevant in the research cycle. The sample projects were explored for these stages. Each stage was coded 1 if it was indicated that it was undergone and 0 otherwise. The scores were added up so that a project scored 6 when all KT stages were undergone and 0 otherwise. The total score of each project was calculated and expressed as a fraction of 6 to give the index of *involvement of knowledge users* in the cycle. The aggregate score of the 10 projects was expressed as a fraction of the aggregate whole (60, for 10 projects) to give a measure of the *extent of involvement of knowledge users overall* depicted by the sample projects. The results are summarized in table 3.

Table 3 : Projects with KT stages covered in the research cycle

Project	Total KT Score	No. of KT Stages	KT Index
Food fortification 2007-2011	5	6	0.83
Development of value-added meat products	5	6	0.83
Dairy processing	5	6	0.83
Fruits and vegetable processing	5	6	0.83
Design and construction of hybrid solar drier	1	6	0.17
Design and construction of manually driven threshers/shellers for maize, coffee, groundnuts	0	6	0.00
Design and construction graders for coffee, groundnuts, maize	0	6	0.00
Design and construction of Ewing III for producing groundnut paste	0	6	0.00
Design and construction of maize mill (hammer mill)	0	6	0.00
Construction of manual and motorized cassava graters (graters tear the flesh into pulp for subsequent processing)	4	6	0.67
Total	**25**	**60**	**0.42**

4.0 DISCUSSION

Findings revealed that UIRI projects are mainly built around identified social and economic needs, for example, low productivity, poor quality/low value of products, malnutrition, and expensive production equipment/technology, among others. Researchers developed products, and then an incubatee was identified to commercialize the products. In other cases, researchers worked with an incubatee to develop the incubatee's product for the market. The first is Mode 1 while the second is Mode 2 generation of knowledge.

The analysis indicated greater involvement of knowledge users (Mode 2) in the projects that were driven by the business incubation programme and those that were financially supported by other stakeholders, with KT indices 0.83 and 0.67. The Meat Processing, Dairy Processing and Fruits and Vegetable Processing projects were motivated by the business incubation programme, and the

facilities were boosted by an additional fund from MSI. The Cassava Grater Project was a UIRI-NAADS collaborative project bringing a pool of resources from both organizations, and the Food Fortification project was a UIRI-USAID-A2Z collaboration, funded by USAID and A2Z.
Solutions to some problems were unsuccessful or underutilized because of poor quality of output, high production cost leading to high cost of the unit, farmers lacking business skills, therefore, not appreciating easily the use of technology and the population finding some of the technology unaffordable and, therefore, being unable to implement it. This was the case with the design and construction projects of the hybrid solar drier, threshers/shellers and Ewing III, details of which are presented in table 4 below.

Table 4: Details of project outcomes

Project	Outcome
Hybrid solar drier project	It was not possible to sustain the project because of the challenge of storing solar energy and lack of a constant supply of biogas for users, which made long hours of drying persistent. Fossil fuel driers remained more adaptable despite the high cost of operation. Modern remedies have to be adopted as drying area per unit solar is large.
Manual threshers/shellers	Electric-driven shellers are preferred due to the toughness of the shells. Farmers are also subsistence and do not easily appreciate use of technology.
Groundnut sheller	The quality of seeds was not good because of the variation in size of seeds produced in different areas… Farmers also lack business skills so they do not easily appreciate/buy the technology and thus some of it has not been utilized. Also, cost of the unit was high for the farmers.
Ewing III	Sustainability of the project was not achieved due to the high cost of fabrication and difficulties in sourcing material requirements.

The six KT stages are opportunities/points of interaction within the research cycle. From the results, the KT index of the same projects is 0. Therefore, there is a link between interactions and project success. This result is in agreement with the study of Lundvall (2004) which explains learning and innovation as an outcome of interaction.

Much as the economy faces social and economic needs such as mentioned earlier in this discussion, it is insufficient for researchers to generate solutions in isolation. Mode 1 (where problems are set and solved in a context governed by the largely hypothetical interests of researchers) is seen to have resulted in push efforts which were sometimes futile because there were disparities in the specific context of application. Push efforts take place when producers of research knowledge plan and implement approaches to push (disseminate) knowledge toward audiences who they believe need to receive it (Gagnon, 2011). To solve the shortcomings of lack of knowledge exchange, CMI implemented a Knowledge Integration Community (KIC) model which brought together four human components, comprising academic researchers and educators, industry participants and government policy makers. Among the lessons learnt through CMI projects was to solicit industry input to identify areas where research could contribute a solution before calling for proposals (Acworth, 2008).

The traditional channels of interaction are observed as in Rast et al. (2012), Arza and Lopez (2011) and D'Este and Patel (2007) as the vehicles for KT between UIRI and the industry, except the Intellectual Property Rights (IPR) channel which involves technology licenses and patents. Communicating knowledge generated to improve industry through conferences/workshops/seminars and trade shows/exhibitions may be appropriate for some audiences, for example, policy makers, consumers and the general public, where the KT goal is to communicate knowledge. However, these forms of interaction are quite linear for the case of industry where the KT goal is to change behaviour. The impacts of knowledge use were largely unknown in the case of working outside UIRI's physical facilities, monitoring and evaluation to assess the impact of knowledge use therefore demanded improvement. Overall, the index of *involvement of knowledge users* in the UIRI project cycle was 0.42. The maximum value that the index can have is 1. This therefore indicated that interactions with knowledge users were inadequate.

Knowledge generated to improve industry requires appropriate contextual considerations (Gibbons 1997; Sibley et al., 2011). During one of the projects where CMI implemented the Knowledge Integration Community (KIC), there were regular visits to industrial partner sites resulting in personal interactions for purposes of addressing specific issues of a technical nature. Diffusion (e.g. use of word of mouth, publications, presentations) is valued for fundamental research, as fundamental discoveries are exposed to the scrutiny of readers and conference participants so as to ultimately be replicated or refuted (Kerner & Hall, 2009).

While dissemination strategies foster collaboration and associations between actors, there is little evidence of their effectiveness at actually changing practice (Sibley et al., 2011). Lavis and Reardon (as cited in Gagnon, 2011) propose some fundamentals that reinforce dissemination, among which is to understand the audiences and their information needs through ongoing relationships between them and those who are producing the research. Part of the reason for underutilization of knowledge/technology was that farmers did not appreciate its use due to lack of entrepreneurial skills. Gagnon (2011) emphasizes existence of a dissemination plan which puts into consideration the nature and size of the audience, the available resources to devote to dissemination as well as what impact the proposed activities will achieve before the plan is implemented to enhance the plan's success and facilitate evaluation of the plan. According to Acworth (2008), CMI discovered that knowledge exchange is a 'full contact sport' and there is no substitute for people moving around and meeting face-to-face.

Therefore, for applied research, as is the objective of UIRI, Mode 2 has greater potential to impact industry and policy in the short run. One outcome of this kind of work is practice-grounded research, research that is based on data that comes directly from practice and yields findings that can inform practice (Rynes, Bartunek, & Daft, 2001). In Graham and Teroe's KT model (Sibley et al., 2011), the knowledge creation phase involves knowledge syntheses with systematic reviews and meta-analyses, and ultimately forms knowledge products such as best practice guidelines. The goal is that knowledge becomes more useful to the end-user as it is funneled through this refinery.

The study of Ecuru et al. (2012) proposed a framework which can be used to describe innovation systems in low income countries, defining Science, Technology and Innovation (STI) as a function of financing (F), governance (G), human capital (Hc) and interactions within the organization and across functional spheres (r).

$STI = f(F, G, Hc, r)$…… (i)

In this study, it was clearly demonstrated that financing and interactions are crucial elements for innovation to take place.

A policy implication emerged. One of the government investment priorities of the NDP (2010, p.49) is STI, and promotion of value addition is a specific intervention area. There is consistency in policy and persistence in the roles assigned to the PRO as a key agent in development. The intervention has led to building long-term research capacity, for example, physical production facilities/incubators within and off UIRI campus and other resources such as new laboratory tools and analytical methodologies that constitute fundamental inputs for the industry. However, the limitations of PRO facilities such as space available in a given time, point towards the need for additional interventions in knowledge user locations. Beside startups, existing enterprises with similar competitiveness challenges can be supported for more interaction with industry. The policy recommendation is that guidelines and regulations for Integrated Knowledge Translation/Mode2 are developed. To encourage complementary innovation efforts rather than firms simply interacting to substitute for innovation activities they do not perform, policy tools should attach some target in terms of investing in in-house innovation as a requirement for firms to interact with the PRO.

Lessons learnt:

The major issues that needed to be addressed are highlighted. Uganda Industrial Research Institute needs a paradigm shift from Mode 1 to Mode 2 thinking. The assumption that developing technologies to be taken to industry and organizing training programmes to pass on knowledge will create uptake by the industry or impact on the industry, for that matter, is challenged. In systems thinking, the technology developed should be together with the end users of the technology. Working together with the end users will also facilitate determination of what they can afford, specific sizes they need, among other details. All the failure in technology transfer or adoption is because of the two actors working in isolation.
Furthermore, developing knowledge/technology together will lead to joint monitoring and evaluation whereby the end use would even give the feedback on the efficiency of technology without necessarily requiring UIRI to demand this information. It is a sure way to facilitate knowledge exchange throughout the process.

Limitations of the Study
It was difficult to retrieve information on projects that were spearheaded by personnel who are no longer employees at UIRI. Nonetheless, personnel who had been involved in the respective sections for longer periods of time were consulted and, therefore, the author is confident that this did not greatly affect the data.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion
Uganda Industrial Research Institute is mandated with spearheading industrial development in Uganda. From the findings of the study, the approaches to knowledge production were both Mode 1 and Mode 2, the latter mainly facilitated by incubator facilities. Mode 1 especially led to underutilization of research results or impracticable results. The findings, therefore, suggest that

to improve the agro-processing subsector, there is need for a paradigm shift from Mode 1 to Mode 2 thinking, since Mode 1 has implications on the usefulness of research results.

5.2 Recommendations

A paradigm shift to Mode 2 research suggests an integrated approach which is potentially more time consuming, demanding, and resource intensive because it requires both researchers and knowledge users to develop new skills, knowledge, and perspectives such as systems thinking and relationship management. Temporary teams can be built to facilitate Mode 2. These can be achieved through collaboration with universities, involving several research groups depending on their area of competence. This solves concerns of human capital shortage. In addition, taking advantage of university human capital partly solves the demand on new skills and knowledge as the university is dynamic with changing student generations, nurturing new persons and new ideas. The institute should adopt the concept of the KIC for every project carried out to bring the researcher and knowledge user communities together through an interactive process. Uganda Industrial Research Institute could explore the possibility of developing consulting opportunities within the industrial partners as an alternative revenue channel that would support costs associated with further research. This is one way the industry can contribute financially towards the KIC's long-range objectives. The projects explored in this study revealed that the impacts/desired outcomes of projects executed were defined. Appropriate indicators for measuring outcomes of an intervention should be developed to facilitate evaluation of projects.

5.3 Further Work

This study has empirical limitations as it is a single case study which means the generalization of results is bounded by specificities of UIRI. A general set of new questions this paper has opened relates to the extent to which the findings can be generalized to other public research institutions in Uganda and more so to other LDCs. Future research should design a larger comparative study that analyzes interactions beyond a case.

Despite the empirical limitations of the study and possibilities for further research, this study is believed to help in deepening our understanding of the status of interactions between public research organizations and industry in Uganda.

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