Interactions between Public Research Organizations and Industry: Simple Additive Weighting Approach to Evaluation of Interactions

Olivia Nakamatte, and Peter Okidi-Lating

***Abstract*---**Interactions between Public Research Organizations and Industry (PRO-I interactions)are important to facilitate learning. This paper seeks to measure interactions between Uganda Industrial Research Institute (UIRI) and SMEs in Uganda. Theoretically, the study relates to the area of interactive learning between the two actors in the innovation system. The study is based on original data collected through a questionnaire administered to SME Managers between January and February 2013. Findings revealedpull efforts by SMEs and strong collaborations between UIRI and SMEs. The study concluded that the firm may be motivated to drive a strong relationship for maximum benefit since the relationship is established primarily based on the firm's interest.

***Keywords*----**Interaction Channels, Interactive Learning, Pairwise Comparisons, Public Research Organizations – Industry Relationships

I. Introduction

A. Background

PRO-I interactions are seen as one of the key elements of the National System of Innovation (NSI). In [1], the author, who is considered as the founder of innovation systems, supposes that learning and innovation is best understood as the outcome of interaction. Interactive learning is defined as a process in which agents communicate and even cooperate in the creation and utilization of new economically useful knowledge.

These interactions can be conceptualized as having three main stages: drivers of interaction, channels of interaction, and the perceived benefits from collaboration [2].

In an earlier study by [ibid] the author explored which channels of interaction are most effective for triggering different benefits for PROs and firms, theirargument based on the idea that interactions may have more knowledge content, and thus more impact on researchers' and firms' benefits if a bidirectional channel is used, and knowledge flows in both directions between the two agents.

Olivia Nakamatte, Master Student, Department of Mechanical Engineering, Makerere University, P.O.Box 7062, Kampala, Uganda

Corresponding author email: plating@cedat.mak.ac.ug

Peter Okidi-Lating, Associate Professor, Makerere University, P.O.Box 7062, Kampala, Uganda.

This conceptual framework is further developed by [3]. However, in [2] the authors conclude that the bi-directional channel brings benefits for both agents and is associated with knowledge flows in both directions. They further show that all channels of interaction play an important role in determining benefits; however, these channels differ in terms of their impact on short or long-term benefits for firms. They suggest that the channels related to joint and contract R&D, property rights, and human resources are the best, as they have a higher impact on long-term benefits for firms.

The aim of this paper is to evaluate interactions between UIRI and SMEs. The research question answered is: how strong are the collaborations between UIRI and SMEs?

The paper is structured as follows. The following subsection reviews the existing literature on PRO-I interactions. 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.

B. Theoretical Framework

Knowledge flows through different channels of interaction. Interaction is the core of the linking process [2] and [4]. The most frequently recognized categories of channels of interaction between researchers and knowledge users include: joint R&D; contract R&D and consultancies; the mobility of human resources; networking; information diffusion (via journals, reports, meetings and conferences, and the internet); training (e.g. training company employees and industrial training); intellectual property rights; incubators and spin-offs/creation of physical facilities [2] and [5]. In [5] the authors present evidence that the five categories of interaction: meetings and conferences, consultancy and contract research, creation of physical facilities, training and joint research are largely non-overlapping. Fig. 1 shows the motivations and channels of interactions.

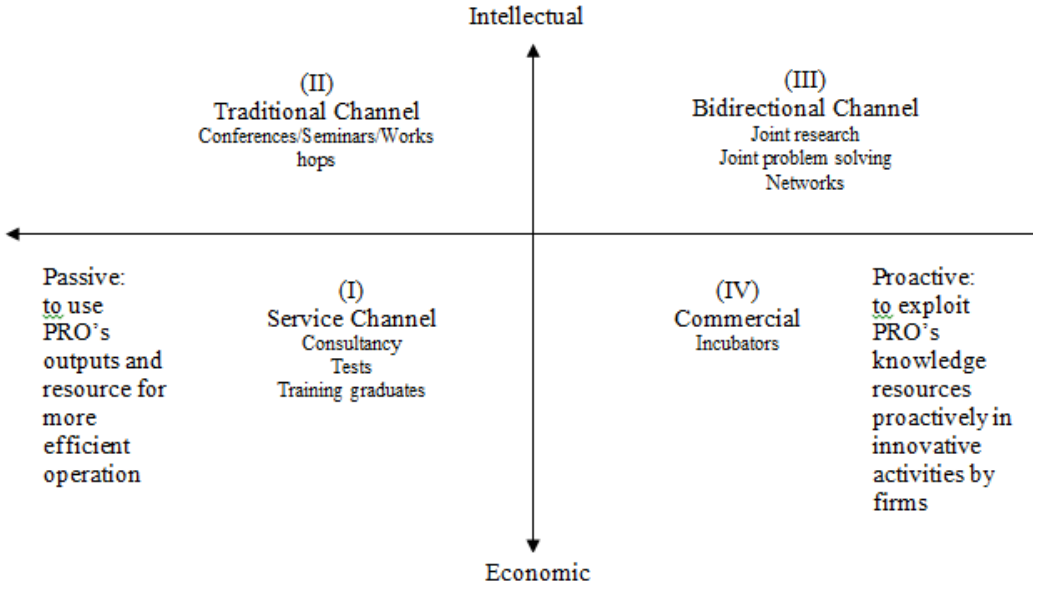

Fig.1 Motivations and Channels of Interaction

Source: Adopted from [3] with modification

Quadrant (I) contains interactions motivated by economic strategies by PROs and passive strategies by firms. The result is interactions that could be associated with the provision of scientific and technological services in exchange for money, where knowledge flows mainly from PROs to firms (e.g. consultancy, use of equipment for quality control, testing and monitoring, etc.). These are usually short-term interactions. Although there may be some degree of personal interaction, much of the knowledge transmitted is mature and can be transferred without intense face-to-face collaboration.

Quadrant (II) is defined by the intellectual strategies of the PRO and the passive strategies of the firms. It is referred to as the traditional channel because it resembles the traditional ways that firms benefit from activities by PROs (e.g. conferences/seminars, training graduates, publications, etc.). Knowledge flows mainly from PROs to firms, but the knowledge content is defined by the traditional functions of the academic/research institutions. Personal interaction between the individuals from the different institutions is not required in this case.

Quadrant (III) includes interactions that originate from the intellectual strategies of the PROs and proactive strategies by the firms. In this case the knowledge flow is bi-directional and the potential for joint learning is high. This quadrant includes joint research and development projects, participation in networks, scientific–technological parks, etc. The bi-directional channel is motivated by long-term targets of knowledge creation by PROs and innovation by firms. Generally, personal interaction is required throughout the period of the interaction agreement and both agents provide knowledge resources.

Quadrant (IV) is defined by the economic strategies of PROs and proactive strategies by firms. This is the commercial channel of interactions, where the main motivations for PROs are the keenness to commercialize their scientific results. Knowledge flows mainly from PROs to firms. Emblematic examples of this channel are spin-off companies and incubators [3].

II. Methodology

A. Research Design

This was a single case study involving analysis of UIRI's interactions with the local food processing industry.

B. Research Approach

The research approach was qualitative.

C. Description of Population

The population of SMEs from which samples were selected to evaluate interactions included agro-industry enterprises which had either collaborated or were collaborating with UIRI.

D. Sampling Strategy

Purposive sampling method was used in this study. The sample included 10 indigenous food processing firms selected from UIRI's records.

E. Data Collection Methods

Data was collected through a questionnaire. Interactive learning can be based on formal and informal activities. To analyze the strength of collaborations, the frequency with which firms were involved in different collaboration arrangements was captured. To capture the frequency, the study drew on the responses to a question about 8 common channels of interaction. The 8 items were developed based on interviews with UIRI and literature on channels of interaction between PROs/Universities and Industry.

F.Data Analysis

Data was analyzed using Simple Additive Weighting (SAW) method. This is a Multi-Criteria Decision Analysis

(MCDA) method based on weighted averages. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by the decision maker, followed by summing of the products for all criteria. The judgment matrix (pairwise comparison matrix of all criteria) is considered consistent if the Consistency Ratio (CR) is less than 0.10 according to [6].

III. Findings

One of the 10 firms surveyed had the collaboration initiated by UIRI after a stakeholders' training, the other 9 had initiated the collaboration with UIRI. It was observed that some knowledge users came across information about UIRI's services and followed up in order to benefit from it.

The 8 criteria (channels of interaction) used to measure interactive learning are defined as follows:

C1 – Joint research projects
C2 – Training
C3 – Seminars/workshops
C4 – Exchange of information
C5 – Incubator/use of physical facilities
C6 – Consultancy/contract research
C7 – Networking
C8 – Joint problem solving

The table I below shows the scale used to develop the pairwise comparison matrix for all criteria.

TABLE I
SAATY'S 1-9 SCALE OF RELATIVE IMPORTANCES

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate Importance	Experience and judgment slightly favour one activity over another
4	Moderate Plus	
5	Strong Importance	Experience and judgment strongly favour one activity over another
6	Strong Plus	
7	Very Strong	An activity is favoured very strongly over another
8	Very, Very Strong	
9	Extreme Importance	The evidence favouring one activity over another is of the highest possible order of affirmation

Source [6]

The first two judgment (pairwise comparison) matrices constructed yielded CRs 0.378 and 0.346 respectively, and therefore, did not pass the consistency test as the CR was greater than 0.10. The process was repeated and the subsequent matrix constructed is shown in table II.

TABLE II
JUDGMENT MATRIX FOR THE DIFFERENT CHANNELS OF INTERACTION

	C1	C2	C3	C4	C5	C6	C7	C8	PV
C1	1.0	7	5.0	3.0	3.0	7	3.0	2.0	0.310
C2	0.2	1	0.33	0.2	0.33	1	0.33	0.2	0.036
C3	0.2	3	1.0	0.33	0.33	3	0.33	0.2	0.061
C4	0.5	3	3.0	1.0	0.33	3	0.5	0.5	0.103
C5	0.5	5	5.0	0.5	1.0	3	0.5	0.5	0.124
C6	0.2	1	0.5	0.5	0.33	1	0.33	0.33	0.045
C7	0.33	3	3.0	1.0	2.0	3	1.0	0.5	0.127
C8	0.5	5	5.0	2.0	2.0	3	2.0	1.0	0.195
Col. total	3.43	28	22.83	8.53	9.33	24	8.00	5.23	1.000

Note: PV is Priority Vector

Test of consistency was done for the judgment matrix presented in table 2. The Weighted Sum Matrix (WSM) was computed. Thereafter, the Consistency Index, CI, was calculated using the relationship given by $\frac{\lambda \max - n}{n-1}$, where n is the matrix size

This was followed by computations for $\lambda \max$, the eigenvalue which was used to determine the Consistency Index (CI).

$\lambda \max$ = 8.477 + 8.468 + 8.546 + 8.637 + 10.810 + 8.356 + 10.339 + 7.608 = 8.905

In this case n = 8

Therefore, CI is then given by, $\frac{8.905 - 8}{8 - 1}$ = 0.129

CR = CI/RI, where RI is the Random Index. Depending on the matrix size n, values of the RI can be read from table 3.

TABLE III
AVERAGE STOCHASTIC UNIFORMITY INDEX TARGET VALUE OF JUDGMENT MATRIX

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.85	0.9	1.12	1.24	1.32	1.41	1.45	1.51

Source [6]

From table 3, the Random Index, RI = 1.41 for the matrix size, n = 8, CR, therefore, = $0.129/1.41$ = 0.092. Since CR < 0.10, the judgments were consistent and hence the weights assigned to the criteria are reliable and are presented in table 4 below.

TABLE IV
THE WEIGHTS OF CRITERIA BY JUDGMENT MATRIX

C1	C2	C3	C4	C5	C6	C7	C8
0.31	0.036	0.061	0.103	0.124	0.045	0.127	0.195

Table V summarizes data collected from the firms regarding the frequency of use of a given form of interaction.

TABLE V
FREQUENCY OF USE OF DIFFERENT FORMS OF INTERACTION BETWEEN UIRI AND FIRMS

Firm	C1	C2	C3	C4	C5	C6	C7	C8
1	1	2	1	3	5	1	4	3
2	4	4	5	5	5	5	4	4
3	5	5	3	4	5	1	3	4
4	1	5	5	5	5	1	3	3
5	1	3	1	4	5	1	5	5
6	5	4	5	5	5	5	5	5
7	1	5	4	4	5	3	4	4
8	3	5	4	5	5	5	3	2
9	1	5	4	5	5	5	5	5
10	3	5	2	5	5	1	2	5

Table VI presents the normalized decision matrix used to evaluate each firm (alternative).

TABLE VI
THE NORMALIZED DECISION MATRIX

Firm	C1	C2	C3	C4	C5	C6	C7	C8
1	0.2	0.4	0.2	0.6	1.0	0.2	0.8	0.6
2	0.8	0.8	1.0	1.0	1.0	1.0	0.8	0.8
3	1.0	1.0	0.6	0.8	1.0	0.2	0.6	0.8
4	0.2	1.0	1.0	1.0	1.0	0.2	0.6	0.6
5	0.2	0.6	0.2	0.8	1.0	0.2	1.0	1.0
6	1.0	0.8	1.0	1.0	1.0	1.0	1.0	1.0
7	0.2	1.0	0.8	0.8	1.0	0.6	0.8	0.8
8	0.6	1.0	0.8	1.0	1.0	1.0	0.6	0.4
9	0.2	1.0	0.8	1.0	1.0	1.0	1.0	1.0
10	0.6	1.0	0.4	1.0	1.0	0.2	0.4	1.0

Table VII summarizes the relative score (total weighted score) of each firm.

TABLE VII
STRENGTH OF COLLABORATIONS BETWEEN UIRI AND THE FIRMS

Firm	**Relative Score**
Firm 6	0.993
Firm 2	0.886
Firm 3	0.830
Firm 9	0.740
Firm 10	0.728
Firm 8	0.696
Firm 7	0.637
Firm 5	0.632
Firm 4	0.588
Firm 1	0.501

The total weighted score is an index of how strong each firm's collaboration with UIRI is. Since the computations involved a normalized decision matrix, the maximum value this index can have is 1. Firm 6 had the strongest collaboration with UIRI whereas firm 1 had the weakest collaboration.

IV. DISCUSSION

Pull efforts take place when knowledge users plan and implement strategies to pull knowledge from sources they identify as producing knowledge useful to their own decision making [7]. Findings revealed that in most cases, industry had initiated the collaboration with UIRI. The study by [8] the authors revealed that technology push or market pull (linear models) are insufficient to induce transfer of knowledge/technology.Uganda Industrial Research Institute is mandated with spearheading industrial development in Uganda, therefore, the organization needed the devise means of reaching out to firms more.

Learning takes place during interaction. In the analysis, the average score was 0.723, and therefore, learning was indicated as good. Since firms were not at the centre of analysis in this study, results were difficult to interpret. Investigation of the factors that affect strength of collaboration would add to the results an explanation of the underlying forces.

Similar studies were carried out by [9]; performing a quantitative measure of interactions in Nigerian clusters. They developed an econometric model of interactive learning using Simulated Maximum Likelihood estimation of trivariatetrobit model of collaboration with a large number of firms (760) and reported that clustering of firms fosters greater learning. The authors in [4] measured the tie strength between academia and industry from academia's perspective and for the two types of knowledge, explicit and tacit. This was done by asking the frequency of communication and closeness of cooperating partners using scale items for a comparatively large scale survey. Their findings suggested that a high frequency of communication seems to be important for the success of cooperation projects, both for tacit and explicit knowledge, and the closeness of partners seems to be especially relevant for projects involving predominantly tacit knowledge.

In his discussion on how to study innovation systems in less developed countries, [1] believes that keeping the firm in focus is crucial for understanding what works and what does not work in the NSI. Studies have shown that the emphasis on each channel or group of channels of interaction is determined by the motivations to interact, and they usually vary according to the field of knowledge, technology and sector [3], [10] and Laursen& Salter, 2004).

Limitations of the Study

There was difficulty in getting information from SMEs outside the central region since most of them could not be reached by e-mail and had no websites, therefore, the data gathered may not easily be generalized to firms in locations outside the central region.

In the analysis of the strength of collaborations, the weights assigned to different interaction channels were subjective. However, weighting was guided by Simple Additive Weighting method to ensure consistency in judgments.

V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

Analysis revealed strong linkages between UIRI and the firms. The firm may be motivated to drive a strong relationship for maximum benefit since the relationship was established primarily based on the firm's interest. Therefore,

it is important to determine the factors affecting strength of collaborations.

B. Recommendations

It was observed that generally firms initiated the collaboration with UIRI. Industries frequently have no connections to researchers and may not know how to initiate a co-production project, and therefore, UIRI should become more proactive in identifying industries with potential for co-production. This also implies more human resources mobility to facilitate proper needs assessment as well as the co-production process, and clear guidelines and targets for industry outreach services.

C. Further Work

Placing firms at the centre of analysis will enable determination the factors that affect strength of collaborations. This will inform public policies intended to increase interactivity and thereby improve the performance of the developing NSI.

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