ISSN 0511-5728
The West Indian Journal of Engineering
Vol.37, No.2, January 2015, pp.4-13

An Assessment of The UWI's Faculty of Engineering Capability and Willingness to Engage in Industrial Collaboration for Innovation

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(Received 12 April 2013; Revised 28 July 2014; Accepted 30 January 2015)

Abstract: *University-industry collaboration (UIC) has been recognised by numerous authors as engendering innovation and economic development. Despite Trinidad and Tobago's highly industrialised economy, the efforts of The University of the West Indies' (The UWI) Faculty of Engineering to foster such UIC has been limited. We use a Conceptual Model of good practice in UIC, which requires that four pillars are in place for effective UIC: high quality academic research; a predisposition on the part of academics to engage; a framework of supporting policies and procedures in the university; and an effective office supporting technology transfer. Our assessment of the capability of The UWI Faculty of Engineering for UIC is against the Conceptual Model. Publications data shows that the relatively low international visibility and impact of research undertaken in the Faculty might harm confidence in potential industrial partners. Although academic members of staff are keen to collaborate and many have industrial experience, the university policy framework does not create sufficient incentives for definite UIC initiatives to be established. The UWI Office of Research, Development and Knowledge Transfer does not have sufficient human or financial resources to fully support UIC. Strategic action by The UWI can alleviate all these limitations and significantly improve capability for UIC. Other universities in the developing world, particularly in Africa, the Caribbean and the Pacific, may be facing similar challenges in UIC and could learn directly from our work.*

Keywords: *University-Industry Collaboration (UIC); Technology Transfer; Caribbean Universities; The UWI.*

1. Introduction

Economic development is, in most nations, very dependent on innovations in product or process. The economy of the Caribbean region is heavily dependent on tourism, which has suffered severe reductions in the past years due to the economic slowdown and recession in the USA and Europe between 2007 and 2012. Some Caribbean nations suffer under the crush of International Monetary Fund (IMF) Structural Adjustment Programmes, while others suffer from the depletion or devaluation of commodities on which they have relied for generations. There has been little innovation to establish economic streams.

The primary economic engine of the English-speaking Caribbean is Trinidad and Tobago (T&T), with rich reserves of oil and natural gas, and a more developed manufacturing sector than other nations in the region. However, in the 2012-2013 Global Competitiveness Report, T&T was ranked 104th out of 144 countries for its Capacity for Innovation (Global Economic Forum 2012, 20). The World Trade Organisation (WTO) stated in its 2012 report on T&T:

> *"Although successive Governments have recognised the need to diversify the economy, and several initiatives have been taken, the low level of reserves relative to current production of oil and gas, and the increase in gas production in some countries means significant diversification is needed in the medium to short-term."* (WTO, 2011, ix)

The Government of Trinidad and Tobago recognises the need to encourage innovation as a core strategy for the diversification of the economy away from an excessive dependence on oil and gas, and stated in its 2012 Budget, one of the three major policy platforms is: *"...creation of entrepreneurial opportunities and an innovation-driven economy to stimulate growth and competitiveness through public/private investment"* (MOF, 2011, 2).

Clarifying and strengthening the national innovation system is a high priority of the Government of Trinidad and Tobago, and significant attention is being paid to the policy framework that will facilitate innovation. According to Etzkowitz and Leydesdorff (2000), an effective system of innovation consists of a series of knowledge-intensive networks between players in the innovation system. Industry, the state and academia are the primary players, with university research providing the primary locus in a triple-helix model.

The vital function of knowledge creation in the

triple-helix model is largely fulfilled by the university system. In this model, the so-called Mode 2 University functions as an "amalgam of teaching and research, applied and basic research, entrepreneurial and scholastic" (Etzkowitz et al., 2000). This stands in contrast to the Mode 1 University where the primary functions of the university are education and discovery-focused research. The presence of such a university that is meaningfully engaged in Research and Development (R&D) has a positive impact on high-technology innovation in its environs. In fact, there is a correlation between University R&D expenditure and technology transfer (Varga, 1998). Where there is an existing concentration of economic activities in a locality, the impact of University R&D on local economic performance is even greater. Engineering faculties are of particular importance due to their central role in the technology transfer process.

As the largest and most diverse university in the region, The University of the West Indies (The UWI) has a pivotal role to play in energising the regional innovation system. By application of the Etzkowitz and Leydesdorff (2000) model and the findings by Varga (1998), R&D emerging from The UWI is critical to regional economic development. The UWI Mission Statement recognises and reflects its role in the development of the Caribbean region (The UWI, 2012, 20). Beyond a statement of intent, such as that contained in The UWI Strategic Plan 2012-2017, it is necessary to determine whether, at a faculty level, the capabilities and commitment required for the University to make its necessary contribution, are present. This paper focuses on the Faculty of Engineering.

2. Methodology

The aim of this paper is to make a reasonable assessment of the willingness and capability of the Faculty of Engineering at The UWI, located in Trinidad and Tobago, for University-Industry Collaboration (UIC) and to identify ways in which these could be improved. A Conceptual Model of good practice in the facilitation of successful UIC, based on practice reported in the literature and augmented by lessons learnt in a study of a sample of leading UK universities, is used as the basis of assessment of the capability for UIC in the Faculty of Engineering at The UWI. The following factors are assessed:

a) The attitudes of academics in the Faculty of Engineering to UIC;
b) Engineering research quality as indicated by an analysis of publications by engineering faculty members; and
c) The role of the Office of Research, Development and Knowledge Transfer (ORDKT).

2.1 Assessment of Research Quality and Publication

An analysis of the publication habits of the Faculty of Engineering was conducted to evaluate whether research issuing from the Faculty has impact on the wider academic community. A high impact would suggest that "credible and high-quality R&D activities must be taking place in the University". The vehicle used for this analysis was citation analysis, which is defined by Smith (1981) as "the evaluation and interpretation of the citations received by articles, scientists, universities, countries, and other aggregates of scientific activity, used as a measure of scientific influence and productivity". Thus, citation analysis is based on the referencing practices of members of the academic community and which are seen as indicative of the regard for the cited work and the impact it has on the scientific community (Van Raan, 2005; Narin, 1976).
One of the powerful tools used in citation analysis is the citation index or database, which is a compilation of citation data from sources in a particular area. Though the use of such databases is subject to technical and methodological problems, these databases still greatly facilitate the use of citation analysis (Van Raan, 2005; Smith, 1981; Klinger, 2006; Garfield, 1996; Kostoff, 2002).

Consideration of Kostoff (2002) and Bornmann et al. (2008) makes it clear that attempting to use simple citation counts is not advisable as sub-disciplines have different publication habits as a result of norms within that particular sub-discipline. Therefore, citation frequencies must be situated in a frame of reference. In this case study the frame of reference used was "field of research" aggregated at the level of each department within the Faculty. The method of aggregation used was inspired by the work of Narin (1976) and Schubert and Braun (1996). Thus the reference standard used for each department was derived via weighting based on the publication activity of its researchers in their areas of research as explained below.

Faculty of Engineering (FoE) publication records were obtained from The UWI Annual Report. These records were systematically reviewed and each article which was published in a journal for the 2006/07 to 2010/11 academic years inclusive was cross-referenced with the Thomson Reuters Science Citation Index (SCI). Articles were evaluated on a departmental basis to obtain the following statistics:

- Productivity (Number of articles) of each department each year;
- Percentage of journal articles for each department present in the SCI;
- Average Citation Rate per Year for Each Department;
- Comparative Citation Rate for a hypothetical similar department;
- Ranking of Researchers based on number of journal articles published each year and over the entire examined time period;
- The h-index of each department for the five-year

period examined.

The average citation rate for each Department per year was computed by weighting on the basis of the number of articles published in each subfield with the total number of articles for that year for that department in the SCI. The comparative citation rate is found by Equation 1:

$$A_{dept} = \frac{c_1 + c_2 + \cdots + c_n}{N} \quad [1]$$

where A_{dept} is the average citation rate for the Department, c_n is the citation rate for each subfield n and N is the total number of articles published.

The comparative citation rate for a hypothetically similar department was computed by obtaining the average citation rate for each subfield in which articles were published by the department in question. The hypothetical department citation rate is found by Equation 2:

$$A_{dept,eq} = \frac{c_{1,avg} + c_{2,avg} + \cdots + c_{n,avg}}{N} \quad [2]$$

where $A_{dept,eq}$ is the average citation rate for a hypothetically similar department, $c_{n,avg}$ is the SCI average citation rate for each subfield n and N is the total number of articles published.

Comparing departmental metrics with SCI citation frequency rates gives a proxy for research quality and indicates the perception of the research quality of each Department in the wider academic community (Rudd, 1988).

2.2 Assessment of Academic's Attitudes

A questionnaire was administered to all full-time members of academic staff in The UWI Faculty of Engineering, to gather data on attitudes to different issues that affect UICs. Standardised questions ensured that all respondents were answering the same questions and a Likert scale ensured that respondents answered in a uniform manner (Mills et al., 2010).

The questionnaire was administered electronically. Using a web-based interface, responses remained anonymous, which was beneficial given the sensitive nature of some of the questions. The questionnaire consisted of five demographic questions fields and twenty-five questions related to different aspects of UICs: twenty Likert scale questions; two "Yes/No" questions; and two close-ended multiple-choice questions. Affirmative statements were generally formulated to allow nuanced responses on a five-point Likert scale. Nine general themes were addressed:

a) The role of universities in innovation and technology transfer;
b) Personal orientation with regard to research collaborations;
c) Personal Orientation to Research Commercialisation and Intellectual Property;
d) Willingness to Accommodate Industrial Partners;
e) Industrial Experience;
f) Government Involvement;
g) Incentives;
h) Barriers to University-Industry Collaboration;
i) Organisational Culture.

After a pilot study, changes were made to the wording of some of the questions and one question added exploring faculty members' previous experiences with industrial research.

2.3 Assessment of Technology Transfer Support

A semi-structured interview was conducted with a Business Development Manager from The UWI Office of Research Development and Knowledge Transfer to gain a more detailed understanding of the operations and challenges of the office. Information was sought about: the organisation of the ORDKT; the processes used by the ORDKT; and the personnel composition of the office. This was combined with personal knowledge derived from close interactions with the ORDKT.

3. Conceptual Model

High-quality university research coupled with strong industrial partnerships is a recipe for successful innovation and strong technology transfer (Dooley and Kirk, 2007). Most partnerships between universities and industry that lead to innovation and technology transfers tend to involve either science or engineering university faculties.

For a university to have a significant positive impact on innovation through technology transfer, and hence contribute to economic development in its locale, a number of important factors must be in place. The model that is proposed here is an evolution of work previously reported by King and Cameron (2013). The model presented here has been clarified and is now augmented with good practice data collected on the functioning of UICs in UK universities. A visual representation of the conceptual model is shown in Figure 1.

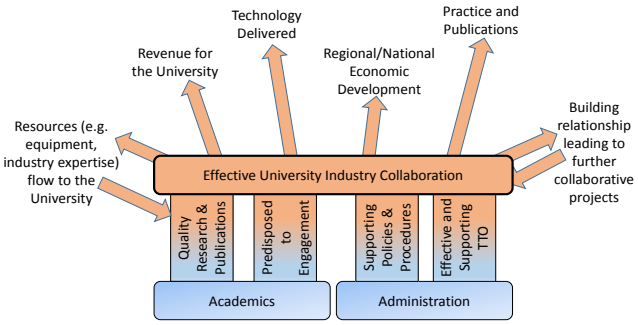

Figure 1. Graphical Representation of UIC Good Practice Conceptual Model

Effective UIC has numerous benefits to company, national and regional development, to the university, to the participating academics and to students. These have been widely reported elsewhere (King and Cameron, 2013) and some of the most important are highlighted as outputs. Effective UIC requires full support of both academics and the university administration. This is illustrated by these two being the 'foundation stones' in Figure **1**.

3.1 Quality Research and Publications

Credible and high-quality R&D activities must be taking place in the university, so that:

a) knowledge is generated that can lead to innovation and technology transfer; and
b) industrial partners will gain confidence in the capability and value of the university;
c) students and researchers will be attracted to the university, who can then be engaged in industrial research activities.

3.2 Predisposition to Engagement

Members of academic staff must value the opportunity to engage with industrial partners in research projects and actively pursue such opportunities (Barbolla and Corredera, 2009). Research in UK universities identified that some academics tend to be much more predisposed to engagement than others, and these are the ones that can make a significant difference in the institution – so-called 'stars'. For academics to develop a predisposition to engagement requires that:

a) there is a connection between engaging in UICs and the formal assessment and promotion structure of the University (Siegel et al., 2003; Link et. al, 2007);
b) recognition be given for the real-world impact of an academic's work, beyond recognition of publications;
c) experience in interfacing with, or working in, an industrial context, which sensitises academics to industrial considerations – new formats of doctoral programme and incorporating industrial placements into traditional doctoral programmes are good practices in this regard as seen in UK universities;
d) relationships between academics and industry leaders are established and maintained – the relationships between academics and industrial partners are key to positive outcomes and sustainability;
e) academics are enthused about research work that lies adjacent to, not only directly within, their established sphere of expertise.

3.3 Supporting Policies and Procedures

Policies and procedures in a university shape the expectations and behaviour of its academics. If a university wishes to encourage UIC, then its policies and procedures should be aligned with that objective. This requires:

a) allocation of adequate resources in the University both toward research and support services to facilitate University-Industry Collaborations;
b) a direct systemic link between engaging in UICs and qualification for increased resources for research, whether through industrial partners or public funding (WIPO, 2005; Acworth, 2008. Mustar, 2008) – this can be achieved by requiring that academics demonstrate the *impact* of their research on real-world scenarios;
c) fair and reasonable sharing of revenues from exercised patents between the inventor academic and the institution;
d) assessment and promotion policies that reward:
   i. application of research and technology transfer;
   ii. generation of research income for the university from industrial partners;
e) recruitment of academics with a predisposition towards, and track record in, UIC.

3.4 Supporting Technology Transfer Office

In UK universities, it is seen that a functional and effective TTO makes a very important contribution to UIC. It serves numerous facilitating purposes and good practice dictates that it should:

a) build social connectivity with potential industrial and other partners – both informally and formally;
b) facilitate academics in matching their research activities to funding partners, whether grant agencies or industrial partners;
c) provide the university with institutional knowledge – breadth of sight of the needs and opportunities in its environment and to which it could respond;
d) enhance the alacrity of the university in responding to emergent needs;
e) ensure that the university has the capability required to deliver desired project results through effective project management;
f) assist in the evolution of university policies and practices to match its ever-changing environment;
g) facilitate the protection of innovations and intellectual property that arise from university endeavours;
h) have programmes that assist in the commercialisation of inventions that are generated by the university, especially through the creation of spin-out companies;
i) integrate the university into industrial and technological agglomerations and partnerships, which must effectively provide a 'market' for the research generated and connect the university directly with the economic life of its locale;

If each of the four pillars described in this model is in place, then a university is well able to engage in effective UIC and contribute positively to the national or regional innovation ecosystem. We can use this model as an assessment tool for any university institution.

4. Results and Analysis

4.1 Publication and Citation Data

Firstly, let us consider the rate of journal publications as an indication of research productivity. Productivity can be used as a measure of research quality if it is assumed that the funding used to finance research is awarded based on judgements of the research quality and merit of previous research work (Rudd, 1988). Note that this metric does not capture contract research that is fully funded by industrial partners and which may not be readily published, but it is known to the authors that little such research takes place at The UWI.

Therefore, the rate of publications serves as a reasonable proxy for overall research activity. The percentage of Faculty members publishing journal articles in the period 2006-2011 is shown in Table 1. The general trend observed from this data is that the majority of engineering academics are not publishing their research by means of journal articles.

Table 1. Percentage of Academic Members of Staff who Published Journal Articles

Year	Percentage Publishing
2006-2007	28%
2007-2008	16%
2008-2009	25%
2009-2010	19%
2010-2011	23%

The 2007 edition of the Faculty Scholarly Productivity Index shows that for the ten universities in the US which produced the highest number of academic publications via journal publication, at least 83% of engineering faculty had published a journal article in the last academic year (The Chronicle of Higher Education, 2007). It is acknowledged that these institutions operate in a different context than The UWI. However, it does illustrate that academic faculty at top-tier universities use the medium of journal articles to disseminate their research, and that The UWI Faculty of Engineering falls far short of the levels of involvement of faculty in publishing that is found at these top tier universities. This represents a significant opportunity for improvement for the Faculty of Engineering.

Secondly, the visibility of the articles that are published can be taken into consideration. Figure 2 compares the number of The Faculty's journal articles that are contained in the SCI with the total published over five (5) academic years. Overall, the ratio of papers contained in the SCI to those published is 40%. Correlation between the number of articles published by a department and the number of the articles which are included in the SCI is weak, giving a linear regression coefficient of determination (R^2) of 0.37. This was not surprising as a number of factors influence the inclusion of an article in a citation, not least the journal in which the article is published (Kostoff, 2002; Cronin, 2001). It could be argued, however, that a high SCI score indicates the usefulness of the research to the wider academic community and implies that the research is of good quality. Consistently high SCI scores would mean good international research visibility, regular citations, and a commensurate research reputation.

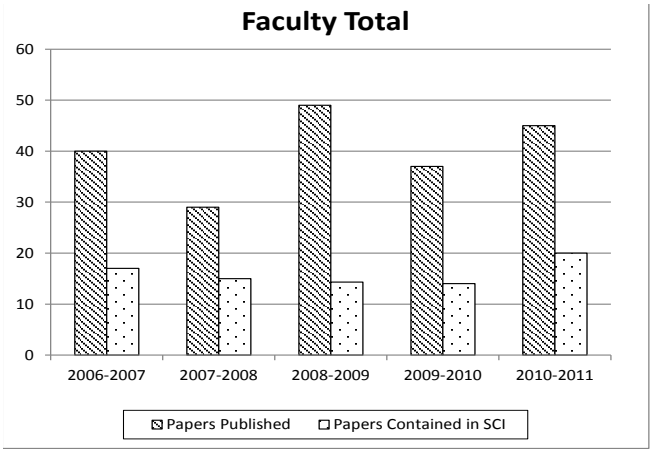

Figure 2. Faculty Total Papers Published vs. SCI References

It is noted that many of the Faculty's publications are in journals not covered by the SCI; whether in Asian journals, regional journals or even non-English language journals. Such publication practices can reduce the coverage of the Faculty's publications in the SCI and cause a reduction in the visibility of the research output of the Faculty (Abramo et al. 2010; Bornmann et al., 2008).

Thirdly, and continuing the theme of considering the impact and usefulness of The Faculty's research, Table 2 shows average citation frequencies for each department (*A*) in comparison with the average citation frequencies for each subject classification to create a weighted average citation frequency for a theoretical department with similar publication norms (*C*). These publication norms would be similar with specific regard to the productivity of that theoretical department in the same subject area classifications. The table below shows the citation frequencies for each department in the Faculty and for their respective comparison theoretical departments.

In almost all cases, in the five academic years examined, the average citation rates are far below the respective citation rates of the theoretical departments.

Table 2. Average Citation Frequencies by Department

Department	Variable	Academic Year				
		2006-2007	2007-2008	2008-2009	2009-2010	2010-2011
Chemical Engineering	A	4.75	2.29	2.33	1.33	1.08
	C	7.06	8.78	5.93	4.16	1.90
Civil Engineering	A	3.00	-	0.50	0.00	0.33
	C	9.39	-	2.22	2.95	1.02
Electrical Engineering	A	2.00	3.38	2.50	2.14	0.00
	C	8.35	6.81	6.98	4.87	1.37
Geomatics Engineering and Land Management	A	3.50	-	2.00	0.00	0.00
	C	9.63	-	5.71	4.16	1.45
Mechanical Engineering	A	6.00	-	1.00	2.00	0.00
	C	6.78	-	4.94	4.43	3.12

This may indicate either or both of: (i) poor regard amongst the wider academic community for the research coming out of the Faculty; and (ii) poor *visibility* of the research reported by the Faculty.

4.2 Questionnaire Responses

Response rates for the questionnaire were 20% of the target group. While this is a bit too low for the establishment of statistical significance, the results can be used qualitatively and indicatively. In the description and analysis presented here, key themes are identified and inferences made as to the dominant attitude among academic staff on that particular issue.

The first issue that will be considered is *willingness of Faculty of Engineering academics to engage in UICs*. The responses to a number of the questionnaire items give positive indications with regard to this issue. Respondents unanimously indicated that they thought that universities such as The UWI should be involved in supporting regional innovation and economic development. They also were generally supportive of knowledge transfer between The UWI and industry and perceived little ethical conflict with those types of activities. Furthermore, most respondents recognised the potential benefit that collaborative research with industry could have for their own research, and most were willing to modify their research and publication habits to accommodate the needs of industrial partners. These responses are important because ethical conflicts, differences in research priorities and lack of accommodation of industrial partners can hinder the success of UICs (Dooley and Kirk, 2007; Barnes et al., 2002). Sensitivity to these issues can be regarded as a positive indicator for the potential success of any future UICs.

Further supporting the impression that Faculty of Engineering academics are willing to engage in UICs. Most respondents had previous industrial experience or would be interested in industrial attachments. In addition, the majority of respondents maintain networks of industrial contacts. This willingness to engage with industrial partners is a positive factor that can contribute to the success of UICs as academics with industrial experience can be effective "boundary spanners" who by virtue of their experience and contacts in both the industrial and academic worlds can facilitate the creation and operation of UICs (Thune, 2011; Pertuzé et al., 2010; Philbin, 2009; Wright et al., 2008). Industrial experience furnishes the academic with knowledge of the possible applications of research carried out in the university environment, and industrial contacts can also help to keep him up to date with the needs of industry.

The reminder of the questionnaire considered other issues that can affect the process of knowledge transfer and therefore affect the success of UICs. The first of these was the attitude of the surveyed academics to commercialisation of their research. While some of the respondents indicated interest in commercialisation of their research, there was a large proportion that expressed indifference towards commercialisation. This suggests that academics in the Faculty of Engineering may not be particularly entrepreneurially oriented. This does not bode well for the potential of commercialising the faculty's research as such attitudes suggest a low level of motivation among the faculty. In addition, a perceived lack of interest in entrepreneurial activities within a faculty has been seen to dampen the level of interest of other academics in pursuing such activities (Tartari et al., 2010; O'Shea et al., 2007).

The next issue considered was attitudes to intellectual property (IP). The majority of respondents indicated that they would have no issue with the university holding the rights to intellectual property they create using university resources. What was also clear was that researchers expect to be remunerated fairly for any revenue-generating IP that they produce. This is in line with recognised practice in other countries where universities hold the rights to the research of their employees. This has been found to be a more efficient and successful way of managing revenue-generating technology transfer (Verspagen, 2006). These findings are supported by previous research that shows that fair compensation should be built into universities' IP policies as this can improve the commitment of academic researchers to UICs (Mustar et al., 2008).

The final issue considered from the questionnaire

data is barriers to involvement in UICs. The major barrier highlighted by the responses is a lack of suitable government funding programmes for UICs in specific areas. In some countries where UICs are more common, government financial support of innovation has been provided often through multiple agencies and programmes set up to fund particular scientific areas. Examples of this are the Biological Sciences Research Council (BBSRC) and the Engineering and Physical Sciences Research Council (EPSRC) in the UK (Acworth, 2008). In many cases, research proposals that include UICs are considered more favourably. The provision of local or regional government funding for engineering projects that included UICs could catalyse engagement with industry by academics in the faculty.

Another potential barrier highlighted was the perception that the majority of respondents had that The UWI's organisational culture does not support innovation. O'Shea et al. (2007) highlighted in examining the contributing factors to the success of the Massachusetts Institute of Technology as a hotbed of innovation and entrepreneurialism highlighted that the development of an organisational culture that supports innovation is key. These responses suggest that greater institutional support is required for innovative research by the Faculty, and that the support services available must be marketed to academics.

4.3 Supporting Policies and Procedures

Although a detailed examination of policies and procedures is not the primary concern of this paper, it is worth mentioning that some are in place at The UWI. Specifically:

a) An IP Policy, in line with the recommendations of the World Intellectual Property Organization (WIPO), is in place;
b) The IP Policy includes specific provision for the splitting of revenues between the academic or inventor and the university in the case that a patent generates income;
c) An invention disclosure process that allows for the assessment of an invention for patenting support by the University; and
d) Recognition of patents as being worth three journal papers for the purpose of academics' assessment and promotion.

There is no apparent deliberate attempt made on the part of The UWI to recruit academics with experience in or disposition towards UIC. Apart from regulations for academics engaging in consultancy with private enterprises, there are no policies or procedures that specifically address wider issues of UIC. In addition, there is no institutional effort towards building functional relationships with industrial partners. Beyond IP and patenting, the policy framework addressing commercialisation of research findings is very weak.

4.4 Technology Transfer Support

The ORDKT provides the typical TTO activities of patenting, licensing and liaising with industry (Lee et al., 2010). Apart from patenting and licensing activities, the ORDKT assists in UIC through administering consultancies and sponsored research. Consultancy is the most common form of UIC that the university engages in. Patents are occasionally pursued, and The UWI currently has a handful of US patents pending.

Barnes et al. (2002) highlighted that engaging in a variety of modes of UICs helps to strengthen relationships between universities and industrial partners. In order to foster UICs, the ORDKT has assisted the Faculty of Engineering in the staging of industry consultations. The aim of such consultations is to ascertain the research needs of industry, but it also served to help build social networks. Being apprised of the needs of industry has been identified as a contributor to successful UICs and activities such as industrial consultations have been recommended in previous research on the subject (Dooley and Kirk, 2007; Siegel et al., 2003). While the activity in these areas is encouraging and shows that there is interest in strengthening UIC, the activity is still immature.

Funding is another issue of vital importance for the success of UICs. The ORDKT is actively involved in seeking financial support for university research projects. Funding comes from a mixture of government and multi-lateral funding agencies, although government funding has been decreasing in recent years. Funds are disbursed through various grants for which researchers can apply. Unfortunately, these budgetary restraints may be a limiting factor for academics seeking to engage in research. The low level of funding for operations of the ORDKT itself, particularly compared with the annual patenting and licensing budgets of TTOs in developed countries, is also a challenge.

Staffing represents a challenge for the ORDKT. While there are a number of professionals with expertise in legal matters and business development there are still gaps in the available skill sets in the ORDKT, which need to be met. The interviewee suggested that one such gap exists in the area of technology marketing. There is also a need for more technical support staff to aid in research and evaluating patent applications. Staff headcount is low compared to the volume of work that could potentially be undertaken, and this limits the extent to which proactive relationship building can take place with external partners and potential partners.

5. Discussion

The conceptual model proposed earlier in this paper posits that if certain factors are present then the institution or faculty will have the capability to engage in meaningful UIC. Therefore, to determine the capability of The UWI's Faculty of Engineering for UIC it is necessary to compare the present situation of The

Faculty with the conceptual model's four pillars of 'good practice'.

Pillar 1: Quality Research and Publications

Comparing the SCI citation rates for each of the department in The Faculty to a theoretical academic department that publishes in the same areas, it is seen that, generally, the rate of citations of the Faculty is significantly lower than those of theoretical departments that publish in the same areas.

Research published by members of The Faculty is not being cited as often as work from researchers in equivalent departments in other institutions that publish in the same areas. This low citation frequency could be indicative of:

a) the scientific community's lack of regard for the researchers and research of The Faculty of Engineering; and
b) a lack of visibility of research from The Faculty;
c) the publication habits of the researchers in the faculty, whereby regional or national journals are targeted rather than international journals;
d) a generally low level of productivity among researchers within The Faculty, with relatively few academics publishing regularly.

Points (c) and (d) above combine to diminish the profile of the university to other members of the scientific and academic communities. On the basis of these findings it can be said that the Faculty of Engineering does not meet the requirement of 'quality research and publications' based on the collected data.

In order to boost the confidence of industrial partners in The UWI for UIC, members of faculty must continue to be encouraged to publish relevant papers in top-tier academic journals. The university should also profile its research nationally and regionally to build respect in the eyes of potential partners.

Pillar 2: Predisposition to Engagement

Based on the responses to the questionnaire, it was clear that the majority of academic staff members who responded recognised the value of engaging with industry in their research, and were willing to do so. The respondents also indicated that for the most part they perceived no difficulty with pertinent issues such as ethical conflicts, difference in research priorities and lack of accommodation of industrial partners. The academics' flexibility with these issues is a positive indicator for the success of UICs. Furthermore, the majority of respondents indicated that they had previous industrial experience and maintained networks of industrial contacts. Both of these points add to the positive predisposition to engagement of the academics of the faculty. The data also revealed that many of the respondents were indifferent to commercialisation and entrepreneurial activity, which would tend to detract from the predisposition to engagement.

Based on our research data, it seems that this pillar for UIC is in place and could be strengthened if The Faculty or the ORDKT were to assist academic members of staff in efforts to build relationships with industrial partners.

Pillar 3: Supporting Policies and Procedures

Supporting policies and procedures have been established at The UWI that could potentially assist in the technology transfer process. However, the shortfall lies in the lack of utilisation of those policies. For instance, the invention disclosure process is generally utilised less than five times per year. Relatively few patents are filed by the university, so despite the revenue sharing algorithms that are defined and the benefit to an academic's assessment and promotion prospects, research that produces patents seems to be scant. Furthermore, there is limited budget allocated to defending patents, and without the means to defend a patent, its value becomes negligible. In its history, The Faculty of Engineering has only produced one spin-off company, which reflects the lack of policies and procedures that incentivise such innovation activities.

It would be in the University's interest to more actively pursue UIC to support the academics and capitalise on the benefits that it can afford. This work indicates that there is a predisposition towards UIC among academics, so the reason for the low numbers of collaborative may be due to university culture. Policies and procedures help to form the culture, so amending the policy framework to positively reward involvement in UICs increases capacity. Such a move would be in line with university policies in other parts of the world (Polt et al., 2001; Perkmann and Walsh, 2007).

Pillar 4: Technology Transfer Office

Industry consultations held by the Faculty of Engineering and supported by the ORDKT address consultations in part points 'a' and 'b' in the fourth pillar of the Conceptual Model and make small steps toward fulfilling point 'f'. The consultations assist in relationship building, assessing the needs of local industry, and enlighten potential industrial partners about the capabilities of The Faculty.

The activity of the ORDKT in facilitating the protection of IP by means of filing for patents where necessary addresses point 'h' in fourth pillar. On the other hand, the interviewee from the ORDKT stated that one of the deficiencies of the ORDKT is staffing including areas such as business development. This suggests that currently the ORDKT cannot fulfill point 'g' of the conceptual model – protection of the IP of innovations.

At present, The UWI does not fulfil the fourth pillar of the Conceptual Model, since the ORDKT has insufficient financial and human resources to provide strong support for UIC, or even, for that matter,

extensive technology transfer support. Increasing the funding of the ORDKT could be seen as an investment if the return is obtained in the form of incoming research funding, revenues from patent royalties, dividends from spin-out companies, and sponsorship from industrial partners.

Implications for Other Universities

The challenges faced by The UWI in engaging in UIC, as a regional university in the developing world, are not unique. It is quite likely that many other institutions, especially those in Africa, the Caribbean and the Pacific (ACP), also have difficulty in competing globally in research quality, might have an orientation towards teaching rather than research, suffer from an underdeveloped policy framework and lack an effective TTO. The Conceptual Model and findings from this study at The UWI might be very useful as a means of comparison for universities across the ACP region. This could be pursued as further work.

6. Conclusion

We have proffered a Conceptual Model for UIC which has as pillars for its success: quality research and publications; predisposition to UIC on the part of academics; appropriate policies and procedures in the institution; and an effective supporting technology transfer operation.

The publication habits of academics in The UWI Faculty of Engineering have not served to elevate the research reputation of the institution, with the result that industrial partners are less likely to have confidence in the value of The Faculty as a partner.

Questionnaire results showed that the majority of the academics who responded are willing to be involved in UICs and to engage with industry in a variety of ways. There is also a willingness to accommodate the needs of industrial partners in collaborations. These findings bode well for future attempts to initiate UICs. However, a low level of social interaction between academics and industry, and an absence of commercial or entrepreneurial orientation in the research agendas of academics are factors that need to be addressed to increase the probability of success of UICs involving The UWI.

Some policies and procedures to support UIC are in place, but incentives are required to encourage academics to engage more actively in UIC. Hence, the ORDKT is significantly under-resourced which limits the range of TTO functions that it can effectively perform. The UWI would be well advised to remedy this situation so that the office can provide much stronger support for UIC. Financial investment in the ORDKT should generate a clear and positive return on investment in terms of research revenue generated.

Recommendations to improve the performance of the Faculty of Engineering with regard to UICs are:

a) Tie the granting of research funds to academics more closely to an assessment of the track record of their research impact.
b) Ongoing dialogue and consultations with industrial leaders to learn the significant issues that their companies face that could become the focus of research studies.
c) Recruiting and retaining faculty in sub-disciplines that are identified as industrially relevant.
d) Government, The UWI and Industry to create and fund research grants in subfields that have particular industrial and national significance for economic development.
e) Establishment of a policy for collaboration with industry. This policy would provide financial incentives for academic inventors for their involvement in UICs. Promotion and tenure policies should also be modified to reward involvement in UICs.
f) Additional financial and human resources should be allocated for the ORDKT taking into consideration best practice and the resources needed to support the University's goals for the ORDKT.

This evaluation has made it clear that achieving strong and productive links and viable UICs between the Faculty of Engineering and local industry requires restructuring and a significant investment of energy by both the Faculty and the University Administration. This situation is probably not unique to The UWI, but may be reflected in many other developing world universities, especially those in the ACP regions.

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