MAURITIUS RESEARCH COUNCIL

Research/Innovation-Industry Linkage Study

Final Report

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EXECUTIVE SUMMARY

The global economy is facing multiple challenges, buffeted by economic and financial instability. Against this backdrop, each and every country is trying to sustain growth, and one of the determinants to sustain growth is innovation. Innovation in all its forms is a core condition for both the growth of the economy and business competitiveness. Enterprises are increasingly introducing innovative processes, products and services to sustain their growth trajectories, particularly in a context marked by rife global competition.

A large body of evidence indicates that the innovative performance of enterprises is not only shaped by entrepreneurs and firms, but extends well beyond its realms. It involves interactions among a wide range of agents operating in an innovation system that favour knowledge transfer and use. In particular, there is widespread consensus that universities and research centres through their research and technological spill-overs are important sources of knowledge that can trigger innovation at industry level. The complementary and mutually-beneficial aspects of research and industry linkages are self-evident, as they contribute towards efficiency, productivity gains and growth.

Mauritian enterprises are no different from their international counterparts. They are also experiencing both internal and external pressures to improve their bottom lines and boost their top lines. Enterprises are facing growth stalls and are increasingly under intense competitive pressures. Leveraging on research and innovation can help sustain their growth trajectories, by enhancing their competitive edge.

However the dearth of existing data on the nature of the linkages between research institutions and the private sector called for a systematic investigation. Given this backdrop it is attempted to investigate, map and characterise the Research/Innovation-Industry Linkage in the Mauritian innovation system. The specific aims of the study are to:

- explore the specific role of Research-Industry Linkage (RIL) in the National Innovation System,

- map, understand and assess the nature of linkages which exist between private sector and research institutions, and
- identify the main bottlenecks which hamper efficient and effective linkages, with the view to enable the development of lasting linkages which spur win-win collaborations for both the innovation/research institutions and the private sector.

Definitions & Conceptual framework

Research comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humanity, culture and society, and the use of this stock of knowledge to devise new applications. It can be categorised as basic, applied and experimental development.

Innovation refers here to the introduction of new ideas, goods, services, and practices which are intended to be commercially useful. Such innovation encompasses performance improvements in products, services, processes and systems. A review of the business and economics literature reveals that innovation is often divided into 5 types, namely product, process, marketing, organizational and business model forms of innovation. This typology is adopted in this study.

For the purpose of operationalising the study, the scope will be at three broad levels, encompassing the users of research and innovation, providers of research and innovation and existing institutions that have the responsibility to promote and/or facilitate linkage between research/innovation (R-I) and industry (Figure 1).

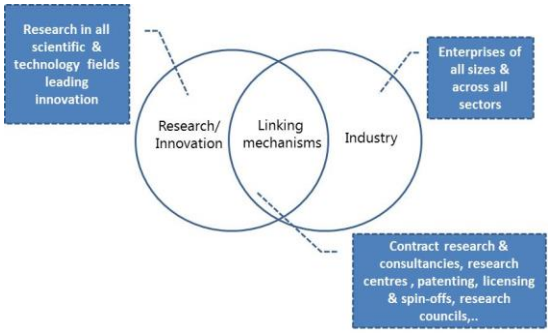

Figure 1: Scope of the study

Methodological approach

The study has been broken down into three distinct parts (different spheres in figure 1) and a mixed methods approach has been adopted.

At the level of providers of R-I

A quantitative approach has been adopted by way of an email survey of academics and researchers. This uncovered the type of services, sectors serviced and also the conditions under which researchers provide their services to industry. The survey also captured the perceptions and attitudes of researchers of the current level of linkage between themselves and industry. This approach was complemented with in-depth interviews with heads of departments, heads of schools, heads of institutions and directors of advisory companies to ascertain how they provide their institutional services to industry and also what would be their propositions to improve such linkages.

At the level of users of R-I

A second quantitative survey was conducted on a sample of 300 companies across sectors to assess how R-I factor into their decision-making model and what are the sources and transfers of such innovation. The survey was balanced with case studies of companies which have successfully linked, sourced and used innovation from research institutions. The objective here, is to investigate the existing mechanisms of innovation transfer.

At the level of institutions that promote linkage between R-I and industry.

This component of the methodology focussed on assessing the roles of institutions that have the responsibility of facilitating linkage between R-I and industry. This hinged on in-depth interviews with heads of institutions to try to appraise existing mechanisms that aim at promoting linkage and the main bottlenecks associated with implementing such initiatives.

Main Findings

R-I at enterprise level

48.4% of firms claimed that they were not involved with research, and 10.2% reported that they commissioned research (Figure 2).

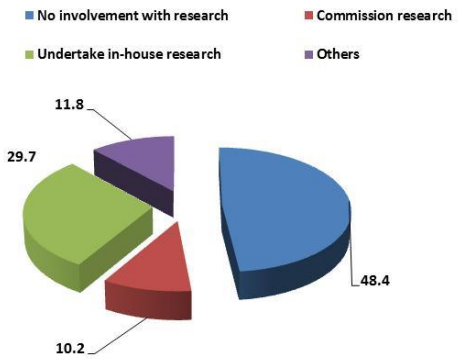

Figure 2: Firms' involvement with research

Of those that claimed to be involved in research, 74.8% reported that they had a dedicated annual budget of less that Rs 100,000 dedicated to research. Most of surveyed firms acknowledged that innovation is an important input in their business strategy and 75.1% of them are involved in product innovation.

Links between R-I and Industry

108 out of 246 surveyed firms have contacted R-I institutions, but only 18.7% of them have established formal links. Reasons explaining this disparity include [1] 'researchers do not understand the reality of business, [2] lack of expertise, and [3] services are too costly.

47.2% (of 46) of established links have been with consultancy firms, 16.7% with publicly funded institutions and 14.8% with universities (Figure 3.0). 71.3% of links were established through personal contacts. 51.9% of links were formalised through contracts. On the other hand many researchers mentioned that they had never linked with the private sector.

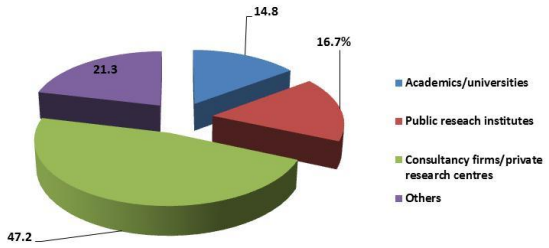

Figure 3: Types of R-I institutions that enterprise link with

31 out of the 46 firms have spent up to Rs 500,000 on external R-I in the forms of contracts, fees and stipends. Zero R-I expenditures in figure 4, can be accounted for by firms that have established links and benefitted from publicly-funded R-I institutions.

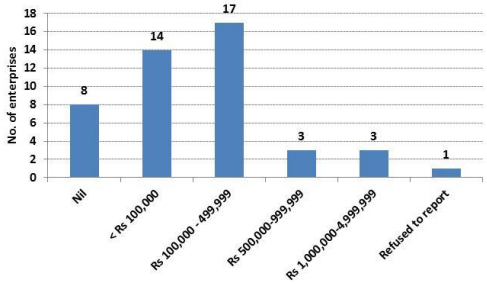

Figure 4: Budget spent on external R-I over the reference period

Figure 5 presents the important reasons that motivate firms to link up with external R-I institutions. Some researchers highlighted that there exist insufficient incentives for them to link and provide their services to the industry.

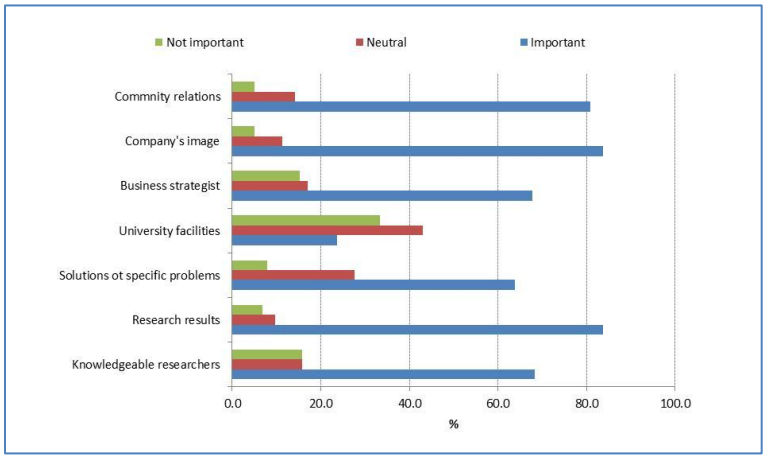

Figure 5: Motivation to link up with R-I

Evaluation of linkages with R-I institutions

77.2% of firms which have linked with R-I institutions over the reference period were satisfied with the outcome of the linkages. Figure 6 provides additional details.

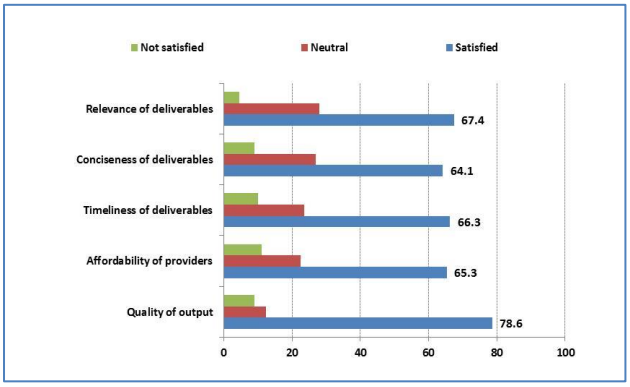

Figure 6: Satisfaction with outcome of linkages

Role of linking institutions

The Centre for Contract Research at the University of Mauritius, and the Mauritius Research Council also have the mandate to foster R-I linkages with industry. Both institutions are respectively hampered by insufficient public funding and the unwillingness of industry to set apart additional resources to fund R-I.

Conclusions

Mauritius is stuck in the middle income country trap, and innovation is often being touted as a precondition to assist countries to get out of the trap.

Stakeholders in general, and firms that have been involved in the commercial use of knowledge generated by R-I institutions strongly assert the role of R-I in addressing critical issues at industry level and contribute to industry growth. There are few firms that have benefited from R-I locally, but these are rare cases.

It is a fact that locally, public funding for research is decreasing. Coupled to that the private sector is currently facing internal and external pressures to improve their bottom lines and boost their top lines, and are less willing and likely to invest in R-I, even though they acknowledge that R-I can underpin industry growth. The challenge here is to increase internal expenditure on R-I without increasing the burden on firms. For R-I to fully contribute towards industry growth it is crucial to increase the R-I funding at industry level and improve the ecosystem within which linkage can prosper, to benefit both producers and users of R-I.

Policy pointers

At institutional level

R-I is not costless, it requires investment. It is proposed to use up to a maximum of 0.5 of the 2% Corporate Social Responsibility fund to finance R-I at enterprise level. The objective here is to make use of part of the funds that companies are already contributing to the CSR fund to

conduct research that is relevant to their needs and that leads to innovation and subsequent growth. The attractiveness of this model is that firms would be using part of their CSR funds to support R-I that would benefit them. Such research would be targeted and relevant as it would be conceived by enterprises to cater for their own needs. Research could be conducted [1] in-house by dedicated internal researchers, [2] externally by either local/international resource persons by developing and adopting different types of linkages. There are existing Private Sector Collaborative Research Grant Schemes that can be amended and tailored to support the above linkages.

At linking institutions' level

There is need for better knowledge management (e.g. a dynamic database) at R-I institutions to facilitate the interfacing of outputs from researchers with the needs of industry.

Conducive structure and mechanism for swift formalisation and operationalisation of linkages (Fees structure, IP agreements,…) need to be set-up at R-I institutions.

At R-I producers' and industry levels

It is proposed to establish mobility schemes between research institutions and enterprises, whereby researchers are encouraged and incentivised to conduct full-time research in an enterprise for a specific duration. Increase awareness of research outputs, skills & expertise [database, cluster forums, one-on-one meeting, ….].

It is important to develop joint research programmes that generate outputs of commercial relevance and cater for the needs of industry [more applied research and experimental development]. Concurrently, research capacity (with industry support) and infrastructure relevant to the needs of the industry can be developed.

The research and innovation culture at the level of the firm should be aggressively instilled and developed. In parallel the absorptive capacity of the enterprise should be improved to internalise and appropriate spillovers.

This study has also highlighted that there were insufficient ideas and input that diffused from research centres, that are transmuted into products, processes and services of commercial value.

The limited role most of existing research play in providing research and innovation services to industry and the challenges they face, call for a re-think of how RI-I linkages are established and funded. There are several reasons explaining this state of affairs. The main ones being the low industry-relevant research output; general unawareness of firms of the types of and the potential impact of innovation and more importantly how they can innovate using either in-house or external research; the general low RI absorptive propensity of industry and the reported inadequate responsiveness of intermediary institutions to the needs of industry.

The challenge here is to increase internal expenditure on R-I without increasing the burden on firms. For R-I to fully contribute towards industry growth it is crucial to increase the R-I funding at industry level and improve the ecosystem within which linkage can prosper, to benefit both generators and users of R-I.

R-I is not costless, it requires investment and this needs to be less dependent on Government funding It is proposed to use up to a maximum of one quarter (0.25) of the 2% Corporate Social Responsibility fund to finance R-I at enterprise level. The objective here is to make use of part of the funds that companies are already earmarking for CSR projects or are contributing to the CSR fund, to fund and conduct research that is relevant to their needs and that leads to innovation and subsequent industry growth. The attractiveness of this model is that firms would be using part of their CSR funds to conduct and support R-I that would benefit them.

Linking institutions must also intermediate between international RI institutions and the local industry. Findings of the study have also shown that a significant percentage of local firms prefer to have access to RI generated internationally. The *modus operandi* of some local linking institutions must be amended and enhanced to also foster cross-border knowledge transfer.

There is a pressing need for a conducive structure and mechanism for swift formalisation and operationalisation of linkages need to be set-up at R-I institutions. These would include fees structure, sharing rights, intellectual property protocols, model contractual agreements, licensing, spin-offs among others. It is fundamental that intermediaries at the level of RI institutions that are mandated to foster linkages with the private sector are experienced and adequately skilled in terms of their research credential and more importantly have a 'private sector' mentality in promoting firms' growth through the adoption of innovative processes and practices.

It is proposed to consider creating the space for the creation of innovation intermediaries. These can be companies, individuals, organizations or groups within or outside organizations that work to facilitate and enable innovation, either directly by enabling the innovativeness of one or more firms.

Given that the majority of researchers locally are from universities, it is fundamental that universities look beyond their traditional role of teaching and conducting basic research, towards being increasingly involved in research and innovation that involve a more direct interaction and contribution to the industry.

It is important to provide the conducive environment for universities to support the creation of networks and make universities as permeable as possible/practical. for the temporary movement of researchers to industry. It is proposed to establish mobility schemes between research institutions and enterprises, whereby researchers are encouraged and incentivised to conduct full-time research in an enterprise for a specific duration.

CHAPTER ONE: INTRODUCTION

1.1 Background/Rationale of the Study

The global economy is facing multiple challenges, buffeted by economic and financial instability. Against this backdrop, each and every country is trying to generate sustained growth, and one of the determinants to sustain growth is innovation. Innovation in all its forms is a core condition for both the growth of the economy and business competitiveness. Enterprises, large and small, are increasingly introducing innovative processes, products and services to sustain their growth trajectories, particularly in a context marked by rife global competition. A large body of evidence indicates that the innovative performance of enterprises is not only shaped by entrepreneurs and firms, but extends well beyond its realms. It involves interactions between a wide range of public and private actors. In other words this innovative performance is more generally shaped by an innovation system. An innovation system is the connected set of organisations (firms, research centres, universities, financial actors) and institutions (laws, regulations, infrastructure, financial schemes) that shape the environment within which firms innovate. For an innovation system to be fully functional, its components should be properly wired. Geiger (2004) and Yusuy et al (2008) complement the above by stressing that apart from being wired, the components should more importantly allow for knowledge transfer and use.

In particular, there is widespread consensus that universities through their research and technological spill-overs are important sources of knowledge that can trigger innovation at industry level and generally develp 'knowledge-economy' capabilities (See Auerswald and Branscomb 2003; Adams 2001). The complementary and mutually-beneficial aspects of research and industry linkages and collaboration are self-evident. At its simplest, researchers may for instance gain access to industry funding, recognition and reward and in many cases industrially sponsored students provides students with exposure to real world research problems, among other things. On the other hand, industry gains access to expertise to

solve/improve specific technical issues; access to university facilities not available in an individual firm; assistance in continuing education and training and even obtaining prestige or enhancing the company's image. Altogether, such linkages contribute to the advancement of the knowledge and National Innovation System Infrastructure, boost efficiency, productivity gains and competitiveness and boost economic growth.

Mauritian enterprises are no different to their international counterparts and are also experiencing both internal and external pressures to improve their bottom lines and boost their top lines. Enterprises are facing growth stalls and are increasingly under intense competitive pressures. Leveraging on research and innovation can help sustain their growth trajectories, by enhancing their competitive edge. The Mauritian Government has identified research as one of the potential generators of innovation for industry and consequently as a determinant in further fostering private sector growth and development. This position was highlighted in the budget speech 2010 under excerpt 207: **'to have a strategic advantage in education, training, research and innovation, we must connect research done in our tertiary institutions to the needs of enterprises and Government'.**

However, despite the emergence of a series of ongoing initiatives[1] locally in the recent past, that have attempted to wire the different components of the Mauritian innovation system, the linkages between the research sector and industry are not properly understood. Existing data on the nature of the linkages between research institutions on the one hand and the private sector on the other hand is at best patchy and calls for a systematic investigation. The scant attention which the area of 'Research-Industry' Linkages has received so far has tended to focus on 'university and industry' linkages and more particularly on teaching and learning aspects rather than on research per se.

[1] For e.g. the Mauritius Research Council currently implements/services the following initiatives: Collaborative Mauritius, Business Research Incubator Centre & Private Sector Collaborative Research Grant Scheme.

Therefore, while there is an official recognition of the significance of research to generate innovation for industry, there is limited data on the interactions between research and industry and more particularly about the nature and forms of interactions; what are the needs of users and providers of research and what are the gaps that need to be addressed. Within this context, this study is warranted in order to investigate, map and characterise the Research/Innovation-Industry Linkage in the Mauritian Innovation System.

1.2 Research Objectives

As stated earlier, the overarching aims of this study are to independently identify innovation originating from the research sector towards industry sectors. The specific aims of the study are to:

- explore the specific role of Research-Industry Linkage (RIL) in the National Innovation System,
- map, understand and assess the nature and types of linkages which exist between private sector and the research institutions including but not limited to the Universities, and
- identify the main bottlenecks which prevent efficient and effective linkages to occur with the view to enable the development of lasting linkages which spur win-win collaborations for both the innovation/research institutions and the private sector.

1.3 Scope of the study

Before going any further, it is worthwhile to explain how the concepts of research and innovation are used in this study. The lines between research and innovation are blurred. In the broadest sense of the word, the definition of research includes any gathering of data, information and facts for the advancement of knowledge. It refers to the creation of new knowledge and/or the use of existing knowledge in a new and creative way so as to generate

new concepts, methodologies and understandings. This could include synthesis and analysis of previous research to the extent that it leads to new and creative outcomes.

This definition of research is consistent with a broad notion of research and experimental development (R&D) as comprising of creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of humanity, culture and society, and the use of this stock of knowledge to devise new applications. It also encompasses pure and strategic basic research, applied research and experimental development.

In this study, the focus is less on basic research and more on applied research. Applied research is original investigation undertaken to acquire new knowledge but directed towards a specific, practical aim or objective (including a client-driven purpose). It is that part of the fundamental research spectrum where generic technology arises out of basic research. It is a vital creative part of research in universities, national laboratories and even within industry. As such it plays a key role in innovation at the end of the research spectrum that links research with subsequent development.

Rather similarly, there is no single definition of innovation despite the fact that its importance has long been emphasized, dating back since Schumpeter (1934) presented his theory on economic development. Innovation commonly refers to the introduction of new ideas, goods, services, and practices which are intended to be commercially useful (see for instance Pirttimaki 2006), whether generated through research or not.

An interesting and expansive conceptualization of innovation which is particularly relevant to this study is in terms of 'innovation ideas' (Konnola 2005). Innovation ideas are defined as: "Concrete and context-related new ideas for innovations that (1) are related to the chosen

issue area (2) are new to the participant or have received insufficient attention, (3) may be related to technological discontinuities, (4) are interesting in the light of present observations, (5) may provide the chance to develop an innovation (applicable new technology, concept, method or practice) within 10-15 years and (6) may require collaboration among different actors." [Könnölä *et al*; 2005).

Business innovation is a broad concept, encompassing performance improvements in products, services, processes and systems. Competition between firms coupled to a more stringent economic environment provides incentives for firms to invest in innovation. This investment in innovation can involve spending on research, or skills, or simply improved management. It is also acknowledged that innovation is also spurred through relationships and networks, with innovation building on previous innovation and drawing in knowledge and lessons from a wider range of sources.

A review of the business and economics literature also reveals that innovation is often divided into 5 types, namely product, process, marketing, organizational and business model forms of innovation. Product innovation involves the introduction of a new good or service that is substantially improved. This might include improvements in functional characteristics, technical abilities, ease of use or any other dimension. Process innovation involves the implementation of a new or significantly improved production or delivery method. Marketing innovation is the development of new marketing methods, with an improvement in product design or packaging, product promotion or pricing. Organisational innovation involves the creation of new organisations, business practices or ways of running organisations. Business model innovation involves changing the way business is done in terms of capturing value (Tuomi 2002; Lattunen 2003; Garcia and Calantone 2002). For the purpose of this study a broad definition of innovation encompassing the above 5 types will be adopted as a working definition.

For the purpose of operationalising the study, the focus will be at three broad levels, encompassing the users of research and innovation, providers of research and innovation and existing institutions that have the responsibility to promote and/or facilitate linkage between research/innovation and industry. A diagrammatic representation of the scope of the study is presented below in Figure 1.

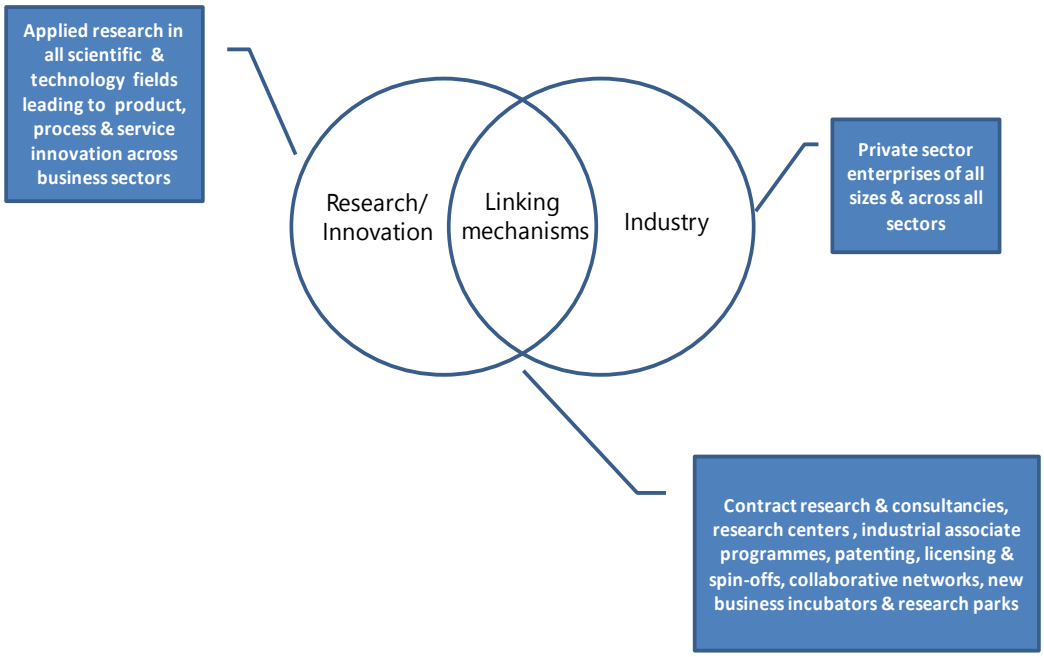

Figure 1: Scope of the study

For the purposes of this study, all Tertiary Educational Institutions which engage in applied research, National Laboratories and Research agencies across diverse disciplines will be covered.

Industry[2] will be operationalised as private enterprises operating in all economic sectors which can be clustered in terms of primary, secondary and tertiary sectors. It is an undeniable fact that technology innovation or 'technovation' is still going to be a determinant in fostering growth in the primary and secondary sectors of the Mauritian economy. But it is also a fact that services now account for 74% of GDP, therefore the scope of this study will be broad enough to look at linkage mechanisms between research organizations and enterprises in the primary, secondary and tertiary sectors of the economy. It will thus look beyond solely the aspect of technological innovation, into how innovation also affects business strategy and operations.

The intersection which focuses on the existing mechanisms which facilitate mediation and collaboration will be critically assessed in terms of their role so far in bringing about effective and efficient linkages.

1.4 Methodological Approach

In order to meet the research objectives mentioned earlier, this study will be broken down into three distinct parts which will be carried out concurrently using a mixed methods approach

1.4.1 At the level of providers of Research and Innovation

A quantitative approach will be adopted by way of an email survey of academics and researchers. This will uncover the type of services, sectors serviced and also the conditions under which researchers provide their services to industry. This survey will also try to capture

[2] The Central Statistics Office categorises the Mauritian economy into fourteen distinct industrial groups, namely (1) agriculture, (2) mining and quarrying (3) manufacturing (4) electricity, gas and water supply (5) construction (6) wholesale and retail trade (7) hotels and restaurants (8) transport and communications (9) financial intermediation (10) real estate (11) Public administration and defence (12) education (13) health and social work (14) social and personal service activities (CSO, 2011).

the perceptions and attitudes of researchers of the current level of linkage between themselves and industry.

The above approach will be complemented with a qualitative component. Firstly, in-depth interviews will be carried out with heads of departments, heads of schools, heads of institutions and directors of advisory companies to ascertain how they provide their institutional services to industry and also what would be their propositions to improve such linkages. Secondly, 5 case studies of researchers who have successfully linked and sold their services to the industry will be carried out. The objective is to provide sufficient contextual and descriptive information about the type of linkage cases under study.

1.4.2 At the level of users of Research and Innovation

A second quantitative survey will be conducted on a sample of 300 companies across sectors to assess how research and innovation factor into their decision-making model and what are the sources and transfers of such innovation. The cross-sectoral nature of this survey will also try to uncover whether there are certain industrial sectors of the Mauritian economy that link more with research institutions as compared to others. The quantitative survey will be balanced with case studies of companies which have successfully linked, sourced and used innovation from research institutions. The objective here is to investigate the existing mechanisms of innovation transfer.

1.4.3 At the level of institutions, mandated to promote linkage between research/innovation and industry.

This component of the methodology will focus on assessing the roles of institutions that have the responsibility of facilitating linkage between research/innovation and industry. This will hinge on in-depth interviews with heads of institutions to try to appraise existing mechanisms that aim at promoting linkage and the main bottlenecks associated with implementing such initiatives.

1.5 Organisation of the Report

This report is structured as follows. After this introductory chapter which has introduced and explained the research problem and outlined the adopted methodological approach, Chapter Two will provide a review of theoretical and empirical literature internationally about the concepts of research and innovation and more specifically examine the extent to which Research and Innovation feed into industry; how these occur and what are the obstacles to systematic and consistent linkages. It also presents an overview of the Mauritian National Innovation System and provides an empirical background of the situation locally.

Chapter Three elaborates and justifies the methodological approach adopted including survey designs and selection of respondents and participants for the various techniques of data collection.

Chapter Four presents the main empirical findings generated from the various research techniques employed in this study. Chapter Five draws the general conclusions and highlights the policy implications of these findings.

CHAPTER TWO: UNDERSTANDING RESEARCH/INNOVATION-INDUSTRY LINKAGES

2.1 Introduction

RIL are not a new phenomenon, but given the urge to find new sources of innovation to boost business growth, their types and importance have been increasing (Geiger 2004). Sughandhavanija et al (2010) point out that universities are increasingly playing a major role in developing technology and knowledge base which underpins economic development process in many developed and developing countries. For decades, the involvement with the industry has been increasing, and policy support from the government has been implemented to promote the university-industry collaboration particularly in the form of joint research. This chapter builds on a review of pertinent literature to examine the nature, forms, drivers and obstacles of research-industry linkages worldwide before locating the situation in Mauritius in order to frame and extend the understanding of the objectives of the study in Mauritius.

2.2 Drivers of Research/ Innovation/ Industry Linkages

In the second half of the nineteenth century, the general consensus about the main roles of the university has broaden to range from the production of knowledge for its own sake to the preparation for professional careers (Krishnan, 2006), as well as to the transfer of knowledge and ideas to industry for the generation of wealth for the nation and promotion of innovation capability (Hofer, 2004; 2005). Governments, after the second World War (more precisely after the Bayh-Dole Act passed in 1980 in the U.S), acknowledging the role and applicability of science and technology to economic development, redirected significant funds to Universities/Research Institutions to undertake R&D. This resulted in broadening the mission of universities/research institutions from traditional education and education to also include the need for setting up collaborations with the industry in different disciplines with the aim of

contributing towards economic and social development (Crespo & Dridi, 2007). This evolution in turn led to new roles for academia, that of “entrepreneurship” and commercialising of research. As “ entrepreneurs” researchers/academics operate to speed up the generation, dissemination and application of innovative ideas and in their role of commercializing research they act to enhance intellectual property, ideas, know-how and research-based skills for the initiation of marketable new products, services and processes that has valuable economic, social, and environmental results (DEST, 2005; Laperche, 2002). Hence, research institutions were seen as a foundation of new ideas and firms facilitated the maximum use of the newly generated ideas.

From the universities’/ research institutions’ perspectives the need for being more involved with the industry lies in the fact that industry can enhance the value of university in the form of funds and aid in directing research activities towards the needs of market and society. In addition, the development of mutual trust between the research institution and industry, will result in long-term strategic partnerships (which can in turn facilitate hiring of young graduates) instead of one-off contracts and in improved competence base by making state of the art industrial equipment accessible to the research institutions. Moreover, research institutions are realising the need to open up to business and international collaboration in order to maintain their competitiveness both in terms of securing high profile students and also in producing quality and marketable research. Moreover other reasons put forward by Peters and Fusfeld (1982), include 1) less “red tape” associated with industrial funding compared to government money; 2) availability of some government grants based on joint collaboration between university and industry; 3) opportunity to perform on intellectually challenging tasks which can enhance prestige and status.

On the other hand industry, is more and more inspired to cooperate with research institutions for continuing training and skill enhancement of their staff; prestige and goodwill of their establishment; use of research institutions’ facilities and access to knowledgeable manpower; solutions to unsolved problems and as well as part for advancing good community relations and networking (Atlan, 1990 and Peters and Fusfeld, 1982). For instance as noted by several authors (Fusfeld & Haklisch, 1987; Sen & Rubenstein, 1989; Berman, 1990 and Wu, 1994) though

internal R&D is critical for competitiveness, external sources of technologies have become increasingly important and among the available sources to develop technologies externally, the one on the top of the list to enhance national competitiveness is, research institution-industry collaboration (Rahn et al, 1988; Avveduo & Silvani, 1988; Belanger, 1988; Wainwright, 1988; Sumney, 1989; Chen, 1990; Novozhilov, 1991; Chen, 1994; Wu, 1994). At the same time the body of science represented by university-based research is a crucial and rising contributor to firms' innovation.

It must further be noted that except in a few sectors,, the service sector today covers all other industries ranging from communication, wholesale and retail, trade, transportation, postal operations, logistics, , education, finance, insurance, real estate, healthcare, criminal justice, government, to a variety of public utilities. This sector has evolved due to globalization, higher automation and technology innovations, to become high-tech which in turn has increased reliance on innovations consulting from research institutions/universities, be it in the form of re-engineering customer products, automating business processes, designing and deploying IT systems or improving service delivery.

The evolving relation between research institutions and industry has also led to the mushrooming of several collaboration modes (Perkmann and Walsh, 2007) ranging from joint research; contractual services to attendance of conferences, just to name a few.

2.2.1 Rationales underlying Research Institutions' Interactions with Industry

Much of the literature related to University-Industry collaboration and technology transfer assume that joint research is beneficial to both university and industry. University-industry linkages can take various forms and levels of partnerships from contract or sponsored research, to joint research, professional courses, consultancy, to creating opportunities for student placements, staff exchange, and joint curriculum development (Sebuwufu et al 2012). Kim et al (2011) stress on 'triple helix' (TH) of the university–industry–government relationship

(Leydesdorff 2012). The TH model can be viewed differently and is one among the major methods of studying the university-industry interactions (Baerz et al 2010).

Firstly, the networks of university-industry-government relations can be considered as neo-institutional arrangements which can be made the subject of social network analysis. This model can also be used for policy advice about network development, for example in the case of transfer of knowledge and the incubation of new industry (Godin and Gingras 2000).

Giuliani et al (2010) developed a theoretical framework with two strands that can explain the formation of such linkages, namely (i) the evolutionary and the resource-based view approach, and the (ii) institutional approach (Giuliani et al,. 2010). The first focuses on the ability and skills of actors from either sides to collaborate, whereas the second approach centers on the type of organization, culture and environment in which the linkage occurs. Studies attempting to determine the determinants of RIL have usually combined both approaches (Boardman, 2009). Tijssen (2006) put forward that the institutional view is pertinent as university research centers constitute important mechanisms with which universities, industry, and governments attempt to promote research environments that are conducive to cooperation between academic researchers and private companies.

Studies that have been carried out to elicit linkage types and channels have highlighted the motivation for cooperation from both the research and the industry sides (See e.g. Yusuf et al 2008 and D'Este and Patel 2007). Some of the factors that would motivate industry to link with research institutions are: (1) access to manpower and knowledgeable faculty to solve specific technical issues; (2) access to basic and applied research results from which new products, processes and services can evolve; (3) solutions to specific problems or professional expertise, not usually found in an individual firm; (4) access to university facilities, not available in the company; (5) assistance in continuing education and training; (6) obtaining prestige or enhancing the company's image; and (7) being good local citizens or fostering good community relations.

In line with the work of Pablo (2007) we categorise the rationales underlying research institutions' interactions with the industry under three main headings: (1) commercialization

(motivated by pecuniary incentives), (2) learning and (3) access to resource which can further be split into funding resources and in-kind resources (motivated by research impulses). These motives are either driven by the research institutions or researchers within those institutions or by both.

Commercialization

According to Bok (2003) research commercialisation can be seen as efforts made throughout the university/research institution to make profit from research. It involves embracing of revenue generation and profit-seeking strategies through technological innovation and research, and research institution-business cooperation. Its emergence dates back to the Bayh-Dole Act in 1980 passed in the U.S. to guarantee USA's competitiveness in world economy and research institutions were given a main role in commercialisation of research to assist in guiding the country's innovation and productivity. The life cycle theories are best suited to explain academic researchers guided by commercialization motives as they assume that young academics will concentrate on building goodwill in academia so that later in their career they can take advantage of their expertise by securing higher returns in the industry (Stephan and Levin, 1992). Alongside authors like Zuckerman and Merton (1972) argue that senior researchers may not be inspired by tenure and publications but rather by financial gains due to family commitments, for example to finance the education of their children. Another literature which can explain the commercialization behavior, is one which focuses on "entrepreneurial academic", where the latter being directly responsible for technical development related to their research activities, are likely to embark on the commercial exploitation of their technology or knowledge (Etzkowitz, 1983; Clark, 1998; Etzkowitz, 2003; Shane, 2004). In brief the drive for collaboration with the industry on the part of research institutions based on commercialization motives, is in terms of the desire for personal monetary gain. Hence this motive is mainly driven by the individuals within the research institutions rather than by the institutions themselves.

Learning

Another critical rationale for academics and researchers to engage with industry can be justified by the "learning motive" which emphasizes on the quest for advancing their research agenda on the part of the academics. The conceptual foundation for this motive is located in theories of interactive learning applied to inter-organizational collaboration (Powell et al , 1996). According to these theories collaboration takes place through exercised routines and established norms and the resulting interaction between academia and industry is exploration-oriented collaboration. For instance, problems in technology development faced during industrial consulting provide new challenges fro follow-on-research activities for academics and hence contribute towards advancing research and developing new solutions and knowledge (Mansfield, 1995; Rosenberg, 1992). In addition, using the "Pasteur" logic (where research seeks basic understanding but also gives weight to its application), Stokes (1997) claims that whenever such "Pasteur"-type research prevails, the learning-based' rationale for collaboration is likely to be dominant.

Resource access

Academics and researchers may network with industry for another key reason: access to resources for pursuing their own research. Similar to the learning motive, the resource access reasoning, is motivated by research-oriented objectives and not commercial ones (Source?). Nevertheless it does not require interactive learning feedback mechanism but rather sharing of resources to pursue their respective goals (Oliver, 1990).

Theories that defend such a motive, view inter-organizational collaboration as reciprocity-induced and a means of accessing resources and skills which are hard to obtain in the university/research institution environment (Powell et al, 1996). The two main types of resources that academics and researchers seek for, as part of their collaboration with industry, are funding and in-kind resources such as equipment, data and materials. Resource funding can be in the form of monetary rewards paid directly by the industry for the services rendered by the academics/researchers. Moreover being involved with industrial partners can also increase

the amount of funds academics can receive from the local as well as international research funding sources/grants (for further details see Cohen et al, 1994; Rip, 1994; Behrens and Gray, 200; Caloghirou et al,2001; Larédo and Mustar, 2004 and Lin and Bozeman, 2006).

It must be further noted that academics'/ researchers' involvement with industry may be informed by the mixture of the above mentioned rationales. In cases where the rationales complement each other, collaboration is likely to take place more often across a spectrum of interaction routes. However, where rationales tend to be conflicting, researchers may choose to be selective in their engagement with industry.

2.2.3 Rationales underlying Industry's Interactions with Research Institutions

Guiding/Complementing/Substituting own R&D activities

Many research-intensive firms are engaged in research activities which tend not only to be more science-oriented but also more uncertain (Rosenberg 1985; Henderson and Cockburn 1996; Hall, Link, and Scott 2003; Branstetter and Ogura 2005) and as such collaborate with research institutions for shaping the direction of their own R&D targets with the aim of reducing uncertainty and hence costs (Kline and Rosenberg 1986; Mansfield 1991). It must be noted that the knowledge flows from the research institutions can act as a complement input to firms' R& D or a substitute for firms' own internal research activities.

Profits

Given the move towards knowledge-based economy, firms have come to acknowledge that innovation is a crucial ingredient to be able to survive, earn higher profits and market shares and benefit from first-mover advantage in the current competitive environment (Dresdow, 1993; Cumming, 1998 and Arntzen Bechina, 2007). Authors like Mansfield, (1981) and Griliches (1986) argue that innovative capacity is enhanced not only through applied but also basic research. According to Agarwal (2001) though in-house research is important, externally

generated scientific knowledge, for instance the one transmitted from universities, is fundamental for innovative capacity enhancement. For example, studies by Cockburn and Henderson (1998) , Brennenraedts et al (2006) and Sandelin (2003) reveal that firms must be intensely involved in research collaboration to gain competitiveness. Another concrete example showing that universities are an essential supply of new knowledge for industry is the MIT in U.S.A which was established more than one century ago to assist close research relationships between university and industry (Matkin, 1990). Hence one of the main rationales behind why firms collaborate with research institutions is to increase sales volume, productivity as well as to raise the granting of patents.

At the same time arguments have been put forward stating that the transfer of knowledge from academia to industry is not a cost-free process. For instance, work conducted by Rosenberg (1982), Mowery (1983), Pavitt (1987), and Cohen and Levinthal (1990) disclose that transferring and applying scientific knowledge is itself an expensive and knowledge intensive process, given it is characterized by division of labour, internal collaboration, coordination and monitoring among R&D, marketing and production departments of a firm. In practice however successful attempts have been made to reduce the cost of knowledge of transfer. An example includes the Innovation Relay Centres (IRCs) network (Newletter, 2010) created by the European Commission to assist in transnational transfer of technology from universities to industry (particularly the SMEs). Yet it must be noted that the success of such arrangements depends on the strategic role assigned to the staff coupled with their skills and competencies.

Firms' specific Characteristics

The linkage between research institutions and industry is also affected by firms' characteristics such as its size, communication flow and absorption capacity. For instance, large and well established companies in order to continue on their growth trend, they need to hunt for functional scientific knowledge and incorporate this knowledge into the organization (Fontana, Geuna & Matt, 2006). Their ability to acquire and adapt scientific knowledge is one indicator of

their performance (Philbin, 2008) and as such justifies why industries seek university/research institution collaboration and the emergence of the "knowledge economy" has even strengthen such a justification. Studies by Mohnen and Hoareau (2003) and Veugelers and Cassiman (2005) indeed reveal that firms' size has a positive impact on firms' innovative partnerships with research institutions.

Moreover, the communication flow within the organization which favours social dialogue can also promote collaboration between research institutions and industry. Empirical evidence from the work of Link and Bauer (1989) which has used data from American manufacturing companies, reveals that, 90% of collaborations between institutions were taking place out through informal relationships and good communication strategies. Another firm characteristic acting as a determinant is its absorptive capacity. Fontana, Geuna and Matt (2006) argue that absorptive capacity which helps in assimilating transferred knowledge to produce economic and value added results, coupled with firm openness and professionalism of the senior management as mentioned by Mohen & Hoareau (2003) are major factors in founding collaboration with research institutions.

Other Factors

A survey by Lee (2000), involving more than 400 research joint ventures, discloses that the main justifications provided by industry participants for their involvement with universities are as follows (ranked as most to least important):

(1) access to new research;
(2) development of new products;
(3) maintaining a relationship with the university;
(4) acquisition of new patents; and
(5) solving specific technical problem

2.2.4 Bidirectional Linkage between Research Institutions and Industry

It must further be noted that the linkage between research institutions and industry needs not only be uni-directional but can also be bi-directional, in the sense that each one depends on the other and this bidirectional link can be illustrated using the work of Doblin (1982). The Doblin's (1982) model which explains the process of "discipline" establishment, states that a discipline is created in an organization,following a step by step cycle of process of the following three elements: practice, education and research. Initially without knowledge there is only practice of trial and errors (role of industry). From the numerous trial and errors some knowledge will emerge and this will be shared to prevent previous errors encountered. When the process of knowledge sharing is formalized and legalized, the 'education' is set up (role of universities/research institutions). Over time with the broadening and deepening of education, there is demand for research to generate more rigorous theories and knowledge (role of universities/research institutions). As soon as the phase of research is attained, the reverse process of knowledge application is launched (role of industry). Hence knowledge cropping up from research feedback to education which sequentially instructs practice, thereby completing the process of discipline establishment, as illustrated in figure 2.1.

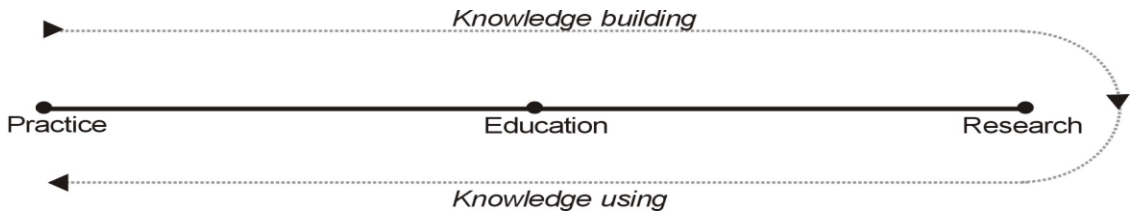

Figure 2.1: The Establishment of Discipline through practice, education and research. (Source in 1982)

As a last point in this sub-section it is worth noting that in the African context, the story is totally different, as stated by Akainwor (2002), according to whom the main barriers to technology

transfer from research institution to firms, in the region may also be related to superstition, conservatism, ethnic jingoism, graft, religious extremism and political differences.

2.3 Forms of R-I Linkages

There are no systematic nomenclature to classify the RIL, but they can generally be categorized in to the following broad categories: (1) general support; (2) contract research and consultancies; (3) research centers and institutes; (4) research consortia; (5) industrial associate/affiliate programs; (6) patenting, licensing and spin-offs and (7) new business incubators and research parks (Wu 1992).

Worldwide, particularly in developed countries there are some successful examples of regions where Universities have contributed to business and economic prosperity such as the as Silicon Valley, the Boston area, and the area surrounding Cambridge in the UK. At the same time there are also illustrations of cases where university developed and patented technology have been "blockbuster" like the chemotherapy drug Taxol (Florida State University), the anti-clotting medication Warfarin (University of Wisconsin) and the Cohen and Boyer gene splicing patent (Stanford University). Moreoever there are also instances of successful companies emerging from research institutions such as companies like Cisco, Google, and Yahoo, which grew out of Stanford University research.

Another useful example of Research Industry linkage is provided by Acworth (2008). He postulates that many countries are seeking to strengthen global economic competitiveness by building a 'knowledge economy' capability and a common is supporting university–industry knowledge exchange linkages. The purpose of his study is to show how a model developed by the Cambridge-MIT Institute (CMI) for the UK offers a more effective approach to knowledge sharing, and to present the results from one of the first projects launched by CMI. CMI looked at the background literature and relevant government policy, benchmarked peer grant-making organisations, studied the Massachusetts Institute of Technology and Cambridge University

institutions, and organized expert consultation through a strategic planning process including 27 stakeholder groups. Based on these inputs, CMI formulated its Knowledge Integration Community (KIC) model hypothesis, as shown in figure 2.2 below:

The six-component model of a Knowledge Integration Community brings together four institutional sectors (Industry, Government, Research and Education) through two binding mechanisms: knowledge exchange (KE) and the study of innovations in knowledge exchange (SIKE).

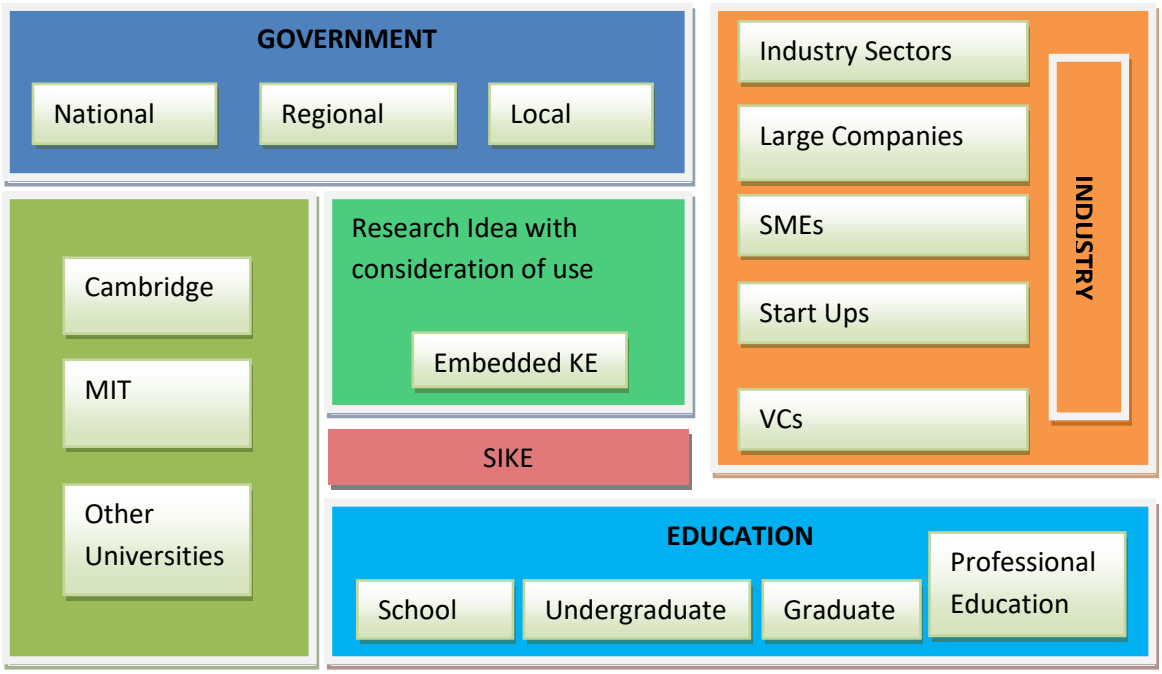

Figure 2.2: Knowledge integration community model
(Source: Acworth 2008)

Rast et al (2012) outline an evaluation framework for university-industry collaborative research and technological initiative at Universiti Teknologi Malaysia, by identifying the success criteria of university-industry collaborative research and technological initiative as perceived by academics. Five type of research collaboration mechanisms, which are; Consultancy and Technical Services Provision, Cooperative R&D Agreement, Licensing, Contract Research, and Spin-off Companies discussed and success criteria for each mechanism adopted from previous models in other countries. This can be illustrated as follows:

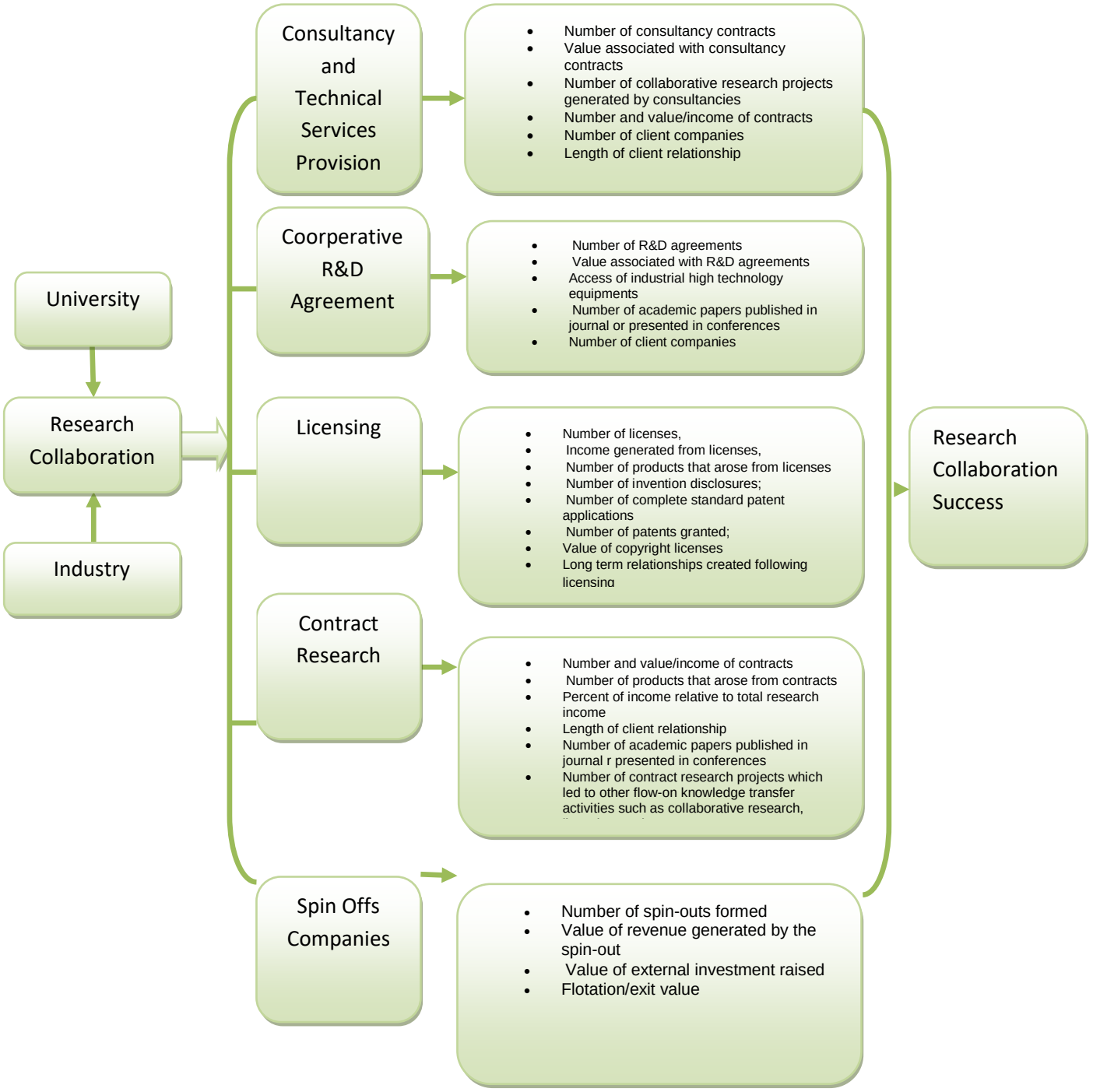

Figure 2.3: Research Framework
(Source: Rast et al (2012)

From a quantitative perspective, the indicator "science link" tries to give an indication of the intensifying RI-I linkages, by looking at the number of academic papers cited in the patent

applications stored at the US Patent and Trademark Office. The index reveals a rising trend in all industrialised economies, though significant gaps are also noted among them. For instance from 1968 to 1985, in the US, the number of academic papers cited per patent application went up from 0.5 to 3.0, while in Japan it rose only from 0.2 to 0.6 for the same time period, thereby demonstrating a considerable breach between Japan and the US in the strength of RI-I collaboration. Other developed countries come between the US and Japan. In terms of field, biotechnology ranks out first, followed by organic chemistry, in science linkage. Again US tops the list of industrialised countries in terms of science linkage indicating that collaboration with research institutions is of utmost importance for commercial success, in this discipline.

Statistics (World Bank's Report) from the developing countries show that Beijing University and Tsingbua University generated more than 60 spin-offs each in high tech areas, in China. In some cases researchers are already benefiting from such spin-offs in terms of earnings, as the latter are being listed on the Chinese stock market and generating profits.

The form that RI-I linkages may take depends on the industrial transformation process and the economic transition the country under study, is undergoing, as shown in figure 2.4 below.

- ***Transitions necessitating the creation of a new science-based industry.***

During such types of transitions the role of research institutions will be mainly in terms of activities include providing various types of assistance to new business formation, pro-active technology licensing programmess and efforts will be geared towards building an identity for the new industry through organization of conferences and workshops, by kicking off standard-setting activities, and by and large acting as industry 'evangelists'.

- ***Transitions involving the relocation of industries into the region.***

In this context the research institutions will have two important roles: first, having to do with providing education programmes customized to the needs of the relocating firms in terms of required skills for manpower; and second to provide technical support to local suppliers and subcontractors.

- ***Transitions relating to diversification into technologically related new industries and out of existing local ones.***

The crucial function of research institutions in such stance, is to nurture technological associations between disconnected actors, for instance by setting up on-campus forums for dialogue regarding new applications of local industrial technologies. Alongside research institutions also have a role in developing the goodwill of the new industry locally.

- ***Transitions involving the upgrading of the technological base of existing industries***.

In this case contract research and faculty consulting become the main channel through which research institutions can assist firms in technical problem-solving exercises.

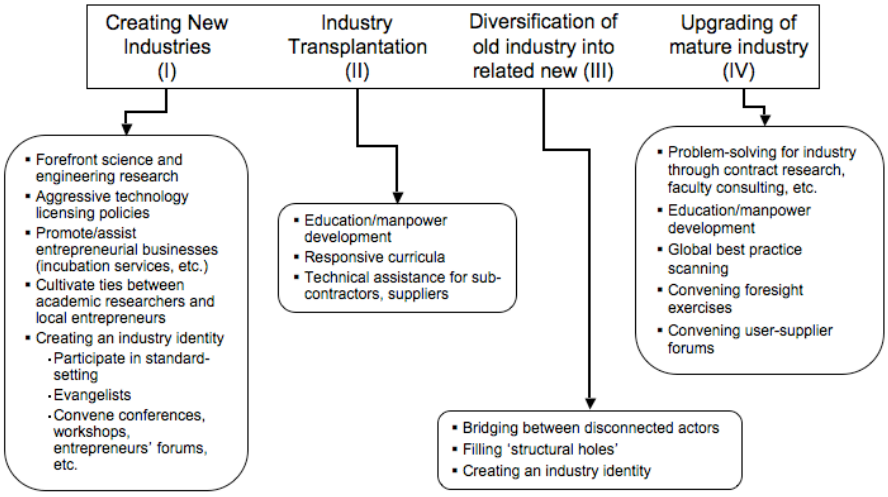

Figure 2.4: Industrial Transformation Room and Economic Transition (Source: Lester (2005))

In sum as can be noted from the above, universities have an increasingly crucial role to play in a globalizing environment in which the competitiveness of firms and the economic prosperity of countries hinges on technological dynamism and the capacity to nurture innovation.

Far more than the typical role of teaching, leading universities in middle and lower-middle income countries are finding that the need to enlarge or build research capabilities in basic research and also in technology development is being urged upon them by governments and by firms.

Typically, there are various ways through which linkages between universities and businesses can be originated and this section elaborates on these as shown in the following.

One common mechanism is when a firm contracts with a university researcher to conduct R&D for the firm. On the other hand, a university researcher can also develop an idea for commercialization and then enters into a contract with a firm especially through a spin off company of the university. An intermediate mechanism occurs when the university helps the firm to enhance its understanding of the underlying basic science and the firm develops the product or technology. While, joint collaboration involves the firm and a university to develop a product or technology (Poyago-Theotoky *et al* 2002).

Besides, D'Este and Patel (2007) advocate that university researchers interact with industry using a wide variety of channels and seem to be engage in consultancy and contract research, joint research or training as compared to patenting or spin-out activities. Traditionally, licensing has been the most famous mode of university technology transfer (Siegel et al 2003 a, b cited in Wright et al 2008). Moreover, DiGregorio and Shane(2003) put forward that the best universities will opt for 'spin-off' while 'licensing' are preferred by second rank universities.

Poyago-Theotoky *et al* (2002) further argue that contract research between a university researcher and corporation involves particularly applied research while consulting involves interaction between the academic and industry in order to find the best and most appropriate solution to a problem (Denis and Lomas 2003 cited in Wright *et al* 2008). However, Argote and

Ingram (2000) emphasize on the skills and experience gained by graduates and researchers, that is the knowledge which is acquired from higher education sector into the industry.

Wright et al (2008) analyze how mid-range universities can contribute to industrial change through the transfer of tacit and codified knowledge in the areas of spin-offs; licensing and patents; contract research, consultancy and reach-out; and graduate and researcher mobility. We use archival, survey and interview data relating to mid-range universities in mid-range environments in the UK, Belgium, Germany and Sweden. Our findings suggest that midrange universities primarily need to focus on generating world-class research and critical mass in areas of expertise, as well as developing different types of intermediaries

Cohen et al (2002) show that while publications, conferences, informal information exchange and consulting are found to be widely important across industries; patents instead are only considered important by pharmaceutical firms. On the other hand, Thursby and Thursby (2000) argue that commercial use of university research has been viewed in terms of spillovers. Recently, there has been a dramatic increase in technology transfer through licensing as universities attempt to appropriate the returns from faculty research. Furthermore, Baerz et al (2010) argue that firms do perform in-house R&D activities, but yet it is not enough for developing their capability in modern technology and innovation and requires them to look for out-source knowledge. Due to huge knowledge storage, universities are a very excellent source for providing the firms' knowledge needs. The effective use of academic knowledge is that universities and industries have appropriate interactions. In this regard, not only university and industry, but also government has a crucial role in providing a suitable basis for the efficient university-industry interaction.

Cohen and Levinthal (1990) argue that there are two factors that will affect a firm's incentives to learn, and, therefore, its incentives to invest in absorptive capacity via its R&D expenditures. First, there is the quantity of knowledge to be assimilated and exploited: the more there is, the greater the incentive. Second, there is the difficulty (or, conversely, the ease) of learning. Some types of information are more difficult to assimilate and use than others. This means that per unit of knowledge, the cost of its absorption may vary depending on the characteristics of that

knowledge. As learning is more difficult, more prior knowledge has to have been accumulated via R&D for effective learning to occur. As a result, this is a more costly learning environment. In such a setting, R&D is more important to building absorptive capacity and the more R&D effort the firm will need to have expended to achieve some level of absorptive capacity. Thus, for a given level of a firm's own R&D, the level of absorptive capacity is diminished in environments in which it is more difficult to learn. In addition, we are suggesting that a more difficult learning environment increases the marginal effect of R&D on absorptive capacity. In contrast, in environments in which learning is less demanding, a firm's own R&D has little impact on its absorptive capacity. In the extreme case in which external knowledge can be assimilated without any specialized expertise, a firm's own R&D would have no effect on its absorptive capacity.

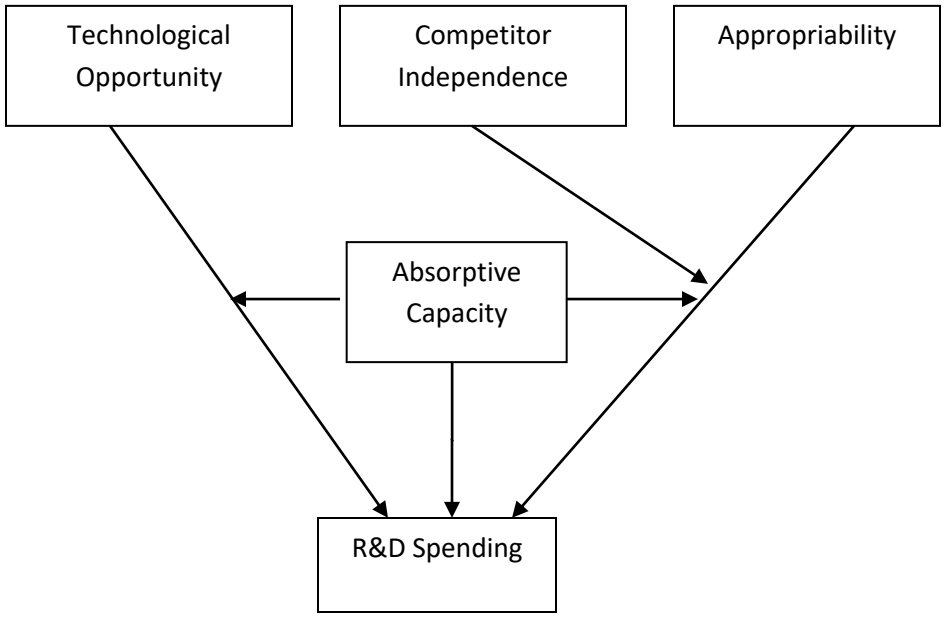

Figure 2.5: Model of absorptive capacity and R&D incentives.

In sum**,** some of the determinants that would prompt research institutions to forge a link with industry would include: (1) industry provides a new source of money for university; (2) industrial money involves less “red tape” than government money; (3) industrially sponsored

research provides student with exposure to real world research problems; (4) industrially sponsored research provides university researchers a chance to work on an intellectually challenging research programs; (5) some government funds are available for applied research, based upon a joint effort between university and industry.

However, while there are substantial barriers to successful collaboration and knowledge exchange between universities and firms, few studies have attempted to measure and map these perceived barriers or investigate what may attenuate them. The analysis depicts many types of barriers plague collaboration between industry and universities from orientation of the university and its researchers, to attitudes and behaviour of university administration. Although the 'classic' barrier to U–I collaboration the university's long-term orientation remains substantial, other factors are important in constraining collaboration, especially those related to intellectual property and administrative procedures.

RIL have played an important role in enhancing the competitive advantage of industry sector in many developed countries. However, RIL do not generally function well in developing countries due to the lack of research skills & facilities in universities, little incentives for innovation in industries and insufficient support system by in governments but despite the inherent weaknesses present in the innovation systems of developing countries, some RIL are increasingly being institutionalised (Guiliani et al 2010, Munyoki et al, 2011). The present study intends to contribute to this burgeoning field and shed some light into RIL in Mauritius.

Research and Industry Linkages in Mauritius

Against the above background, this section presents through a review of existing data, the body of knowledge in terms of research and industry linkages in Mauritius. The recognition of the importance of reconciling the needs and demand of industry with research and innovation has led to the formulation of a Science, Technology and Innovation Policy (STIP) in 2010. The STIP focuses on the role and responsibilities of the government, research institutions, academia, private sector and NGO's in supporting STI and on the importance of building effectively networked structures to implement STI policies and measures. The importance of scientific research and innovation in laying strong foundations for sustained economic growth and prosperity cannot be over-emphasized. The aim of the STIP framework is to develop a cohesive strategy to promote the sustainable development of an economy increasingly driven by science, technology, research and innovation, for enhanced economic growth and quality of life.

At the outset, it is noteworthy that in spite of the fact that science and technology have played an important role in the development of Mauritius, public and private sector expenditure (including the sugar sector) in R&D is a low 0.36% of GDP. It compares unfavourably with the target of at least 1% of GDP, proposed by the AU Commission/NEPAD and rates of 2.4% and 2.7% reached by Singapore and South Korea respectively. Many developed countries have reached the level of 4%. According to a World Bank report (Strategic Approaches to Science and Technology in Development, 2006), there is a strong correlation between R&D spending and economic performance. Thus, a higher and sustained level of economic growth will inevitably need an effort to increase R&D investment, along with 23 well coordinated initiatives to benefit from the investment. The World Bank recommends four policy areas for countries like Mauritius to progress from a scientifically developing country to a scientifically proficient country (like China, India, South Africa, Singapore)(Science, Technology and Innovation Policy 2010).

Mauritius was given a score of 3 (on a score range of 1-7, with 7 being the best), as per a survey of 128 countries conducted by the World Bank on private sector expenditure in R&D. The score of 3 was lower than Asian, Latin American as well as African countries such as Mozambique, Uganda, Madagascar, Kenya, Zimbabwe, Tanzania and South Africa.

In terms of University/industry research collaboration, the Global Innovation Index Report (2012) ranks Mauritius 95 out of 141 participant countries with a score of 36.8 out of 100 as shown in the following table

Table 2.1: University/Industry Research Collaboration

Countries	University/ industry research collaboration (Score 0-100)
Australia	69.2
France	54
India	47
Israel	73.4
Jamaica	41.4
Kenya	47.9
Madagascar	36.7
Malaysia	65.1
Mauritius	36.8 (Rank 95 out of 141)
Singapore	74.5
South Africa	60.3
United Kingdom	79.2
Source: GII 2012	

Moreover, while the tendency for business and governments during economic downturns is to cut back on expenses such as R&D, training and innovation, it appears that better results are achieved from doing the opposite. The OECD for instance advocates support to innovation and R&D during times of crisis': "The crisis can magnify the competitive advantage of research-intensive firms who seize the opportunity to reinforce market leadership through increased spending on innovation and R&D. Many of today's' leading firms such as Microsoft or Nokia were born or transformed in the "creative destruction" of economic downturns. Finland and Korea provide good examples. During the economic crisis of the first half of the 1990s, the Finnish government cut public expenditures almost across the board and raised some taxes, but increased its R&D spending. This helped lay the ground for a strong rebound, and helped set the Finnish economy on a stronger, more knowledge-intensive growth path following the crisis. Korea's response to the Asian financial crisis of the late 1990s was rather similar: the Korean government increased its education expenditure, and its R&D budget, and used the crisis as an opportunity to develop a technology-based SME sector, using the Special Law to Promote Venture Firms.

Table 2.2: Innovation Linkages in Mauritius

	Score(0-100)	Rank(Out of 141)
Innovation linkages	46.1	31
State of cluster development	48.4	39

(Source: The Global Innovation Index 2012)

Statistics also indicate that there is a divide in R&D expenditure between developed and developing countries. Table 3 below illustrates the comparison of expenditure on research and development between developed and developing countries for 2002, 2007 and 2009.

Table 2.3: Developed Countries versus Developing Countries R&D Expenditure (GERD) 2002, 2007 and 2009

	GERD(in Billion PPP $)		
	2002	2007	2009
Developed countries	650.0195	882.8579	931.4505
Developing countries (excl. least developed countries)	136.4382	270.6828	343.2855

(Source: Unesco Institute for Statistics, 2012)

Existing Studies on academia-industry linkages

While the linkages between research per se and industry have not received much academic attention, there have been a couple of studies which have explored the linkages between academia/universities and industry which to some extent include research. An overview of studies carried out by Baguant (2009) and World Bank (2007) indicates that there are Relatively weak linkages in spite of the 'intention' of university leadership to increase and strengthen University Interaction with Private Sector. They also argue that linkages take place in a random rather than in a systematic manner. Also, linkages take place mainly in terms of teaching and learning rather than in terms of research partly due to the fact that there is limited R&D investment from private sector. Overall, there is a clear lack of a coordinating body/mechanism between university and private sector.

From the users' perspective ie industry, the main constraints tend to be in terms of the following: financial constraints; traditional rigidities against technical change and little or no incentives for innovation and lack of absorptive capacity; mindset of certain firms that prefer to acquire more expensive technology rather than investing into the possibility of upgrading their existing state of technology through more research; lack of initiatives to carry out multidisciplinary research. It is also argued that it is customary in private sector circles not to consider fresh university graduates as finished products. Also, in spite of a legislative

framework addressing IPR in Mauritius, there are a number of obstacles surrounding IPR implementation issues by local entrepreneurs (European Union Report, 2006). These obstacles include: Lack of awareness on IP issues in general, lack of effective legal protection in IPR, inadequate awareness of the benefits of owning and commercializing IP assets, high costs of legal advisory services on IPR high R&D costs, lack of comprehensive institutional framework to promote the commercialization of IP assets. All these identified obstacles need to be overcome in order to facilitate innovation in science and technology in general.

It is equally important to note that there have been a number of policy measures have been put in place in order to facilitate the interaction between private sector and industry. These include structures such as the Consultancy and Contract Research Centre at the University of Mauritius as well as a number of schemes and projects operated by the Mauritius Research Council in order to promote, support or develop the interface between research and the needs of industry. These include the Collaborative Maurtius Initiative, the Business Angels Forum, support to Incubatees with innovation business ideas, the setting up of an I.P Office, as well as research grant schemes.

CHAPTER THREE: METHODOLOGICAL APPROACH

3.1 Introduction

This chapter outlines and explains the research techniques and sampling procedures adopted in order to meet the research objectives mentioned earlier. The empirical research work has been broken down into three distinct parts which has been carried out concurrently using a mix of methodologies including: (1) a survey of 300 private sector enterprises (2) an email survey of academics and researchers and (3) one to one interviews with intermediary institutions which are mandated to bridge users and providers of research. In addition to these research techniques, interviews and case studies of users and providers of research have also been implemented in order to reach a deeper understanding of existing linkages and illustrate the driving forces and good practices but also the obstacles and gaps that hinder smooth linkage mechanisms.

3.2 Sampling design for survey of private sector enterprises

For the survey of users of research and innovation, the focus was on private establishments and institutions operating in the country and covering all secondary and tertiary economic activities. A random sample of 300 establishments have been drawn by means of a sampling design which ensures representativeness of activities, geographical region (urban and rural), and size of establishments/institutions (large and other than large).

3.2.1 Sampling Frame

A complete list of 'large' establishments engaging 10 or more persons was obtained from Statistics Mauritius. Information on each establishment on the list are:

(i) Name

(ii) Location

(iii) Activity description

(iv) Activity code (coded up to 5-digit level of the National Standard Industrial Classification of all Economic Activities)

(v) No. of persons engaged

A frame of 'Other than large' Establishments was not available. However, a list of some 38,000 businesses registered at SMEDA was available. For the purpose of the survey this list was suitable for the following reasons

(i) it is believed that those which register at the SMEDA are more structured than those which do not.

(ii) the list covers all economic activities and is geographically representative

After comparing the list of 'Large' establishments from SM to those from SMEDA and removing duplicates from the latter, the resulting lists, i.e the one from SM and the one from SMEDA adjusted for duplicates, constituted the sampling frame for the survey.

3.2.2 Sample Size

The sample size was as follows:

n_1 = 200 from the 'Large' establishments

n_2 = 100 from the 'Other than large' establishments

The sample size was mostly determined by the resources available and more weight was given to the 'Large' establishments which are expected to have higher probabilities of having industry linkages than the 'Other than large' ones.

3.2.3 Sampling Design

The sample design used was a Stratified Random Sampling scheme. The criteria used for stratification are

(a) Activities

(b) Location (Urban, Rural)

(c) Size of establishment

3.2.4 Sampling Methodology

The 'Large' establishments are classified according to their activity in line with the National Standard Industrial Classification of all Economic Activities as well as according to region (Urban, Rural). Within each stratum or group the establishments are further sorted according to their size. The allocation of the sample (size 200) to the strata is done according the proportionate allocation. Finally a systematic random sample is drawn from each stratum. The same methodology is applied for the list of 'Other than large' establishment, except that the sample allocated to the strata is of size 100.

The benefits of this sampling methodology are that it ensures random selection of the sample, a characteristic which gives the possibility of carrying out further inferences such standard errors, confidence intervals and hypothesis testing. The stratification ensures representativeness of the sample and thus improves precision compared to a simple random sample.

On the other hand, the sample size of 300 was based on resources available. Precisions for results concerning questions applicable to all respondents are adequate. However inference at lower levels (e.g) by activities, size of establishment, location etc., should be treated with care as the precision of the results decreased depending on the number of establishments interviewed at the respective level. Also, questions applicable to only a part of the respondents will entail less reliability since the number of establishments responding to these questions will be less than the total sample size. It is also assumed that the frame of establishments

represents the target population. However as explained earlier, the choice of using the list from SMEDA was due to the absence of a better frame. The list from SMEDA undercovered those units which are SMEs but have not registered at the institution and the latter are expected to be less structured compared to those which are on the list. Furthermore, the theory underlying the sampling technology does not favour substitution of non-respondents. The ultimate response rate was 82% of the sample and the non-respondents were not substituted in order not to affect the randomness of the sample.

The quantitative survey was balanced with interviews and case studies of companies which have successfully linked, sourced and used innovation from research institutions. The objective here is to investigate the existing mechanisms of innovation transfer.

3.3 Email Survey of providers of Research and Innovation

A quantitative approach will be adopted by way of an email survey of academics and researchers. This will uncover the type of services, sectors serviced and also the conditions under which researchers provide their services to industry. This survey will also try to capture the perceptions and attitudes of researchers of the current level of linkage between themselves and industry.

3.4 In-depth Interviews

The above approach will be complemented with a qualitative component. Firstly, in-depth interviews will be carried out with heads of departments, heads of schools, heads of institutions and directors of advisory companies to ascertain how they provide their institutional services to industry and also what would be their propositions to improve such linkages.

Secondly, 5 case studies of researchers who have successfully linked and sold their services to the industry will be carried out. The objective is to provide sufficient contextual and descriptive information about the type of linkage cases under study.

Thirdly, interviews will also be carried out at the level of institutions, mandated to promote linkage between research/innovation and industry. This component of the methodology will focus on assessing the roles of institutions that have the responsibility of facilitating linkage between research/innovation and industry. This will hinge on in-depth interviews with heads of institutions to try to appraise existing mechanisms that aim at promoting linkage and the main bottlenecks associated with implementing such initiatives.

Table 3.1: Summary of the research techniques and target groups

Target Group	Research Technique	Remarks
Users of Research	Questionnaire Survey of Enterprises	Initial n=300 ; Actual n=246 Broken down by NSIC Category and size of Firms
Providers of Research	Email Survey of Researchers	n= 54 Convenience Sample Researchers from TEIs and other research institutions
Linking Institutions	One-to-one interviews with heads of institutions	MRC; MSIRI; CCRC; MEXA,etc
Case Studies	Semi-Directive Interviews with researchers and entrepreneurs who have linked up	Illustrations of Good practices and Hinderances

CHAPTER FOUR: RESULTS AND FINDINGS

4.1 Introduction

This chapter draws from and analyses the data collected from the different research methods adopted to answer the bulk of the research questions which form the basis of this study. Sections 4.2 and 4.3 respectively focus on the findings from the quantitative and qualitative components of the study. These findings are presented in a manner that mirrors the conceptual framework adopted in the conduct of the study that is to focus:

- users of research and innovation,
- producers of research and innovation and
- linking institutions.

4.2 Findings from the quantitative component

This section focuses on the findings from the quantitative components of the study, namely the representative quantitative survey at industry level and the convenience survey at the level of research institutions and consultancies.

4.2.1 Users of research

4.2.1.1 Firm's' profile

This section focuses on the profile of respondents. The length of time during which the firms have been in operation is fairly dispersed between less than 5 years and more than 30 years. 83.4% of firms have been established for more than 5 years, with 17.5% having been in existence for more than 21 years. Figure 1.0 below provides additional information on the number of year that responding firms were in operation.

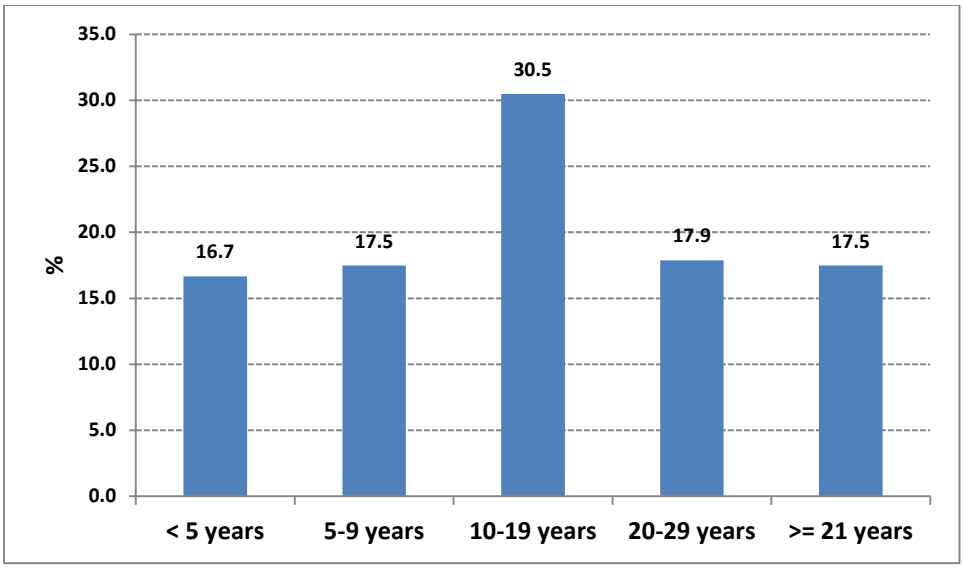

Figure 4.1: Length of time in operation

As regards the size of the company determined by the number of persons employed, the majority of the responding firms can be classified as small and medium enterprises employing less than 50 persons. Only 2.8% of the respondents employ more than 500 persons. The majority of firms (94.3%) are locally-owned. Interestingly though 2.8% of firms are foreign-owned and 2.8% are co-owned. Figure 2.0 presents data on the turn-over of responding firms. 37.4% of them had a turn-over of less than Rs 2 million and 36.1% of them had a turn-over between Rs 2 and 50 million. 15.4% of firms had annual turn-overs exceeding Rs 100 million.

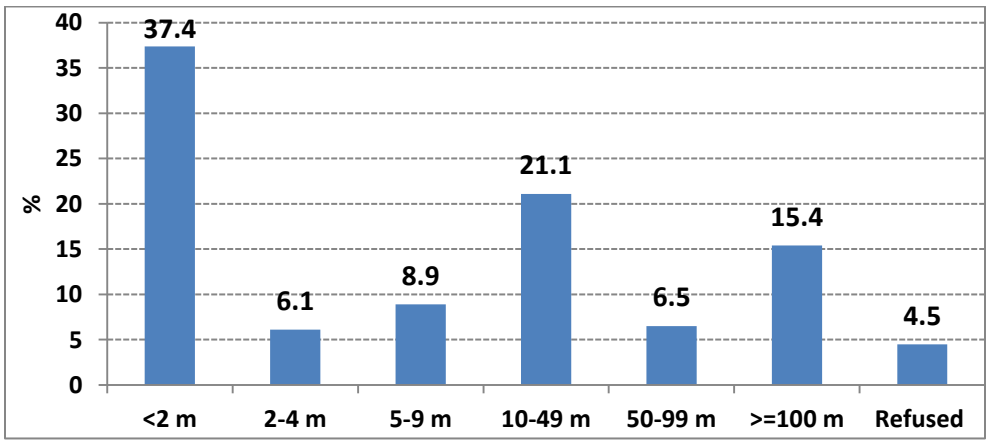

Figure 4.2: Annual turnover in the preceding year

80 of the responding firms were from the manufacturing sector and 125 were from the services sector. Out of the 125, 61 were from 'wholesale and retail trade' and 36 were from the 'real estate, renting and business'. Figure 3.0 presents a detailed breakdown of the responding firms.

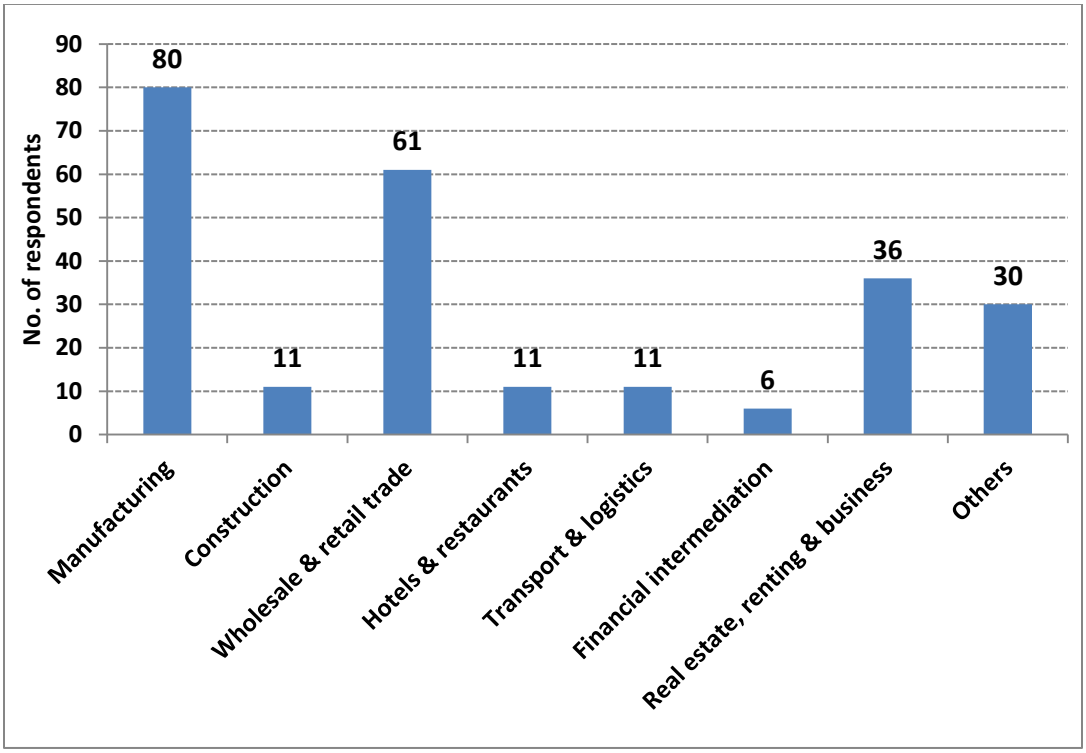

Figure 4.3: Firms' main activities

4.2.1.2 Research at firm level

In the broadest sense of the word, research may be defined as the studious inquiry or examination; especially: investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws. For the purpose of operationalization research has here been categorised as basic, applied and experimental development.

This section considers the extent and ways in which the company is involved with research. Respondents were asked about their involvement with research and the question was not bounded by any time frame. 48.4% of respondents claimed that there are not involved with research, whereas 10.2% of them claimed that they commission research. Interestingly it was also reported that 29.7% of them who undertook in-house research. Moreover, there are firms which are involved with both in-house and commissioned research. In general most of the research undertaken at firm level could be categorised as experimental development[3].

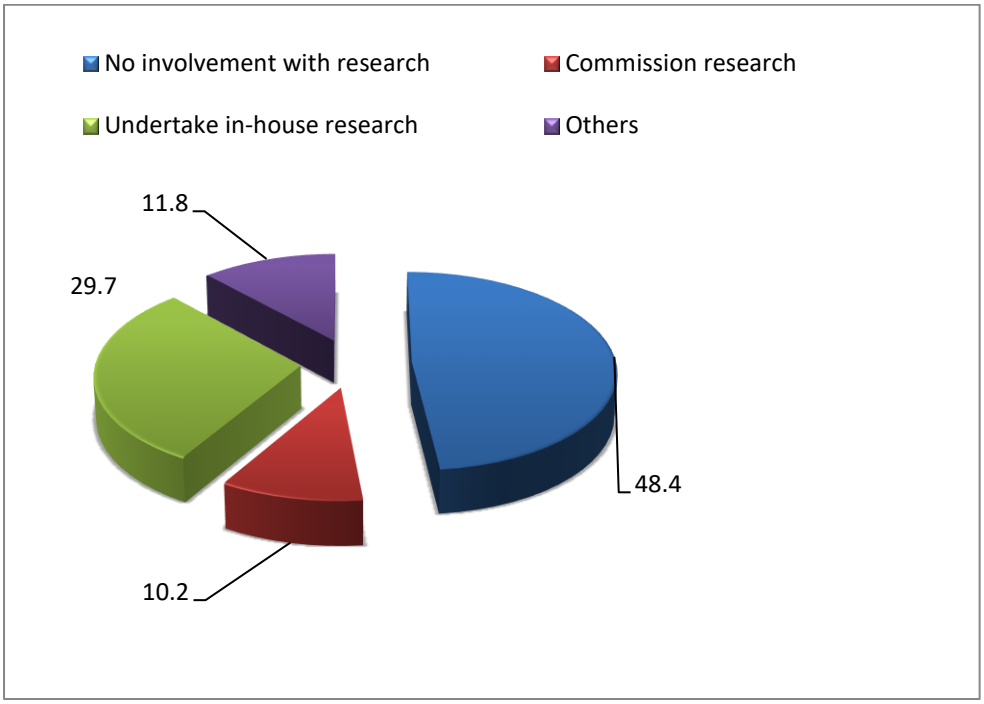

Figure 4.4: Firms' involvement with research [Base=246]

In addition, when questioned as to the significance of research as an input in their business strategy, 97.6% of the respondents recognized its importance. 56.7% even admitted that it is very important. Nonetheless, 0.8% was neutral while 1.6% said that research is not so important to their business.

[3] Experimental development is systematic work, drawing on existing knowledge gained from research/or practical experience, that is directed to producing new materials, products or devices; to installing new processes, systems and services; or to improving substantially those already produced or installed.

Despite the realization of the importance of research as an important business input, however, the investment made by firms is not generally significant. Out of the 127 respondents that claimed to be involved in research 74.8% reported that they have a dedicated annual budget for research, whereas 25.2% did not earmark any research budget. 41.7% had no research budget, whereas 3.9% of such firms had earmarked between Rs 1 and 5 million or research (figure 5.0).

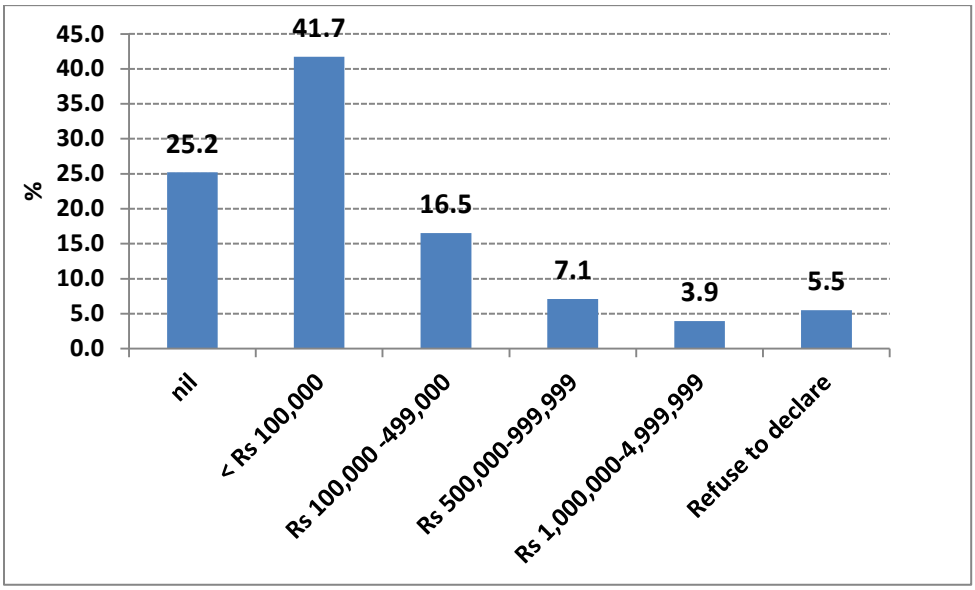

Figure 4.5: Annual budget devoted to research [Base=127]

4.2.1.3 Innovation at firm level

The previous section showed that the majority of respondents view research as being an important business input. Concomitantly research can be a significant input towards innovation, and not surprisingly 91.5% of the respondents considered it to be an important input in their strategy. This finding correlates with the one for research. In general it can be argued that most respondents value research and innovation, even though they were not generally involved in research of innovation activities. Such findings corroborate those of Arza and Lopez (2011), who conducted a survey to assess firms' linkages with public research organisations in Argentina and found that both linked and non-linked firms valued research outputs.

For the purpose of operationalizing the study innovation has been categorised into product, process, marketing, organisational and business model innovation. 75.1% of respondents who claimed to have been involved with innovative practices over the reference period reported that the main type of innovation was product innovation. The remaining types of innovation in order of importance were respectively process, marketing, organisational and business mode innovation (see figure 6.0 for additional information).

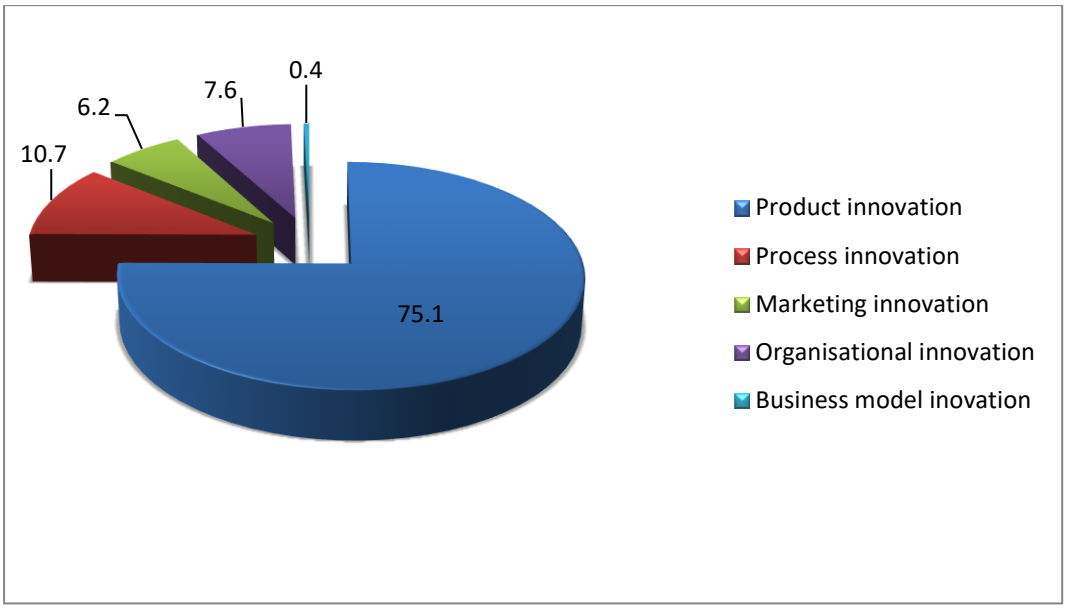

Figure 4.6: Types of innovation at enterprise level [Base=225]

38.6% of firms reported that they had no earmarked budget for innovation. This compares negatively with Arza and Lopez (2011) who reported that 16% of firms in Argentina have zero expenditure on innovative activities. 46.7% of respondents claimed that they had earmarked up to Rs 500,000 for innovation activities (figure 7.0).

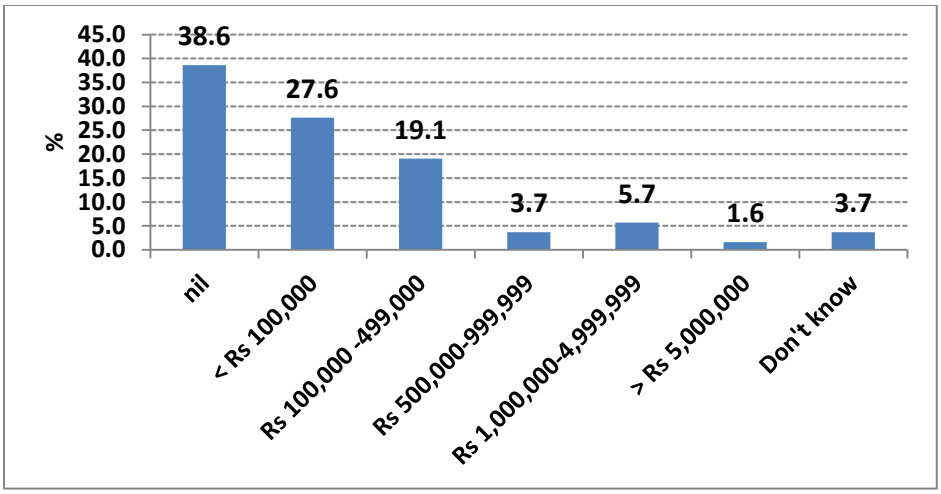

Figure 4.7: Annual budget devoted to innovation [Base=246]

4.2.1.4 Overview of links between Research-Innovation and industry

Initial contacts with R-I institutions and linkage

Over the reference period 108 out of 246 firms reported that they have contacted R-I institutions to inquire about seeking their services to support their innovation activities. Out of them, only 46 have forged formal links with R-I institutions, resulting into a linkage rate of 18.7% (figure 8.0). Linked firms generally invested more in innovative activities, thus suggesting that they could have a higher predisposition towards innovation.

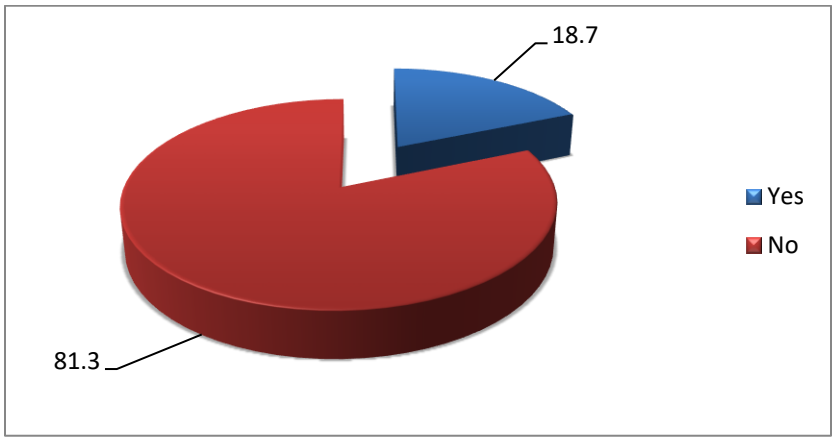

Figure 4.8: Firms that have sought the services of RI institutions [Base=246]

There are 62 firms who have contacted R-I institutions, but have not established any form of linkages. The three main reasons behind this discontinuation in interest in order of importance are that 'services of local researchers are too costly', 'researchers do not generally understand the reality of business' and 'there is no local expertise to tackle the issues identified by firms'.

Of the 46 firms that have established formal linkages with R-I institutions, 12 have linked once over the reference period. Interestingly though 32 and 4 firms have respectively linked more than once with R-I institutions (see figure 9.0 for additional information). Such firms have witnessed the benefits of research and innovation on their business and have thus established multiple linkages with R-I institutions.

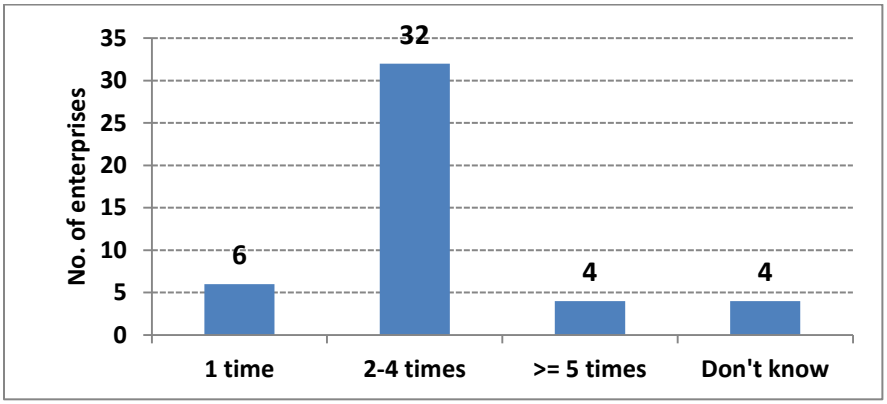

Figure 4.9: No. of times enterprises have established links over the RP [Base=46]

Over the reference period responding firms have linked with different types of R-I institutions. Figure 10.0 provides additional information. The base for this question is 79, as the question allowed for multiple answers. Thus 29 firms established links with more than one R-I institution over the reference period. 47.2% of firms have linked with 'consultancy firms/private research centres' and 14.8% of them have established links with 'academics/universities'. 16.7% of those who have established links have done so with public research institutions. Such institutions include the Agricultural Research an Extension Unit, National Productivity and Competitiveness Council, the research department at the Small and Medium Development Authority among others.

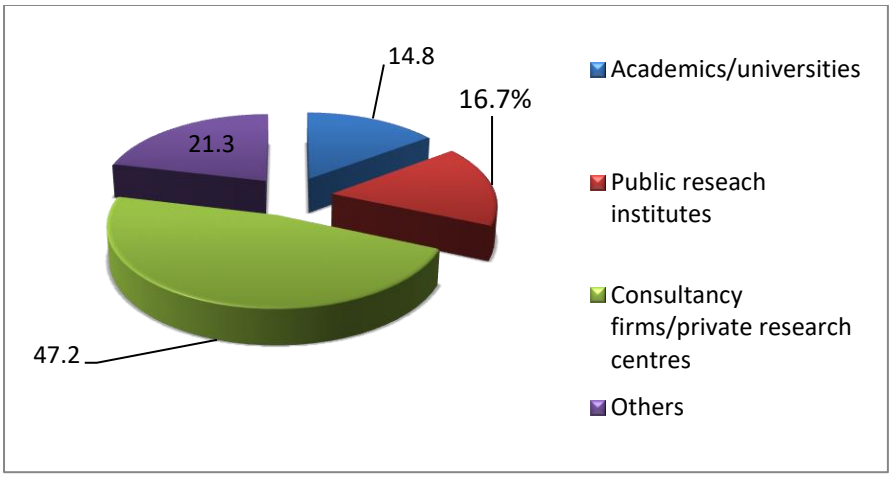

Figure 4.10: Types of R-I institutions that enterprise link with [Base=79]

In this section the emphasis is on firms' expenditure on external R-I institutions. Such expenditure can be in the form of contracts, research fees, stipends among others. Out of the 46 firms that have established links with R-I institutions, eight have zero research expenditure (figure 11.0). This can be accounted for by firms that have established links and benefitted from services by from publicly-funded institutions.

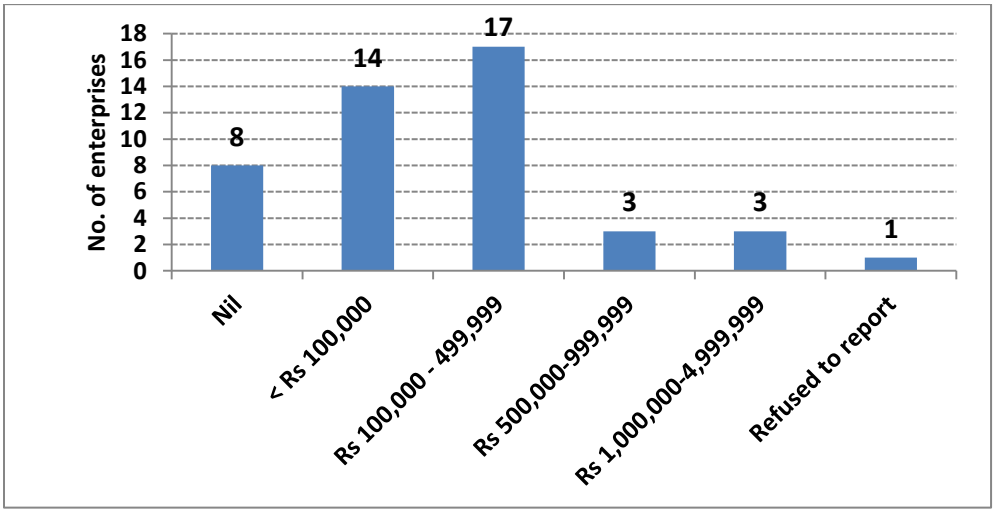

Figure 4.11: Budget spent on external research over the reference period [Base=46]

Establishment of linkages

Of the firms that have established linkages over the reference period, 71.3% reported that these have initially been formed through personal contacts. This finding actually corroborates the literature, showing that the human factor is a prime driver in creating and forging linkages. Interestingly some of such linkages are formalised through the respective institutions, whereas some R-I services are informally provided that is they are not formally paid for. This is a common feature RI-I interaction in developing countries where the ecosystem for RI-I is not properly structured (see Arza and Lopez (2011)). Figure 12.0 also shows that 11.1% and 8.3% of firms that have established linkages have also done so through the respective R-I institutions or departments.

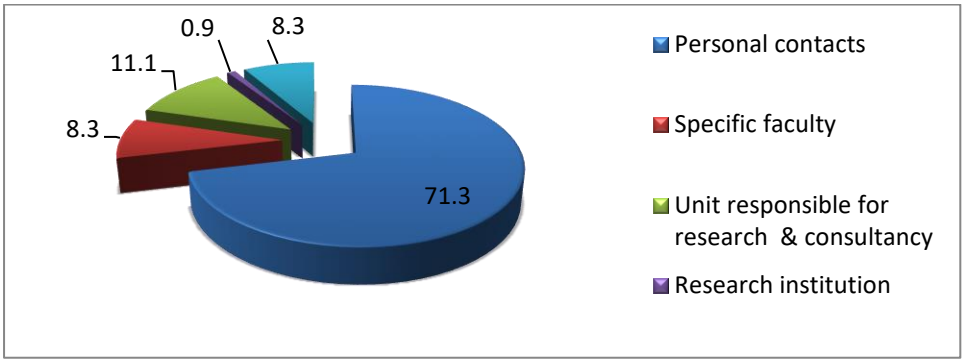

Figure 4.12: Establishment of institutional contact

51.9% of links have been established through individual contacts, that is only the services of one researcher is solicited to address the R-I issues at enterprise level. In fact, contract research is a kind of formal or informal collaboration and is directly commercially relevant to firms. Figure 13.0 also shows that 25.3% of linkages have been formed with publicly-funded R-I institutions and these were formalised either through 'memorandum of understandings' or 'responses to official requests from firms'. In 11.4% of cases, linkages were also established through 'student placements'.

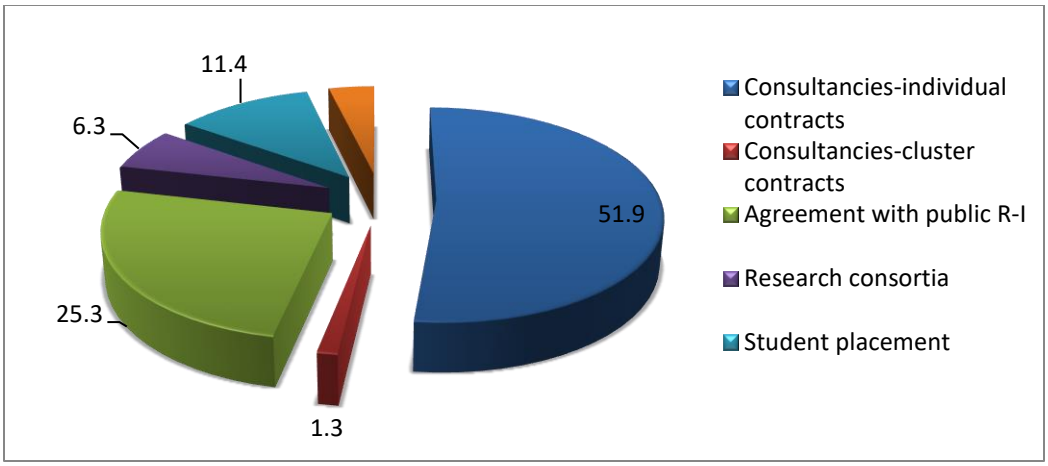

Figure 4.13: Formalisation of R-I activity [Base=79]

The results presented here show that the modes of interaction between RI institutions and industry are relatively basic to what is usually reported. Arza and Lopez (2011) show that the modes of interaction between firms and public research organisations in Argentina in order of importance are:; informal exchange, consultancies, research contracts, joint R&D, licences, networks, patents, scientific parks, incubators, university owned firms and spin offs. It is observed that the most commercial forms of interactions (e.g. licences, patents, scientific parks, incubators, university owned firms and spin offs) are non-existant locally. This finding tends to suggest that entrepreneurial capabilities are not highly developed in the RI institutions locally.

Motivation behind linkages

More than 80% of the firms that have established links over the reference period reported that the main reasons behind linking with R-I institutions were namely to: have access to research results, improve the company's image, foster good community relations, have access to knowledgeable researchers/business strategists and find solutions to specific issues (see figure 14.0 for more details).

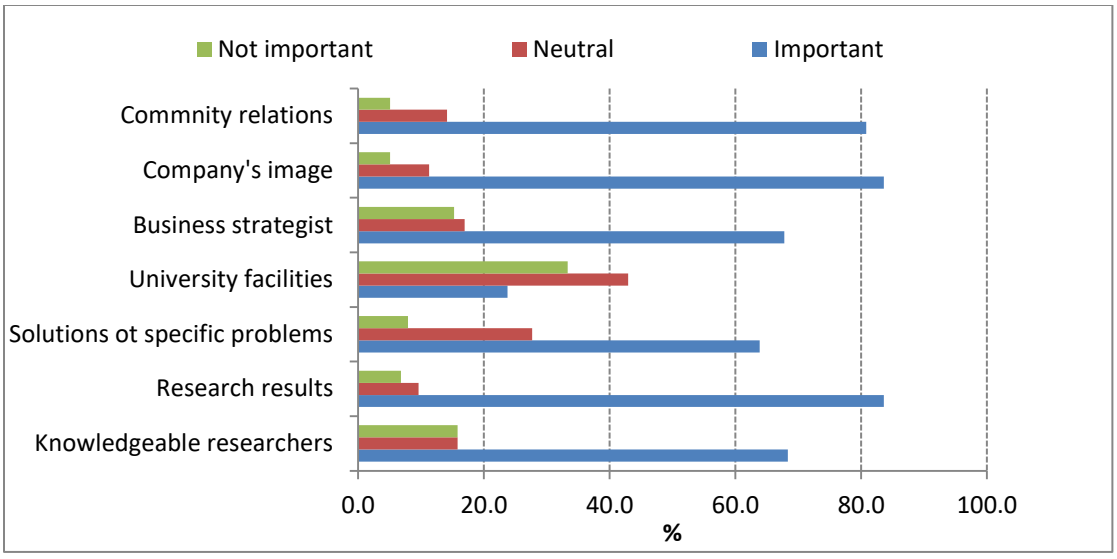

Figure 4.14: Motivation to link up with external R-I [Base=46]

International linkages and foreign shareholding

Out of the 46 firms that have established links with external R-I institutions, three of them reported that they have done so with international ones. The main reasons motivating their choices towards international institutions over local ones were: higher standards of outcomes, more prestige to be associated with international institutions[4], absence of local expertise in specific areas and better price/quality ratio.

5.7% of firms that participated in the survey asserted that they were of international shareholding. Six of them reported that their mother company actually conducted internal research and development and that there was knowledge transfer to the Mauritian subsidiary. 13 out of the 14 firms with international shareholding reported that innovation processes and activities were transferred locally. Figure 15.0 shows that innovative processes were more commonly transferred.

[4] This was more prevalent for firms that were conducting organisational and/or marketing innovation.

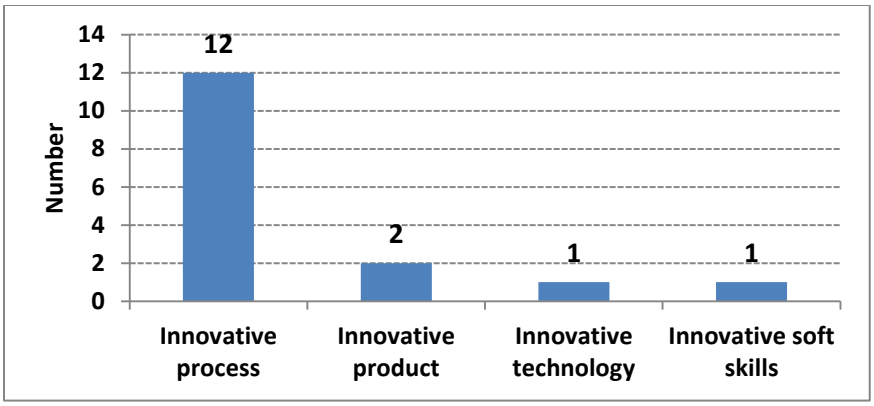

Figure 4.15: Type of innovation transfer from parent company [Base=13]

Innovation at firm level

Innovation at firms' level occurs in a multi-faceted fashion and innovative firms build upon a range of innovation sources and activities to improve their businesses. Such activities are most of the time non-research related. Responding firms were asked how innovation was generated and 41.1% reported that their main source of innovation was internal brainstorming. 'Trial and error' and 'employment of expatriate' staff respectively accounted for 8.1% and 2.8% of innovation generation. More interestingly 48% of firms reported that they do not know how to generate innovation that can impact their business. This finding shows that there is an opportunity and scope to promote innovation at firms' level either through better linkages or other alternative mechanisms.

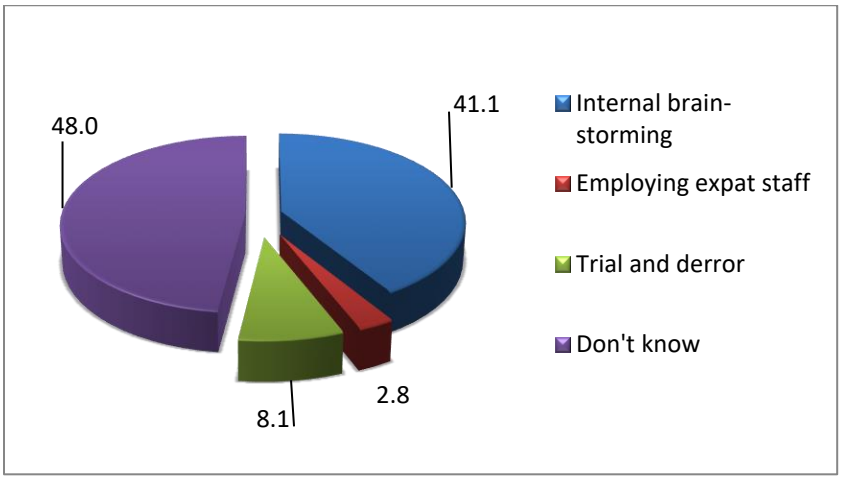

Figure 4.16: Generation of innovation apart from research [Base=246]

4.2.1.5 Evaluation of linkages between Research-Innovation and industry

Firms which have forged linkages in the past were asked about their satisfaction of the outcome of such linkages. Interestingly 77.2% of them reported their satisfaction, with only 8.7% being not satisfied (figure 17.0). Reasons evoked for non-satisfaction were a mismatch between available knowledge in RI institutions and the one needed by firms and the low sensitivity of RI institutions to the demands of industry. Our findings corroborated the literature, which reports that the majority of linked firms are usually satisfied with the outcome of their linkages with RI institutions.

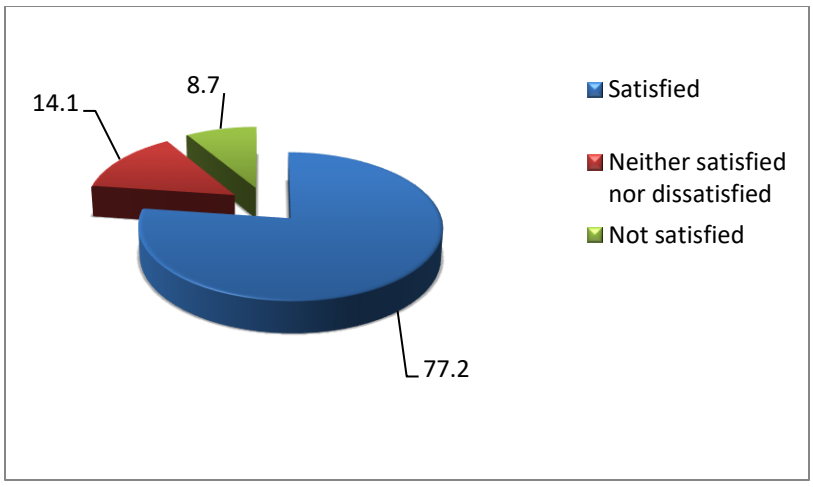

Figure 4.17: Satisfaction with service delivery in the past [Base=92]

The degree of overall satisfaction of the outcomes of linkages was further disaggregated into individual satisfaction criteria, and figure 18.0 shows that in general respondents were satisfied with the relevance, timeliness, conciseness, affordability and quality of the output of linkages with R-I institutions. An important finding to highlight is that 78.6% of respondents who have been involved in R-I linkages have been satisfied.

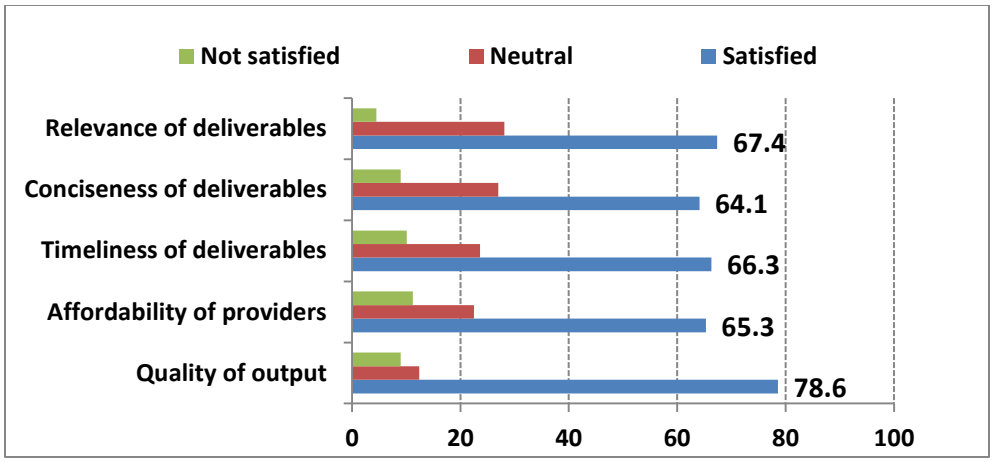

Figure 4.18: Degree of satisfaction with outcome of linkages with R-I institutions [Base=92]

4.2.1.6 Proposals from industry

This section focusses on the proposed measures which could be implemented to establish, improve, promote R-I linkages by the three important stakeholders making up the innovation triple helix namely the Government, the industry and the research institutions. Figure 19.0 presents the proposals that should according to industry improve R-I industry linkages locally. The four main proposals in order of importance are: the provision of research and development incentives to firms, tertiary education institutions to improve the research credentials of students, to increase public research funding and to widen the coverage of the corporate social responsibility levy to also cover research and development.

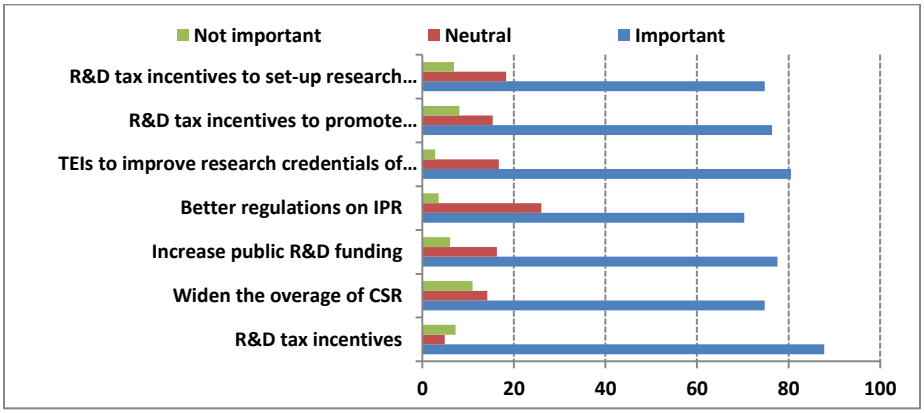

Figure 4.19: Proposed measures that Government should implement to improve R-I-Industry linkages [Base=246]

Firms were also asked to propose what they should do to promote research and innovation at industry level. Figure 20.0 categorises the main proposals. Interestingly more than 90% of respondents affirmed that it is fundamental that firms either individually or collectively increase awareness about their issues that warrant research attention, and that subsequently lead to any of the five forms of innovation. More than 70% of respondents also asserted that it is important to: increase investment in targeted industry research at the level or research institutions, set-up appropriate structures for research student placement both at universities and at industry level, and present as far as practical industrial problems as potential research projects. About 50% of respondents proposed that the industry could fund incubators at research institutions level to study specific issues related to their line of business.

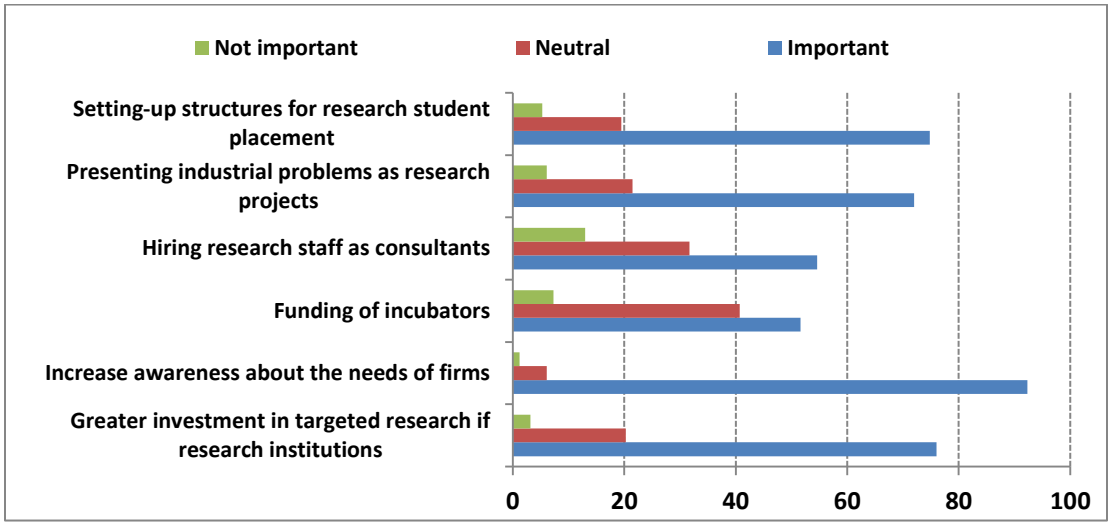

Figure 4.20: Proposed measures that industry should implement to improve R-I-Industry linkages [Base=246]

Respondents also proposed that research institutions should set-up and increase their involvement in collaborative networks, design research programmes that match the needs of industry and increase awareness about their research activities and output (see figure 21.0 for other proposals).

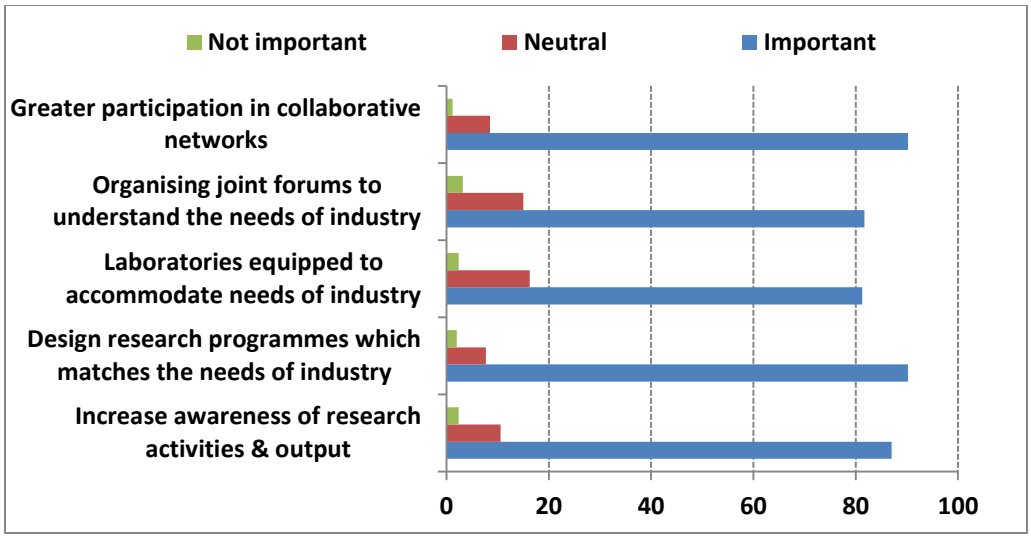

Figure 4.21: Proposed measures that research institutions should implement to improve R-I-Industry linkages [Base=246]

4.2.2 Producers of Research

4.2.2.1 Respondents' profile

The present section describes the profile of the respondents. The questionnaire was set mainly to conveniently target researchers in the tertiary education institutions. Figure 22 below illustrates the number of respondents categorised by broad research categories.

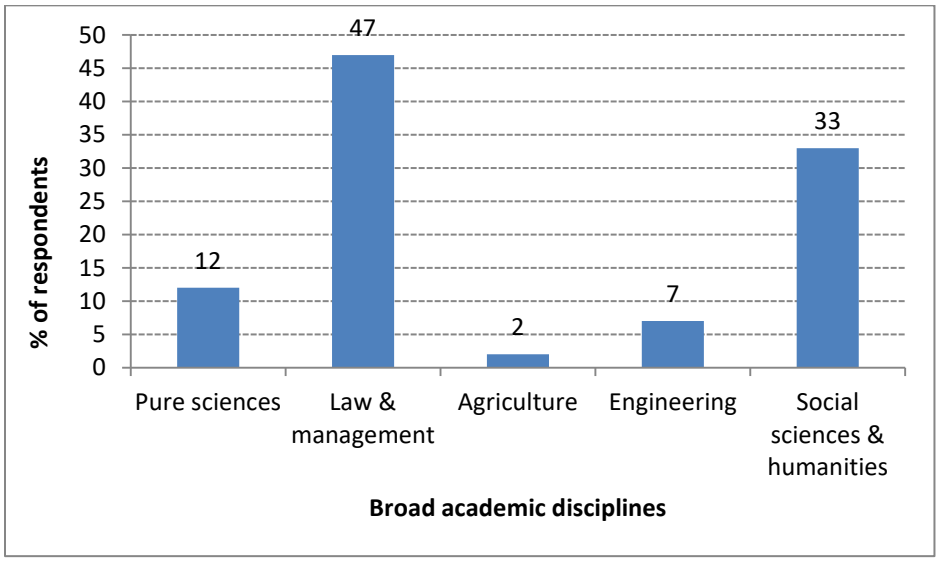

Figure 4.22: Categorisation of respondents from tertiary education institutions

47% of respondents were from faculties /schools covering academic disciplines related to 'law and management' and 2% were from 'agriculture'-related faculties/schools. At the time of the survey 44% and 15% of respondents were respectively involved in their own research and in commissioned research, with 12% of them claiming that they were involved in both conducting research based on their own interest and are concurrently also involved in commissioned research work for third parties (figure 23).

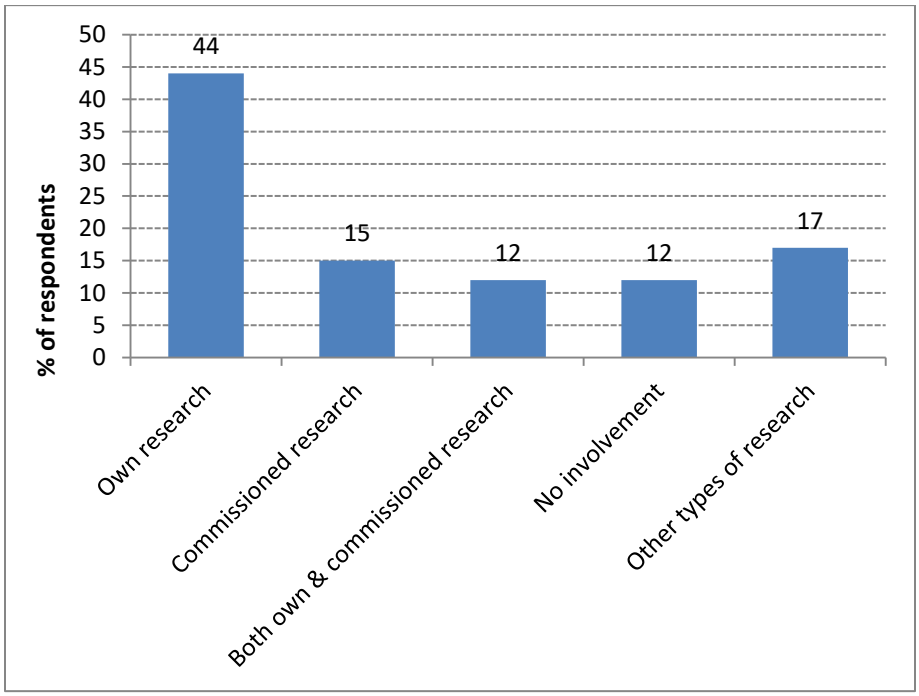

Figure 4.23: Research undertaken by respondents

4.3 Findings from the qualitative component

This section presents the salient findings from the qualitative interviews with heads of research institutions, in-depth interviews with companies and in-depth interviews with institutions who are mandated to mediate linkages between the R-I institutions and the industry. The various responses were analysed and thematically categorised across users, producers of research and linking institutions. The sub-themes used to further categorise the responses were:

- Perception on RI-I linkages
- Driving forces for linkages
- Obstacles to linkages
- Proposed recommendations

4.3.1 Users of Research-Innovation

4.3.1.1 Perception on Research/Industry Linkages in Mauritius

Interviewees from selected companies and industry representatives generally stated that according to them there is a lack of interest in RI-I collaboration locally. This is due to a lack of sustained interest from both the industry and researchers. From their perspective, they mentioned that industry generally focus their time and resources on production issues (example, waiting for orders, managing customer relations) and so are unable to dedicate themselves s on creating linkages and collaborating with research institutions.

4.3.1.2 Current Status of Research/Innovation at Users' Level

From the responses obtained it is clear that companies' decisions to get involved in RI-I linkages may differ across industries, company characteristics, and the business and legal environments in which companies function. Overall most of the interviewees revealed that they have never collaborated with local research institutions for research or innovation input as part of their business strategy. In two cases respondents mentioned that they had made initial contact with RI institutions for specific services but the linkage was not established. One firm mentioned that it has linked with a researcher through a collaborative research grant scheme partly supported by the Mauritius Research Council, to innovate and improve its production line. This linkage reaped fruitful outcomes and that would be a significant determinant for that company to again link with RI institutions.

4.3.1.3 Driving Forces

Firms acknowledged that they have to innovate to remain competitive, and that would be the principal determinant that could encourage them to link with RI institutions. According to firms, one of the ways to promote such linkages is to ensure that there is a conducive institutional and fiscal environment that promotes the establishment of linkages and that does not further burden their cost structure. Some respondents mentioned that another factor that would motivate future RI-I collaboration would be the outcome of previous collaboration experiences.

4.3.1.4 Obstacles

One recurrent observation from representatives of industry was that there lacked research and advisory expertise locally in certain specific areas, mainly in the services sector. They mentioned that the structure of the economy is geared towards services and that research effected in research institutions are not necessarily addressing issues faced by companies in this sector. Research and innovation services should be developed to respond to concrete market pull demands.

Majority of the responses from representatives of firms reveal that most of the laboratories found in research institutions lack accreditation and hence cannot be trusted for testing and analysing new products meant for the international market. For some such doubts are even more pronounced, in the case of private research institutions that are not particularly known for their high academic and scientific performance, while others (mainly in high-technology sectors) prefer to deal with private research institutions given their less bureaucratic structure of organisation. Moreover with regard to patenting and exploitation of inventions policy, the respondents declare that patenting and IPR have never been their main issue as most of the time they have not contemplated the development of new products or services as part of their business strategy while collaborating with research institutions.

For the medium firms the chief hindrance to successful RI-I is the lack of communication as academics/researchers tend to use technical or scientific jargon which is not completely

understood or appropriate for those from the industry. The responses from the small firms (measured by number of employees) mainly in the low technology industry further disclosed that the lack of understanding of possible collaboration process, of detailed gains, inadequate funds and technical resources are the key barriers that prevent them from contemplating participating in research partnership. One respondent reported that "except for accommodating students for internship in our firm or tailor-made training programmes for our staff, we are not approached by researchers/academics to establish research and innovation related collaborations and as such our worlds are detached from each other and as such linkages in the field of research and innovation is unlikely to take place." Others claimed that the core obstacles come from the government in terms of highly bureaucratic procedures, red tapism, lack of entrepreneurial behaviour, delays in funding and rules and labour market regulations which inhibit staff exchanges between the public and private sectors. Furthermore, some enterprises in low-technology industries even mention that the government may have initiated policies to promote the transfer of knowledge from research institutions to the industry, but they are not aware of such strategies.

One firm from the light engineering sector stated that it do not fund projects unless they see that such initiatives have the possibility of application or adding value to the business. Some from the manufacturing industries perceived that knowledge produced by research institutions as being mainly scientific knowledge that does not help in solving industry problems and thus are less keen to be involved in RI-I for innovative and research activities. One interviewee asserted that "most of the time faculty members involve in research based on their specialisation/expertise without giving much consideration to the possibility of commercializing the outcomes of the research. Their main objective is rather to conduct research for publication in order to fulfill promotion requirements of their academic career.

Yet a few respondents revealed that bad collaboration experiences may generate new techniques at solving problems and avoiding part similar difficulties thereby leading to more formalised agreement on required standards and on how to manage internal mechanisms of

the partnering institutions which in turn can result in further development of the collaboration process. One of the interviewees further stressed that for him "what matters to him from a business standpoint is not the research outcome but rather its impact for example on firm's performance, manufacturing designs and processes and logistical efficiencies." Among other common motives stated by the industrialists respondents to be involved in RI-I are higher profits/returns, increased market share, access to a research network, feedback for development process and in some outlier cases to ensure the long-run sustainability of the firm.

Interviewees further stressed on the different time horizons and different notions of evidence between the research and industry spheres, as being another obstacle. The firms state that a researcher needs as long as research takes and findings are often packaged in an academic manner, whereas firms often need clear findings at key points of their business processes.

Representatives from the knowledge-based industries confirmed that some professors having acquired goodwill, provide consulting services for several companies from their own contacts without involving the research institutions. At the same time, previous successful collaboration projects do act as motivators for future collaboration while those which did not met the expected results or created hurdles for the parties involve will have a negative impact on future collaboration. The respondents from such types of firms also believe in two-way communication and hence social dialogue as a contributor to the success of research institution-industry collaborations, as it helps in acquiring knowledge as well as assists in the adaptation process of the firm.

4.3.1.5 Proposed Recommendations

Some of the interviewees were of the view that firms should employ academically trained scientists that can assist a firm to quickly identify, comprehend and utilise scientific and technical knowledge and hence facilitate interaction with the RI institutions as well as to the creation of new scientific knowledge in collaboration with the research institutions. Thus

targeted production of knowledge through research by RI institutions for use in industry, becomes more dynamic when interacting with firms due to challenges created in the resolution of specific production problems. Users of RI need to also build in-house capabilities to assimilate and exploit different sources of knowledge that could be generated by R institutions.

Responses from industrialists emphasised the need for research institutions to display good management of projects through the application of good governance and develop ways to speed up Intellectual Property (IP) agreements through for example, by coming up with model contracts and protocols for IP and promoting new forms of formal and informal set of contracts between the representatives from the industry and researchers/academics.

To enhance the commercialisation of the research undertaken by the research institutions/universities, representatives from firms highlight the need for such institutions to sensitise industrialists about the importance of research and innovation in contributing towards higher profits and performance. According to firms Government should intervene to facilitate linkages through research and development tax exemption.

4.3.2 Providers (Researchers/Academics) of Research/ Innovation

4.3.2.1 Perception on Research/Industry Linkages in Mauritius

Producers of research reiterated the importance of research as an input towards innovation at industry level and that it should be supported. They further asserted that research institutions and their interactions with the private sector should play a central role in the creation, diffusion and use of knowledge in the national innovation system. This finding concurs with Charles (2003) who investigated the reshaping role of universities in the UK and highlighted the need for a sea change in knowledge generation coming from universities. According to respondents, the specific problems of industry are so complex that they require a combination of technologies that no individual firm could develop individually, but that could rather be generated by a pool of knowledge and resources have would be available at RI institutions. All

those interviewed in this category, agreed that in general there is an acute lack of RI-I collaboration in Mauritius. According to them, this lack of linkages is felt across industrial sectors, as well as at research institutions level. Researchers at universities felt that industry in Mauritius generally prefers to establish linkages with international institutions, and that the outcomes of such linkages were mainly to generate marketing, organisational and business model innovation. The linkages established with local research institutions (especially universities) were to address issues related to manufacturing processes or improve marketing strategies.

4.3.2.2 Current Status of Research/Innovation at Providers' Level

Interestingly producers of research (mostly form universities) generally observed that there is insufficient RI-I linkages between research producers and industry. However they affirmed that they have either individually or as part of a research consortium been involved in linkages with industry over the duration of their career. Most of these linkages were formalised through the Consultancy and Contract Research Centre (CCRC) of the University of Mauritius, which managed the contracts. There researchers either offered their services s consultancies or were part of contract research projects that targeted issues at industry level. These respondents also generally affirmed that services provided related more often to the provision of specific services (testing, monitoring and consultancy) rather than research to generate innovation. Such findings corroborate those of Dutrenit and Arza (2010) and Arza and Vasquez (2010) who respectively investigated RI-I linkages in Latin American countries. Interviewees nevertheless acknowledged that such linkages (even more so for purely research linkages) were not established and institutionalised frequently enough or in a systematic manner, resulting in industry not fully benefit from expertise existing at universities. Some of the senior academics/researchers interviewed, revealed that they had forged linkages with industry over the reference period and most of the time this was done informally. They provided their services more for advisory purposes, but in certain rare cases to also conduct research to address technical issues or to generate innovative ideas at firms' level. Sectors covered included manufacturing, ICT, environment and financial intermediation.

One in-depth interview was also carried out with a representative of the Mauritius Sugar Industry Research Institute (MSIRI). The MSIRI was established in 1953 as a linkage mechanism, mandated to 'promote by means of research and investigation the technical progress of the sugar industry'. The mission of the institute is to carry out high quality research and development on sugar cane and other crops that meet the agricultural, commercial, and societal needs of Mauritius. The institute establishes quinquennial research and development plans in close consultation with the sugar industry and for the purposes of the sugar industry. It employs more than ninety two scientists and technicians who implement the R&D plan of the institute. The MSIRI is a statutory body financed by a global cess on sugar produced by all cane growers and the Government and is governed by a Board of Directors, comprising seven representatives of millers, growers and the Chamber of Agriculture and three Government representatives who ensure that the R&D programme is actually implemented. The plans are flexible enough to accommodate the evolving and dynamic needs of the industry. Over the years the demands from the industry have been increasingly technical in nature as the corporate sector has sourced innovation internationally to improve their productivity. The institute has consequently had to adapt to provide support mainly through experimental development and extension so that the sugar industry could reap the full benefits of this innovation transfer. The MSIRI is therefore a perpetual linkage mechanism between sugarcane research and the needs of the sugar industry.

4.3.2.3 Driving Forces

On a positive note one respondent claimed that "with the decreasing public funding for research exacerbated by economic crises there is pressure on extracting social and economic benefits out of invested public funds in the academic research base and this pressure had been changing the attitudes of academics to also focus on activities that are concerned with the use, application of knowledge and thus generate funds''. A few academics/researchers are being proactive and are investigating new linkage mechanisms with industry by directly contacting the industry and either selling their advisory and consultancy services or informing specific companies of their current research and its likely commercial potential. It is fair to note that

this type of pro-activeness is a result of individual drive of particular researchers and not as a result of an established system at the levels of RI institutions.

4.3.2.4 Obstacles

The main barrier mentioned by many of the high profile academics and researchers, is the lengthy procedures and formalities involved when their linkage contracts are formalised at the level of their institutions. For instance, one researcher went further to state that if he would have waited for all internal procedures and the paperwork involved, at the research institution to be cleared then he would have never been involved in any collaboration with the industry and deliver the project within the specified time frame specified by the industry. The researchers further pointed out that there is a lack of academic and commercial incentives for individual researchers to work with the industry. For example academics at the Universities stated that their personal promotion system at the level of their respective institutions is academically based, that is it rests on the number of academic publications and peer review systems, which unfortunately do not explicitly incorporate or give enough weight to RI linkages with the industry. This severely inhibits the commercialization of research results. Another noteworthy barrier, revealed by this category of researchers, is ego. The idea here is that researchers must be ready to accept assistance and advice and work with others and should acknowledge the fact that given the diverse skills required for research uptake at industry level, it's highly unlikely that any one person would have the required skills and competency set to address multidisciplinary issues at industry level.

On the hand for junior researchers/academics, the key concern is that though research is part of their duties as faculty members, the teaching and administrative workload was quite high and as such the time allocated to research was inadequate. At the same time the researchers declared that firms in Mauritius lacked faith in local capacity for innovative ventures and preferred to rely on foreign expertise or to buy new ideas and products from abroad. Moreover, they also asserted that the divergence between universities and industry in terms of

aims, culture, bureaucratic structure, and human resources profile, acted as another major hurdle to successful RI-I linkage.

4.3.2.5 Proposed Recommendations

Given that researchers/academics and firms have different aims and objectives which sometimes may be conflicting and thus inhibit RI-I linkages, the main proposed solution was the need for improved communication between the two parties to deal with the different values, beliefs, traditions and "culture clash" between academics/researchers and representatives from the industry. Both stakeholders need to be open and flexible to accept such differences and maximise on this diversity. Communication channels can take different forms like shared meetings , networks established among the organizations, planned visits to firms, periodic reports made by academicians, one-on-one meeting between individual researchers and industry and dynamic websites interfacing needs of industry and RI supply from research institutions.

One respondent from a public university indicated that there is a need for improved knowledge management at the research institutions level in order to manage projects more efficiently, learn from successes and failures and broaden their aptitudes through close contacts with the industry. In fact the Consultancy & Contract Research Centre (CCRC) of University of Mauritius (UoM) does contribute to the knowledge management process at UoM, but respondents still believe there is much to be done in terms of mechanisms to capture the experiences associated with projects so that mistakes are not repeated.

Respondents have also pointed out that firms should invite researchers to display their potentials and assist them in commercialising their research projects. For example one academic mentioned that "in Scotland a firm has taken the initiative of inviting submission from academics to support their efforts in implementing nascent technologies and the submissions were assessed in terms of many factors such as their technological novelty, potential economic impact on the country among others". The interviewees also acknowledge that fact that even

research institutions have to fulfil certain roles such as giving incentives to researchers to encourage them to participate in knowledge/technology transfer activities and these incentives should not only be in monetary terms (such as a share in profits made when licensing or spinning-off innovative ideas) but contribute towards boosting career progression.

Some responses also pointed to the need for inviting eminent researchers outside the university system who can promote RI-I collaboration through their earned goodwill, locally and/or internationally. As far as the role of the government is concerned, academics pointed out the need for complementary policies such as reducing teaching and administrative load so that more time and effort can be attributed to research. Some academics even made reference to initiatives such as those undertaken by the Kauffman Foundation to be introduced in Mauritius to encourage University-Industry Collaboration schemes.

4.3.3 Intermediaries (Heads of Departments, Directors/Officer in Charge of Research Institutions)

4.3.3.1 Perception on Research/Industry Linkages in Mauritius

Intermediaries, that is those institutions that are mandated to promote RI-I linkages affirmed that there was a reasonable level of interaction but that was insufficient if research and innovation were to more significantly contribute to industry growth. The promotion of such linkages was not parcel of a national research and development plan, but rather the result of isolated of schemes operated by individual institutions. They further mentioned that such linking institutions are under-resourced both in terms of man power and finances and perceived that such RI-I linkages could be further promoted and improved if more resources could be made available to them.

4.3.3.2 Obstacles

According to respondents, one of the reasons underlying this low rate of RI-I linkage was that research conducted at the level of research institutions did not necessarily meet the needs of

industry. Therefore the industry were not motivated enough to collaborate with research institutions. Research funding institutions also act as linking institutions through specific private sector collaborative research grant scheme and the main deterrent to supporting such research grants is the lack of public and private research funding and private capital. Supporting systems in place at linking intuitions level are inadequate and do not necessarily respond to the current economic realities and conditions that companies currently face.

In addition some heads of departments stated that there was no clear rules and guidelines regarding the transfer of knowledge and management of Intellectual Property (IP) when researchers linked with industry. It was further noted that in some cases due to lack of continuous professional development the personnel working on knowledge transfer at particular institutions level tend to be relatively inexperienced and did not possess the required skills to carry out their tasks effectively. Those who possessed the required skills to efficiently and effectively deal with the industry did not interact much among themselves and less so with other staff and this acted as a barrier to pooling of knowledge transfer competencies.

4.3.3.4 Proposed Recommendations

Interviewees from linking institutions recommended that mobility schemes should be set up locally that would facilitate the movement of researchers from RI institutions to industry for a specific period of time to tackle specific researchable issues at industry level. Mobility schemes should be instituted such that time spent and research effected for the purpose of companies be considered for personal promotion at the level of research institutions. The successful example of the "Marie Curie Industry-Academia Strategic Partnership" scheme was quoted as an example which supports the development of such long-lasting linkages through the exchange of researchers. Such schemes would contribute towards promoting an entrepreneurial mindset among researchers and academics.

Another interesting solution proposed is using alumni with industrial background to act as mentor for junior academics/researchers in providing knowledge of local and global business

trends. Among other mentioned solutions are building of trust, new corporate laws fostering RI-I, holding of open sessions and encouraging further exchange through the media.

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

All countries are contemplating the kind of policies, institutions, business organisations, skills sets, investment and funding mechanisms and incentives that are required to substantially augment the level of innovation at industry level, with the objective of promoting economic growth. They are striving to piece together the above components and render effective their national innovation systems. Mauritius is no exception. Over the last four decades is has developed into a middle income country. Like many other countries with the same level of economic development, it is affected by the middle income country trap syndrome and is looking for growth factors that can propel it to high income country status. Innovation at both the public and the private sectors level is often being touted as a prerequisite to assist countries to get out of the trap. It can significantly contribute to future national productivity, industrial competitiveness and export competitiveness. This reliance on the national importance of innovation has restated interest in the main sources of innovation, including what is being generated at research institutions level. However there was a dearth of existing information on the nature of the linkages between research institutions and the private sector locally and most of the published literature in RI-I linkages was generated in the context of developed countries, where the structural characteristics of agents and their interaction across their national innovation systems would be markedly different as compared with developing countries. Such a situation justified the need for a systematic investigation locally. Given this backdrop it was attempted to investigate, map and characterise the Research/Innovation-Industry Linkage in the Mauritian innovation system using a well structured methodology framework. The specific aims of the study were to:

- explore the specific role of Research-Industry Linkage (RIL) in the National Innovation System,
- map, understand and assess the nature of linkages which exist between private sector and research institutions, and

- identify the main bottlenecks which hamper efficient and effective linkages, with the view to enable the development of lasting linkages which spur win-win collaborations for both the innovation/research institutions and the private sector.

Relevant stakeholders in general, and firms that have been involved in the commercial use of knowledge generated by R-I institutions strongly assert the role of R-I in addressing critical issues at industry level and contribute to industry growth. There are few firms that have benefited from R-I locally, but these are rare cases. This study has also highlighted that there were insufficient ideas and input that diffused from research centres, that are transmuted into products, processes and services with economic value. It has also confirmed that the traditional division of labour between researchers doing basic research or research leading to academic publications as opposed to also focussing on applied research (or experimental development) that seeks to convert scientific knowledge into usable technologies or services is still preponderant locally. The limited role most of existing research play in providing research and innovation services to industry and the challenges they face, call for a re-think of how RI-I linkages are established and funded. There are several reasons explaining this state of affairs. The main ones being the low industry-relevant research output, general unawareness of firms of the types of and the potential impact of innovation and more importantly how they can innovate using either in-house or external research, the general low RI absorptive propensity of industry and the reported inadequate responsiveness of intermediary institutions to the needs of industry.

It is a fact that locally, public funding for research is decreasing. Coupled to that it is acknowledged that the private sector is currently facing internal and external pressures to improve their bottom lines and boost their top lines, and are less willing and likely to invest in R-I, even though they acknowledge that R-I can underpin industry growth. Nevertheless it is fundamental that there is a more active participation of the private sector as a key agent and guide of research activities. The challenge here is to increase internal expenditure on R-I without increasing the burden on firms. For R-I to fully contribute towards industry growth it is

crucial to increase the R-I funding at industry level and improve the ecosystem within which linkage can prosper, to benefit both generators and users of R-I.

Policy recommendations

The current study depicts and portrays the state of affairs of RI-I linkages in Mauritius. Given the context painted in the previous paragraph and the current findings, it is crucial to make research institutions become important axes of the national innovation system and their research outputs and findings more commercially relevant. The recommendations proposed here are based on the findings of the study, coupled to international best practices. It is important to pinpoint that RI-I linkages are not established out of a vacuum, but within the national innovation system. Therefore proposed measures to improve RI-I linkages must also seek to address issues at different levels, namely: institutional, intermediaries, RI institutions and industry.

At institutional level

The promotion of interactions between R-I and industry should first of all be part of a national plan for science, technology and innovation, and should not solely be the focus of isolated policy instruments. Such instruments and policies should be wired with remaining measures that support the plan for science, technology and innovation so that the whole system can meet its objectives.

It is fundamental to devise a research strategy for the private sector within the science, technology and innovation plan that mirrors the structure of the economy and more importantly also seeks to identify and address the current and future challenges faced and to be faced by the private sector locally. R-I is not costless, it requires investment and this needs to be less dependent on Government funding It is proposed to use up to a maximum of one quarter (0.25) of the 2% Corporate Social Responsibility fund to finance R-I at enterprise level. The objective here is to make use of part of the funds that companies are already earmarking for CSR projects or are contributing to the CSR fund, to fund and conduct research that is

relevant to their needs and that leads to innovation and subsequent industry growth. The attractiveness of this model is that firms would be using part of their CSR funds to conduct and support R-I that would benefit them. Such research would be targeted and relevant as it would be conceived by enterprises to cater for their own needs. Research could be conducted [1] in-house by dedicated internal researchers, [2] externally by either local/international resource persons by developing and adopting different types of linkages, or [3] in a collaborative manner involving both in-house and external researchers. There are Private Sector Collaborative Research Grant Schemes that exist locally, but are not being fully operated for a lack of finance. Such schemes could be reformatted and upgraded in light of the above recommendation. Additional work should be done in terms of the definitions of research and innovation and in terms of the eligibility of R-I activities that would fall under the above scheme.

At linking institutions' level

Findings have shown that there is a disconnect between the two parties, both in terms of language, culture, perceptions and expectations. Intermediaries should endeavour to take knowledge from one domain and transmit it to be applied in another. They should also convey the perceptions, ideas and expectation of each to the other. Institutions and individuals that are mandated to mediate the exchange and use of knowledge between research institutions and businesses should set-up the required framework to facilitate this exchange. The findings have also highlighted that to achieve effective knowledge exchange and use, there is need for a midwifery of existing intermediaries, whether internal or external to RI institutions to work in concert and within a well articulated research-innovation ecosystem. It is first of all fundamental to expand the concept of connectedness and a collaboration culture within RI institutions to better enable both internal and external collaborative culture.

There is need for better knowledge management (e.g. a dynamic database) at RI institutions to facilitate the interfacing of outputs from researchers with the needs of industry. The project findings have highlighted the pressing need for a conducive structure and mechanism for swift formalisation and operationalisation of linkages need to be set-up at R-I institutions. These

would include fees structure, sharing rights, intellectual property protocols, model contractual agreements, licensing, spin-offs among others. It is fundamental that intermediaries at the level of RI institutions that are mandated to foster linkages with the private sector are experienced and adequately skilled in terms of their research credential and more importantly have a 'private sector' mentality in promoting firms' growth through the adoption of innovative processes and practices. Such internal intermediaries need to have the particular expertise to both communicate knowledge (e.g. scientific) to industry and to also communicate industry's requirement to scientist of RI institutions. RI institutions must upgrade the skills of designated intermediaries to transfer both explicit and tacit knowledge to industry.

Once linkages are formalised units responsible for linkages at RI levels need to ensure that resource persons display good project management skills leading to timely deliverable of contractual outcomes. This is fundamental in determining the success of linkages and the establishment of future ones

Findings from the study have also indicated that some firms were not satisfied with the current institutional intermediation process between RI institutions and firms. It is thus proposed for intermediaries to involve a range of actors on top of those internal to the university, through intermediate organisations (e.g. incubators, knowledge transfer offices, research councils), to those that are external to both RI institutions and industry (e.g. private entrepreneurs, development agencies). Here it is proposed to consider creating the space for the creation of different types of innovation intermediaries. These can be companies, individuals, organizations or groups outside RI organizations that work to facilitate and enable innovation, either directly by enabling the innovativeness of one or more firms. They can do so by intermediating on the interorganizational level by creating and nurturing networks in the innovation gap between firms and research communities. Under some instances (for e.g small firms with low or no absorptive capacity) innovation intermediaries could even manage the innovation process for specific firms. The potential services that could be provided by innovation intermediaries could be an interesting addition to the Mauritian Innovation system.

Linking institutions must also increasingly intermediate between international RI institutions and the local industry. Findings of the study have also shown that a significant percentage of local firms prefer to have access to RI generated internationally. The modus operandi of some local linking institutions must be amended and enhanced to also foster cross-border knowledge transfer.

At R-I producers' and industry levels

There is need for knowledge creation and generation through research for academic, individual or institutional interest to be increasingly geared towards a broader context of economic and industrial application of that knowledge. Given that the majority of researchers locally are from universities, it is fundamental that universities look beyond their traditional role of teaching and conducting basic research, towards being increasingly involved in research and innovation that involve a more direct interaction and contribution to the industry. It is important to provide the conducive environment for universities to support the creation of networks and make universities as permeable as possible/practical. for the temporary movement of researchers to industry. It is proposed to establish mobility schemes between research institutions and enterprises, whereby researchers are encouraged and incentivised to conduct full-time research in an enterprise for a specific duration. This exposure of researchers to industrial would result in more dynamic research to resolve specific production problems, thus furthering applied research. Such mobility could be parcel of the various possible university-industry linkage types. Given the state of IR-I locally, it is proposed that universities should consider start-ups and eventually spin-offs as potential linkages especially in sectors where some forms of nascent linkages have been reported as being successful (e.g. ICT).

Apart from the direct pecuniary benefits ascribed to offering their skills to industry, it is important to formally and increasingly acknowledge this linkage in the career promotion mechanisms of RI institutions. A more formal recognition of linkages with the private sector would favour linkages. The existing linkages could also be strengthened through the appointment of industry representatives on boards of RI institutions so that they can relay the

RI needs of industry and make significant input in developing the research agendas of institutions.

Linkages can also be derived from the supply side. Universities and research institutions need to increase awareness around their research outputs, skills and expertise through a series of pathways, including through service databases, cluster forums, one-on-one meeting and individual contacts. RI institutions must invest in training their resource persons in business communication skills and proposal building, and more importantly how to propose their ideas in a cogent and rationale manner which appeals to businesses. Social dialogue using the appropriate terminology is a major contributor to the success of research innovation-industry collaborations. Building on establishing preliminary contacts RI institutions must endeavour to strengthen and develop the linkages. It is important to develop joint research programmes that generate outputs of commercial relevance and cater for the needs of industry [more applied research and experimental development]. Concurrently, research capacity (with industry support) and infrastructure relevant to the needs of the industry can be developed.

Firms should also significantly improve their knowledge bases to be better able to search, generate and exploit the additional knowledge from research and innovation. Thus firms having broader knowledge bases would enjoy better absorptive capacity.

The research and innovation culture at the level of the firm should be aggressively instilled firstly by removing the hindrance factors, and secondly through the adoption of proactive knowledge-seeking strategies. and developed. In parallel the absorptive capacity of the enterprise should be improved to internalise and appropriate the spillovers of R-I. Even though it is acknowledged that during testing economic times firms increasingly focus on minimising costs and maximising profits, they need to find the financial space to invest in the appropriate structures that can foster linkages with RI institutions. It is here proposed that firms favour more individual contract consultancies with RI institutions within a well structured and phased organisational RI strategic plan to address firms' level issues.

Firms should make the most of the proposed mobility schemes and host scientists and researchers for a specific period of time to work on a specific industrial or organisational issue. This should assist the firm to quickly identify, comprehend and utilise scientific and technical knowledge to improve their efficiency and productivity. Concurrently firms also build in-house capabilities to assimilate and exploit different sources of knowledge that could be generated through their linkages with RI institutions. Such linkages can also have symbiotic effects. This targeted production of knowledge through research by RI institutions for use in industry, becomes more dynamic when interacting with firms due to challenges created in the resolution of specific production problems, and this new knowledge can also be fed back to teaching or be posited as new research questions.

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