

**Report of the study**  
**on**  
**“Role of public policy in promoting relationships among**  
**universities, research institutes and industry in Sri Lanka”**

**By**

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## Preface

Industry-Institute relationship is a topic which is new and being discussed at different forums where academia, researchers and industrialists take part. Need for the establishment of industry-institute relationships for mutual benefits have been well recognised and various attempts are tried out at different corners of the system. Lack of proper understanding of the issues and policy interventions by the Government as well as participating institutions hamper the effectiveness of those attempts.

In this context, the NSF has taken initiatives to carry out an in depth study to identify existing nature and characteristics of the University-Industry-Research (URI) relationships in Sri Lanka and propose such policy initiatives. The author has used international literature and experiences related to developed countries as well as developing countries to view and recommend the policy initiatives for Sri Lanka. The policy initiatives, which are already in place are highlighted while the policy initiatives evolved from the interviews with the eminent scholars/scientist etc. of the study are emphasized:

This study was carried out as a part of a PhD degree programme. The author eagerly invites the academia, researchers, policy makers and industrialists to review the recommendations critically and take practical measures to implement suitable recommendations.

The author is entirely responsible for the data and interpretation of the data, and not necessarily represents the views of the NSF.

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## Abbreviations used

AbC	- Agro-business Centre
ACCIMT	- Aurthur C Clark Institution of Modern Technology
ADB	- Asian Development Bank
AgEDIS	- Agro Enterprise Development & Information Service Center
BI	- Business Incubator
BIT	- Bilar Institute of Technology, India
BOI	- Board of Investment
BT	- Biotechnology
CARP	- Council for Agricultural Research Policy
CEA	- Controlled Environment Agriculture
DOA	- Department of Agriculture
EDC	- Engineering Design Centre
FDI	- Foreign Direct Investment
FITT	- Foundation for Industrial Technology Transfer
GDP	- Gross Domestic Product
GERD	- Gross Expenditure on Research & Development
HRD	- Human Resource Development
HTDE	- High Tech Development Zone of China
ICB	- Industry Consultation Boards
IFF	- Industry Facilitating Forum
IMF	- International Monetary Fund
IP	- Intellectual Property
IT	- Information Technology
ITI	- Industrial Technology Institute of Sri Lanka
MNC	- Multinational companies
NARESA	- Natural Resources Energy and Science Authority
NARS	- National Agricultural Research System
NASTEC	- National Science and Technology Commission
NBRO	- National Building Research Organization
NCUIIC	- National Committee on University Industry Interactions in Chemistry
NERD	- National Engineering Research & Development
NGO	- Non Government Organization
NIC	- Newly Industrialized Countries
NSF	- National Science Foundation
NSI	- National System of Innovation
OECD	- Organization for Economic Cooperation and Development
PAEA	- Protected Agricultural Entrepreneurs Association
PG	- Postgraduate
RSE	- Research Scientists and Engineers

<b>SEA</b>	- South East Asia
<b>SEMEDEC</b>	- Small and Medium Scale Enterprise Development Corporation
<b>SME</b>	- Small and Medium Enterprises
<b>STPD Project</b>	- Science and Technology Personnel Development Project
<b>SWT</b>	- Seminars, Workshops and Training Programmes
<b>TBIU</b>	- Technology Business Incubation Unit
<b>TT</b>	- Technology Transfer
<b>UGC</b>	- University Grant Commission
<b>UIIC</b>	- University Industry Interaction Cell
<b>UNESCO</b>	- United Nations Educational, Scientific and Cultural Organization
<b>UNIDO</b>	- United Nations Industrial Development Organization
<b>UOM</b>	- University of Moratuwa
<b>UOP</b>	- University of Peradeniya
<b>URI</b>	- University - Research - Industry
<b>USA</b>	- United State of America
<b>US-AID</b>	- United State Agency for International Development

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## **Executive Summary**

The importance of the URI relations is emphasized as a tool to enhance mutual benefits to both users and producers in the framework of NSI. Also it is believed that the URI relationships play a dynamic role in knowledge utilization producing economic benefits to the country. Hence, it is imperative to have an understanding on the features of the relationships at the national context as well as international context in order to formulate policy interventions and tools for implementation.

The features of the URI relationships in developed countries are better described in the international literature. The features of the URI relationships in developing countries are not only little known due to scarcity of emphasis to do investigations but also more complex in nature due to complex social systems shaped by the cultural & economical factors. These features of URI relationships in small developing countries seem to be not adequately exposed in the international literature also. However, the governments in developing countries tend to implant policy tools that are seen in promotional context of developed countries, without taking trouble to understand properly the country specific conditions which are critical for operational context and performance. Hence, the purpose of the research is to explore the features of the existing relationships and explain those features in relation to existing local conditions and international literature. By doing so the researcher wishes to contribute to the literature, new concepts in relation to URI relations in small developing countries and recommendation for policy interventions for further consideration by policy circles in Sri Lanka.

Accordingly, the research problem was developed based on the hypothesis that the URI relations in small developing countries are not operated in a vacuum but the nature of relationships and the factors surrounding the relationships are different. Taxonomy of relationships was adopted in the light of features of relationships seen in the literature. The major characteristics that were taken into consideration were type of relationship, motivation, barriers, funding, communication, coordination and benefits. Within this hypothesis, the existing features of the relationships in small developing countries are looked at. Hence, the features of the relationships in the

literature, which are mainly based on developed countries and large developing countries contexts, were taken as features of the research framework.

Weak industrial base and lack of R&D capabilities, including level of R&D expenditure are considered as the baseline framework /structural deficiencies in most developing countries. These deficiencies can usually be overcome by generic policy interventions focusing on promotional aspects. Despite the presence and absence of such policies, how different actors of the URI spheres react to the emerging requirements appears to have country specific formula. Hence, the research problem looked beyond the generic policy interventions and concerned about bottom level (micro level) elements that constraint the potential to generate interactions. In this context, micro level aspects such as procedural and behavioural issues are taken as research outline.

As the researcher has to start from the scratch to find out the characteristics of the relationships, the investigation was started with a postal questionnaire survey for the actors of the URI system. The questionnaire was sent to a stratified sample of researchers, academia and industrialists. The survey was followed by a series of interviews with the respondents to the survey. The reason for interview is to get a deeper understanding on the characteristics and investigate the reasons for such characteristics. The findings of the questionnaire survey and interview were analysed. They were used as a source for the second set of interview series (i.e. with the decision makers in the National System of Innovation). Decision makers are defined as a set of people who are involved in taking decisions on institutional/ national S&T activities. The findings of these three sets of data (i.e. survey data, data set related to the interviews with the respondents and the interviews with decision makers) are compared for triangulation.

The research findings show that relationships in Sri Lanka are based on lower end of the spectrum which are characterized by short-term orientation such as education & training and service based relationships. In relation to framework conditions, the lack of structural mechanisms, financial constraints, regulatory rigidity, inadequacy of laboratory facilities and absence of inter organizational communication seems to be major features that constrain relationships.

The researcher observed that process related constraints and weaknesses are widely spread in all three types organizations in addition to the above weaknesses related to the framework. Despite these weaknesses of the framework conditions, the URI relationships contain a vast potential of opportunity but the present process related issues prevent them from exploiting the opportunities for mutual benefits. The evidences show that the actors of all types of organizations understand those weaknesses.

Accordingly, three sets of issues based on internal and external factors for a particular type of organization were developed which could be widely used as check list of issues for any developing country. This checklist was tested with new forms of organizations which have evolved to overcome such weaknesses, by adopting the responsive-adaptive approach. The new forms of organizations show features such as heterogeneity, organizational diversity and trans-disciplinarity as well as internal transformation, influence of one type of organization upon another, creation of new organizations and networks. These features are more prevalent in organizations in developed countries.

The findings lead to conclusion that the URI relationships in developing countries show in a broad context similarities to those of developed countries but at the same time differ in nature. The concepts and models used in developed countries to explain the URI relationships can also be used to explain those in developing countries. The importance in understanding micro level conditions and taking remedial measures to overcome negative impact is imperative.

Finally, the public policy interventions that are necessary to promote URI relationships, while eliminating weaknesses in the framework and micro-environment are proposed in this study.

## 1.0 Introduction

University-Industry-Research (URI) relationships are considered as one of the most important tools for the development of technological capabilities of a country. These relationships are adequately developed in industrialised countries despite the phenomena is comparatively new and the underpinning theories and concepts are being investigated even in industrialised world. The importance of URI relationships are recognised by the less industrialised countries also, but it's nature and characteristics are not adequately explored. Systematic investigation into the issues related to URI relationships assist the decision makers and the participants in the URI relationships to embark on appropriate policy interventions rather than mere copying policy tools from more advanced countries. In this line, the present study was designed and attempted to formulate policy initiatives suitable for small developing countries like Sri Lanka.

### 1.1 What is URI relationship ?

University-Research-Industry (URI) relationships can be defined in many ways. Conceptually, the relationships among universities, industry and research institutions are considered as any interaction taking place in the form of education & training, service or Research & Development (R&D). Education and training based interactions can be carried out in the form of exchange of ideas on skill requirements or specific nature of skill developments of the human resource. Service based interactions can take place in the form of testing, certification, trouble shooting and short term consultancies on solving a specific problem of a commercial enterprise. The R&D based relationships can be carried out in a more structured form, which are usually extended over a long period with specific resource allocations. Also, these three types of interactions can take place in a combined form in a specific relationship between firms and universities or research institutes. In other words, relationship between a firm and a university or a research institute may consist of a combination of above three forms (or modalities) of interactions (Alam M. S., *et al.* 2003). Within these modalities, the relationships can take place either in a rather informal manner (e.g. personal contacts – informal) or in a more organized manner (formal). It can also take a combination of formal and informal relationship depending on the context. All these interactions can be classified as URI relationships.

The intense nature of the URI relationships vary from country to country, according to the technological advancement, knowledge base and the industry base of the country. Also, the nature and characteristics of the relationships can be different depending on the availability of resources, social and cultural issues and policy environment.

## 1.2 Why URI relationships are important ?

The importance of the URI relationships emerged in developed countries as a key agenda specially at the higher education policy making circles at both national and institutional level during the latter part of the 20<sup>th</sup> century. In the context of knowledge intensive economies, the governments have increasingly considered the importance of higher education and research institutes as strategic actors in economic development. For example, in the USA linkages were not active until 1965 (Baba 1988). Subsequently the pressure from the federal support has stimulated creation of relationships in new forms to meet the technological advancement. Such developed countries have considered URI relationships as a means to keep up the leading edge research capabilities, to improve applicability of knowledge for social needs and to use the resources for international competitiveness. OECD (2002) observed the increased commercialisation of public research and accelerating development of formal mechanisms for industry science relationships in OECD countries.

In this context, the universities, industries and research institutions act as complementary organizations where they share resources to achieve common goals. Furthermore, the developed countries increasingly provide the necessary indirect services such as venture capital, intellectual property protection laws to promote knowledge creation and utilization. In other words, all the components of the National System of Innovation (NSI) are stimulated to provide necessary back-up for URI relationships.

Industrialized countries may need to keep up the technological frontiers and leading edge research where URI relationships are instrumental to provide complementary skills and resources. In this context, industrialized countries seem to have taken various measures to promote URI relationships, ranging from structural development

approaches such as Science & Technology (S&T) parks, innovation centres, incubators, collaborative research centres, *etc.*, to create incentives and passive promotional approaches and incentives such as various tax concessions, loans and grants scheme as promotional measures. The other passive promotional approaches seem to be facilitation and promotion of Intellectual Property (IP) issues, and information flow between users and producers of knowledge. In this way, governments in industrialized countries play a crucial role by long range planning followed by a catalytic role.

Globally, universities, industries and research institutes have a social responsibility towards the society to improve the quality of life. One of the purposes of URI relationships may be satisfying social needs while achieving their own benefits. The social responsibilities of universities, industries and research institutes in industrialized countries are equally applicable for less industrialized countries.

However, less developed countries do have less capabilities for leading edge research due to lack of skills, competencies and weak industrial bases. Hence, the goals of URI relationships in less industrialized countries may vary in terms of intensity and nature.

### 1.3 Conditions in less industrialized countries

The typical features of less industrialized countries are less developed S&T infrastructure, less developed industry base, and to some extent inadequate skills at required levels. However, the firms in these countries still need to keep them competitive in the local market or limited export market. In this context technological capabilities have become a major determinant of the competitiveness which in turn support industrial growth. Hence, firms in less industrialized countries also need to capture the required skills and know-how to become competitive. Firms can do this through networks and relationships with academic and research organizations either within the country or outside the country. Even to understand the technology borrowed from outside, a substantial level of know-how is required for these companies. This can be achieved in many ways. One is to recruit skilled staff who can understand or access the knowledge to utilize the technology efficiently. Otherwise,

companies need services of technical experts who can explain the new technology. Even after acquiring the technology, they may need process related changes or modifications to suit the environment or raw material. This needs purposeful access to the local S&T base. Collaboration with the local S&T base seems to be the most appropriate and productive solution as the local S&T base has better knowledge on local conditions and material. Such collaborations can also be cost-effective in the long run as capability building through technology adaptation reduces the knowledge gap between the knowledge “Producers” and “Users”.

These three reasons may drive the local firms to involve in relationships with local S&T base, *i.e.*

1. To become competitive in local & export markets
2. To understand borrowed technology
3. To adapt the technology to suit local conditions

However, the local S&T base in less industrialized countries shows its own weaknesses such as inefficiency and irrelevance. On the other hand, the industries are working on their own agenda despite the need to overcome many weaknesses such as lack of technological capabilities. Hence the governments in less industrialized countries need to play a more active interventionist role than to be a catalyst to facilitate relationships between firms and universities or research institutes.

#### **1.4 Government interventions**

In order for the government to intervene effectively, it needs to understand properly the features of existing relationships, how these are different /similar to the relationships in industrialized countries, what are the concepts and models suitable for less industrialized countries *etc*, before embarking on either copying or introducing new policy instruments.

This calls for systematic study of existing relationships, their similarities and differences to features in industrialized countries, and the appropriateness of the models in industrialized countries to explain the relationships in less developed countries. The present paper expects to provide important insight to the situation of a small developing country and look for more appropriate policy recommendations. The

findings can be used as a guideline for any other small developing country which possess a similar level of technological and industrial advancement.

### 1.5 Approach of the study

We can start with the argument that despite those difference among the countries, the URI relationships shows many similarities. However, the difference in the actors participating in the process creates changes in the nature and characteristics of relationships. Compared to industrialized countries, less developed countries like Sri Lanka possess a less developed industrial base, limited capabilities in skill, under-developed S&T infrastructure and facilities. For example, interactions in developed countries may focus on advanced technologies and basic research while the interactions in developing countries may focus on efficient utilization of resources. Apart from that, firms in developing countries tend to import technology from abroad rather than developing locally. However, they need to interact with the local S&T base for understanding and process changes for efficient utilization of resources. Developing countries such as Sri Lanka are believed to involve in minor and adaptive nature of innovations such as scaling down of products, processes, and plants, as well as the substitution of some raw materials to others (Niosi, *et al.* 1993). This leads to the question as to whether the URI relationships seen in less developed countries show the same characteristics of the relationships in industrialized countries.

It is noted that the nature of the linkages in developed countries vary from country to country and , hence, the instruments used to promote relationships also vary. There is no standard formula for promoting relationships. Formation of new structures with new functions, allocating financial and other resources for the new forms such as university based incubators, facilitating spill over concept, and promotion of venture capital are general features of evolution of linkages in developed countries. These structures seem to have promotional effect in general. The real contribution from such structures for technological development has not even been demonstrated. For example, Dierdonark, K.Debackere *et al.* (1990) reports that the academia in Belgium shows that technology transfer mechanisms may offer some limited help. This suggests that the operations of these structures need to be evaluated critically to see the effect of the environment that it operates. This shows that understanding on how

external environment shapes the relationships is important to maximize the effectiveness of the structures.

The context of issues affecting the non R&D mode is quite different to that of R&D mode of relationships. R&D mode is more controlled/motivated by the framework conditions, which are generally discussed in the concept of NSI. But the non R&D mode is more controlled by process related conditions where NSI does not provide landscape for clear explanation.

## 1.6 Critical issues

The governments regard the URI relationships as an important concept and hence intervene in several ways to encourage industrial technology and economic development by formulating necessary policy instruments (Baba 1988). In other words, URI relationships have been considered as a facilitating process of promoting innovative behaviour of the actors in the National System of Innovation (NSI) of a country which help to keep up with the changes in the technological innovations and extract opportunities for industrial growth in the local and international market. However, the governments in developing countries tend to implant policy tools that are seen in promotional context of developed countries, without taking trouble to understand properly the country specific conditions which are critical for operational context and performance. For example, constraints in most developing countries such as a weak industrial base, less developed skills and lack of R&D capabilities, including level of R&D expenditure can usually be overcome by adapting generic policy interventions. Governments can also intervene by copying the establishment of promotional structures, which are seen in developed countries. Despite the presence or absence of such policies, how different actors of the URI spheres react to the emerging requirements, appears to have country specific formula. This seems to be the real nodal dynamism in developing countries, which needs the attention of the interventions. Sutz (2000) emphasizes that understanding the micro strengths are equally important to promotional mechanisms such as structural mechanisms. Hence, research issues need to go beyond the generic policy interventions and be concerned about bottom level (micro level) elements that retard/promote the potential to generate interactions.

## **2.0 Characteristics of URI relationships**

The issues related to small developing countries where in most of the time the structural arrangements are absent or in infant stages, are not adequately expressed in the policy literature. However, in the above context, small developing countries with less market opportunities and limited production capabilities may be operating in a different sets of factors that determines the level of interactions for technological growth and hence, the URI interactions in these countries may take different shapes within the socio-economic environment. This requires a different set of policies and government interventions to be adopted in these countries. Hence, it is assumed that the small developing countries do not operate in a vacuum but some features of the interactions in the developed countries do exist and are being evolved.

The relationships are supported and constrained by the elements of the NSI and other process related S&T environment of a country. The S&T environment can be described in terms of institutional arrangements, interactive mechanisms, policy interventions as well as behavioural features which should be considered as the elements of the NSI. Hence the study expects to provide inputs to the concepts and innovation theories in relation to importance of framework and process related issues where systems are being evolved. Proper understanding of these issues will make the role of the government intervention to facilitate relationships.

### **2.1 Interventions related to framework conditions**

With respect to frame work level intervention, the government interventions in supporting structural mechanisms such as liaison offices, university innovation centres Technology Innovation Programmes, University Companies, Teaching Companies, joint R&D programmes and University Industrial Parks may be capable of fostering frequent and informal contacts, and more effective formal interactions. OECD (2002) has observed the accelerating development of such formal mechanisms in OECD countries. In relation to incentive schemes, the government can also offer financial incentives to firms, and specially to Small & Medium Enterprises (SMEs), to contract out R&D work to universities.

Government intervention can either end up at the creation of framework conditions (leaving the different actors to perform the rest of the functions according to their mandates) or continue finetuning and providing additional interventions in the form of process related interventions or new forms of framework related interventions. To continue the interventionist's role, a government needs to perform coordinating and consensus building–role while participating and allocating resources at different stages. For this to happen, evaluation on impact of interventions and incentives needed to be put in place.

## **2.2 Process related interventions**

The facts on process related interventions are comparatively little known in the literature. The reason for such scarcity may be process related interventions are mostly practiced at institutional level rather than macro level and hence contain case/situation specific behaviour. Macro level regulatory mechanisms can be regarded as another set of process related interventions.

The influence of the government in determining the research programmes, which can be regarded as process related intervention, varies from country to country. For example, in Japan, Germany and also in India, the major research programmes are closely related to government policies (Rothwell and Zegveld 1981). Although, it is obvious that the government support linked to an overall industrial strategy can have an integrative effect, in many countries, the government involvement in determining directions of research is relatively small. Behaviour of institutions and individuals can be changed by the regulatory interventions. For example, regulations related to human mobility and freedom can change the institutional outlook and individual character.

The most common policy instrument related to promoting innovations, used by many developed and developing countries, is to encourage investments in collaborative R&D by their respective enterprise sector in the form of tax incentives, variety of research grants and loans, and government backed venture capital (Mani 2002). These policy interventions are clearly articulated for developed countries as those enterprises are usually technology leaders or close to the leaders and need to keep up-to-date with

the basic research. Developing countries are perceived to be assemblers or imitators of technology that are usually developed elsewhere and imported through various channels. In this direction, more advisable policies for the government interventions are to promote technology flow into the developing country economies and conduct adaptive R&D to suit local conditions and materials (Niosi, *et al.* 1993). The interventions for promotion of process of adaptation and imitation need not be only financial instruments but also non-financial instruments such as policy instruments on human resource development and other non-financial incentive schemes. In other words, for developing countries, non-financial based interventions are equally important compared to the developed countries.

I wish to highlight the case of Latin American countries as it gives relevant examples for most of the developing countries. The experience of the Latin American countries shows the operations of relationships in two modalities ; institutional effort and situational effort.

With respect to framework conditions, the top down policies were basically institutionalised approaches designed for the management of relationships through different schemes and financed with public and foreign donor agencies. However many shortcomings have been observed in these mechanisms in Latin American countries.

According to Sutz (2000), the shortcomings are;

- Firm involvements both in quantitative and in qualitative terms were below expectations,
- Lack of “Knowledge relevance” of the problems and the industrial demand finally begins to spread
- Low impact on the general behaviour of firms regarding relationships with universities

These shortcomings relate to the features of the NSI, which is evolved through the historical and cultural essences. The NSI is supposed to provide the network of institutional arrangement to support innovations on one hand and social awareness of

the positive role of the knowledge for the economic growth on the other. In the absence of these pre-requisites, the mechanisms to foster URI relationships are bound to face both lack of demand and of scope (Sutz 2000). In this context, Sutz (2000) proposes that the understanding of the micro-strengths of the URI relationships is needed in order to improve the top down policies to counter-balance the above shortcomings.

In the context of situational effort, it is characterized by the micro strengths which seems to be stronger in relation to institutional efforts. The relationships are initiated based on personal interest, previous working experience and personal contacts. It also cantered on a specific well-defined problem in the industry. A prerequisite seems to be the partners ability to communicate on hard technological terms. In this background, the features of the micro strengths are accumulation nature of interests, development of innovative web, widening the scope of the problem (Sutz 2000). As the nature of the bottom-up micro-strengths shows weaknesses in relation to consolidation, expansion and diffusion, it may need a third partner to facilitate development and maturity. This can be the case for many developing countries where such interventions are required to become matured. Sutz (2000) argues that many things are not done in developing countries because people do not know that they can be done although URI relations have potential-if the diffusion process works properly.

### **2.3 Sri Lanka context**

Most of the developing and Newly Industrialized Countries (NIC) countries focus on promotional mechanisms to encourage URI relationships. This trend is seen in all OECD countries also (Polt 2001). However, Sutz (2000) emphasized the importance of understanding the micro level process related to issues in order to formulate more appropriate policy tools to promote industrial growth. Developing countries tend to assume that the framework conditions worked in a developed country will give similar results in a developing country also where it ignores the differences of micro level conditions. This mode of thinking is even promoted by the donor agencies in their packages of donations/grants and loans. Therefore, framework conditions may tend to impose alien procedures where the conflict of interests can occur. On the other hand, the framework conditions can act for removing negative micro level conditions

which may naturally create an impact on other related conditions. The way it behaves will entirely depend on the social and behavioural attributes of the countries. The context of Sri Lanka needs to be looked at within this practical problems.

The question in this line is “why it is important to Sri Lanka?”. The knowledge about the most important framework conditions and the micro level process related conditions in Sri Lanka are very little known due to their unexplored nature. This limited literature on Sri Lanka context provides some in sight to scan the nature of URI relationships and related issues. For example, it has been found that the URI relationships are operated at a low key in Sri Lanka due to inefficiencies and weak capabilities in the R&D sector, including universities (Wignaraja 1998). In the mean time, weak capacity of industrial managers to assess the economic implications of technology, inability to compete with imports in terms of quality and price and private sector interest only in short-term benefits and not in R&D are identified as key issues for lack of industrial growth (Ramanathan 1988).

However, these investigations have not looked into the broader framework conditions and process related issues on one hand. On the other hand, the changes in the recent past such as evolution of new organizational forms, current dialogues between actors of the different helices and interest shown by industrial organizations on product/process development *etc*, have not been captured. Hence the ground level dynamics in Sri Lanka are not been exposed in the available literature.

### 3.0 Method & scope

The research was carried out in Sri Lanka which possesses less developed industrial base. Exploratory survey, follow-up interviews, interviews with decision-makers and case studies were instrumented to analyse the issues quantitatively and qualitatively. The research is focused on the URI relationships in Sri Lanka. The existing government organizations, universities, research institutions and manufacturing industries who are dealing with Science, Engineering and Agriculture were taken as informants. The informants are divided into two major groups. One is operational level informants (for example academia, researchers and practicing industrialists) and the other is the managers and the persons who are more directly involved in the policy-making process. Analytical tools used in the grounded theory approach were used to deal with qualitative data.

To narrow down the scope, informants were selected from five industrial sectors namely food S&T, rubber, fisheries, textile & clothing, and IT. The selection of industrial sectors was decided on the sense of the researcher about the potential for URI relationships in those sectors and the importance of the sector in the economy.

### 3.1 Sample size

The sample sizes for different data sets according to the type of respondents are given in table 1.

Table 1 : Sample sizes of different data sets according to the type of respondents

Data set	Industrialists	Academia	Researchers	Other	Total
A	39	24	26	-	99
B	11	11	9	-	31
C	3	3	5	9 <sup>1</sup>	20
D	3	7	7	3	20

A – Responses to the structured questions of the questionnaire survey

B - Interviews with respondents

C - Snow ball sample

D - Decision makers

<sup>1</sup> These respondents in the snow ball sample were interviewed to get additional information on specific issues and not included in the coding process. (example; interviewees from the Industry Facilitation Forum and Board of Investment )

#### **4.0 Evidences (Data and analysis)**

##### **4.1 Evidence from survey**

The evidences show that personal contacts are more prominent in URI relationships in Sri Lanka. The person-oriented relationships can be seen as more prominent even in coordination and communication patterns. The only exception seems to be little institutional support received by the research institutions in terms of coordinating, funding and communicating with the partners. These evidences lead to a preliminary conclusion on the non-existence of proper systematic mechanisms to promote relationships in the URI system. The institutional arrangements seem to have low capabilities to take initiatives to promote relationships. The findings from the exploratory survey are summarized in the table 2.

##### **4.2 Interpretation of survey data**

The findings on barriers suggest that there is a need to establish an information system to have a closer look on the counterpart. This indirectly means that present perceptions on each other are based on limited experience from person-oriented relationships. These circumstances may develop positive as well as negative environments. Limited person-oriented relationships may create boundaries preventing them to see the best options, while in contrast, person based relationships may increase reliability, confidentiality and speed.

The claim by academia and researchers on the lack of research orientation of industries seems to be an expected outcome considering the above findings. What is important in this context seems to be to find out why such orientation is lacking and how industries compensate the need for innovativeness to keep viable in the market place.

**Table 2 Summary of major characteristics and important attributes by type of respondent**

Major Characteristic	Industry	Academia	Researchers
Type of relationship	Seminars, workshops & training programs	Seminars, workshops & training programs	Seminars, workshops & training programs
		Student Projects	Extension services
		Consultation (informal)	Consultation (informal)
Motivation	Access to new knowledge	Application oriented research	Application oriented research
	Keep company updated with knowledge	Assist product/process development	Assist product/process development
Management & Coordination		Managed by individual	Managed by individual
			Assisted by institution
Communication	Informal talks/ meetings	Site visits	Site visits
	Official correspondence	Informal talks / meetings	Informal talks/ meetings
		Personal communications	Official correspondence
Funding			Funding from the institution
Barriers to initiate	Lack of rewards & incentive systems	Time commitment to find a suitable partner	Lack of rewards & incentive systems
	Lack of information on research capabilities	Lack of information on research capabilities	Lack of information on research capabilities
Barriers to continue	Bureaucracy of the research institute	Lack of research orientation of the industry	Lack of research orientation of the industry
	Lack of communication	Dissimilar motives	Lack of communication
Actual benefit	product/process development	Jobs for students/ new recruitments <sup>2</sup>	product/process development
	Solving technical problem	Solving technical problem	Solving technical problem
		Upgrading lab facilities	

<sup>2</sup> For industry

These preliminary conclusions and suggestions call for further investigation into the issues related to the existence of such relationships. Such investigation needs to address more qualitative features of the circumstances such as how things are done, what the constraints are, what needs to be done, why the players do not have long term oriented relationships, how they see the counterpart organization, what they expect from the others, the systematic failures that prevent such developments and what sort of policy interventions are proposed *etc.*

On the other hand, with respect to the university and research institution domains, the questions such as what their present approaches are, how do they see the industrial partners and how the industries fit into their approaches, what they can offer to the industries, what are the real constraints to approach industries, what are the institutional and systematic support/drawbacks and how those can be rectified and what kind of policy interventions are proposed *etc.* arises.

It was seen that the URI relationships still show underdevelopment in structural, financial, managerial and coordination terms. Now it has become important to bring out the underlying issues, which usually provide explanation to the existence of particular characteristics. The interviews with the respondents helped to obtain in depth information to explain these issues.

#### 4.3 Qualitative data & analysis

The literature on the process of innovation largely concerns the incentive structures and other promotional structures which could be implemented by different actors including the governments. It ignores internal structures and pays less attention to the process through which research is converted into commercial innovation (Mowery and Rosenberg 1989). In developing countries, the explanations need both promotional approaches as well as process related approaches.

Qualitative analytical tools using grounded theory approach to analyse interview data enabled to understand the dynamism in details. Frequency of occurrences was used to measure the level of importance of each of the framework/ structural condition.

#### **4.3.1 Findings- Framework conditions**

The counting against framework issues and the relevant frequencies are given in table

3. The most frequently cited issues were;

- Lack of systems and mechanisms to support relationships
- Rigidity of rules and regulations
- Limitations in the communication facilities
- Lack of policy directions, absence of incentives
- Lack of facilities/programmes for industries
- Inadequate laboratory facilities and services in Government labs
- Lack of funds for interactions

When these issues are looked at from the point of view of different sites, it can be observed that industry is mostly concerned about the following issues.

- Lack of systems and mechanisms to support relationships
- Limitations in the communication facilities,
- Inadequate laboratory facilities and services in the Government labs

In addition, the industrialists consider market factors such as limited market due to the smallness of the country and the purchasing power of the customers, which is related to the economic condition of the country.

From the point of view of academia and researchers the mostly cited issues are;

- Lack of systems and mechanisms to support relationships
- Rigidity of rules and regulations
- Limitations in the communication facilities
- Lack of policy directions
- Absence of incentives and rewards
- Lack of facilities/programs for industries

**Table 3 Framework conditions and the frequency of respondents according to issue by type of respondent**

Issue	Industry (n=14)	Academia (n=14)	Researchers(n=13)	Academia + Researcher (n=27)	Total (n=41)	Percentage
Rules & regulations / flexibility	2	6	5	11	13	32%
Change mandate	-	1	3	4	4	10%
Lack of incentives	3	6	3	9	12	20%
No national recognition on technologies developed locally	2	2	5	7	9	22%
Lack of recognition of academia	-	2	-	2	2	5%
Absence of standards	2	-	1	1	3	7%
Lack of systems and mechanisms	6	7	7	14	20	49%
Inadequate facilities, capabilities in Govt laboratories	11	-	-	-	11	27%
Absence of policies on patent rights	1	-	1	1	2	5%
Need industrial experience & tech training	4	2	1	3	7	18%
Brain Drain	-	-	2	2	2	5%
System not conducive for innovations	1	-	-	-	1	3%
Absence of policy directions	3	7	5	12	15	37%
Need Government funds for industrial research & development	6	5	2	7	13	32%
Non-availability of venture capital	2	-	-	-	2	5%
Inadequate / dissimilar tax incentives	3	-	1	1	4	10%
No facilities / programs for industry	3	5	5	10	13	32%
External influence	3	1	-	1	4	10%
Lack of communication among sites	6	4	6	10	16	33%
Avoid political interference	1	2	-	2	3	7%
Low purchasing power of customers	4	-	1	1	5	10%
Socio-economic values	-	-	1	1	1	2%
Limited market	3	-	-	-	3	7%
Need to avoid over shadowing national needs	-	-	1	1	1	2%

Total number of issues (25)

These findings suggest that the government has a major role in taking policy initiatives to overcome the constraints in the framework conditions. Different institutions also can play a major role within institutional policy arena. These conditions partly explain the characteristics of existing relationships. For example the absence of mandates of the institutions for demand oriented approaches, IP and Quality related issues give rise to occurrence of product /process development activities at low key.

The analysis on framework conditions explains the reasons for the lack of structured research-based relationships. It also shows, what industrialists expect from the universities and research institutions and the constraints faced by industrialists in achieving them. Furthermore, the systematic support mechanisms/drawbacks that are seen in Sri Lanka are also revealed. However, the questions related to micro level process related issues are still not clear and need explanation.

#### 4.3.2 Findings-Micro level conditions

The summary of findings related to micro level conditions are clustered and given in the table 4.

Table 4. Summary of clusters

Cluster	Summary
Access to know-how	Industrialists tend to use the available sources of knowledge such as Internet and journals rather than rely on local research institutes and universities. In order to make use of these organizations for industrial activities, much focus 'conscious orientation' is recommended.
Characteristics of the market	Influence of economical factors such as low purchasing power on the market lowers the demand for quality of products, and hence affect the level of technological growth. Furthermore, it was observed that the market opportunities vary in different sectors and initiatives have been taken by industries (specially SMEs) at micro level to capture these opportunities. Hence the policy initiative in this regard needs to capture and promote micro - level initiative capacity.
Modernization	Contractual and permanent placements in industries, industrial experience and permission for private practice was highlighted under modernization of skills The need for performance of testing and experiments by the industrialists

	appeared as an issue for modernization in testing and experimentation facilities. This calls for Science park type structures. Apart from revision of Administrative and Financial procedures, regulations related to keep what they earn for their benefit was again highlighted as an issue for modernization of regulations.
Orientation	All types of respondents have taken steps to change the positions or process to meet the expectations. Essential attributes for relationships such as confidentiality have been recognized. Research institutes expect the need for new forms of organizations for commercial ventures with outlook of a private sector organization. University authorities have taken steps to lessen the rigidity by allowing the departments to retain funds generated from consultancies.
Perception	Respondents from different types of organizations do not have positive perceptions of each other. The negative perceptions are mainly on behavioural aspects and can be controlled within the boundaries of the organization.
Policy culture	Lack of support for SMEs from the existing policy structure, ineffective incentive structures and need for new policy initiatives to meet the challenges of globalisation have been highlighted.
Responsiveness	The need for interactions for mutual benefits. The universities and research institutions have responded to find ways to get closer to the industrialists within the organizational mandates. Also, individuals have found different ways to respond where organizational norms do not allow to do so.
Technology culture	Industrialists tend to outreach to grab technological information while experimenting in-house innovations. However, they tend to keep informal relationships with the universities and research institutes. The technological skill of proprietors (entrepreneurships) seems to matter in SMEs. The research institutions seem to facing many constraints related to technology transfer and commercialization activities.
Systematic failure	Unfavourable work attitudes, lack of Intellectual Property (IP) /Quality consciousness, mandatory & regulatory inadequacies, poor management and inadequate technical training are viewed as systemic failures.
Functional failure	The functional failures such as lack of communication, limited outreach activities to meet industrialists, poor internal management and leadership, duplication & lack of coordination, lack of focus on resources and capabilities and lack of industry orientation are highlighted. Drain of human capital is seen as another issue that research institutes confront and is also highlighted as a functional failure.
Opportunity	All types of respondents have shown the desire to take the window of

	opportunity to utilize their capabilities. Also, legislative and functional barriers seem to prevent the academia and researchers from capturing those opportunities.
Industry dynamics	Weak technological capabilities in industries has been highlighted. Lack of skills, facilities, and size of the firms are seen as possible reasons for these weaknesses. Need for collective approach has been felt and been practiced in addition to relationships with local experts and contacts with foreign sources.
Research	Despite the need for funds, the image of the research institutions seems to matter to develop research based relationships. The functional failures, poor management, inflexible operation, rigidity of procedures and lack of industry orientation seem to blur the image of research institutes.

Some of the issues such as research, structure and composition of market, access to knowledge *etc.* are more generic and hence can be generalized at least for a small developing country. The above analysis enabled to find suitable answers to how industries access the know how and technological capabilities, how industries see the university and research institutes, what they expect from the universities and research institutions, and what are the constraints faced by the industries to involve in relationships and enhance their technological capabilities. The answer for the questions such as what is the benefit they gain from relationships and why the players do not have long term oriented relationships need to be interpreted in relation to the findings of the analysis.

On the other hand , the findings could propose answers to some of the micro level questions (with respect to the university and research institution domains) such as, how they see the industrial partners and what are the real constraints in approaching industries

However, the questions such as how those drawbacks can be rectified, what are the present approaches towards interactions, what they can offer to the industries and how the industries fit into their approaches should be examined with the practical world examples.

In this context, the research direction diverted to examine the ways that the actors attempted to overcome the constraints and weaknesses. It was noted that all three types of organizations involved in changing their role towards interactive modes, sometimes by setting up organizational structures where multidisciplinary, multi-actor interactive

approaches are performed. Finally the answer for the question “what sort of policy interventions are needed” should take the form of recommendations where the actual answer will need more focused investigation and supporting information.

## 5.0 Case studies

The case studies are selected to test the above findings with four new types of organisations evolved in the URI context. The conditions such as need for funding, flexibility, lack of incentives, lack facilities in universities and research institutions, need for change of mandates of public institutions to facilitate commercial activities etc. are highlighted as framework conditions to promote relationships. The issues such as modernization, orientation, perception, responsiveness, functional failure opportunity and research were highlighted as important micro level conditions.

In this context, it was investigated how different new organisations reacted to those weaknesses. The case studies deals with a few such examples from the URI system in Sri Lanka, in which these institutions tried to overcome the negatives features with respect to relationships by the evolution of new forms of organizations and discuss how these new form of organizations manage with the framework conditions and micro-level conditions.

Table 5

<u>Name of organization</u>	<u>Type of Organization</u>
1. Agro Business Centre (ABC)	Centre in the university sector
2. Agro Enterprise Development & Information Service Centre (AgEDIS )	Centre in a research institution.
3. Protected Agricultural Entrepreneurs Association (PAEA)	Industrial association
4. University-Industry Interaction Cell (UIIC)	Cell in the university sector

The above cases taken from university, industry and research environments show the evolution of new form of organizational structures to facilitate dynamic interactive process. Firstly, most of the framework conditions such as incentives, funding by the government, mandates & organizational reforms, policy directions, new systems, rules and regulations are outside the reach of the actors involve in these new forms of organizations. However, these organizations are capable of lobbying for those framework conditions (e.g. PAEA lobbying for tariff relief and AbC lobbying for workable set of rules and regulations). Secondly, these new forms of organizations can make an impact on the creation of the other framework conditions such as IP culture, quality

consciousness, development of skills in terms of capitalizing on existing knowledge, improve facilities and facilitate information flow. A summary of actions taken by these new forms of organizations against framework conditions is given in Table 4 .

**Table 4 Overview of reaction to framework conditions and micro level conditions by the new forms of organizations**

Condition	AbC	PAEA	AgEDIS	UIIC
Funding	Generate funds through contract research	Generate funds through membership	Government block allocation	Generate funds but initially supported by project funds
Skills development	New knowledge generated through interactions are transferred to curriculum students	Regular seminars and workshops on productivity and management focus on enhancing entrepreneurship skills	Regular training programmes on agriculture technologies for the needed groups	Frequent demand driven training courses, seminars and workshops for industries
Rules & regulations	financial incentives provided to those who authorize transactions	Flexible as function as a private organization	Limited flexibility were given	Flexibility granted by the University Council
Improvement of facilities	Contract research comes with new facilities which are not available at the Faculty	Provide necessary technological know-how and how to utilize	Utilize existing facilities as new facilities are anticipated as not required at this stage	Improve facilities of the Faculty by contributing to the faculty fund
Mandate	New mandate expected	Not applicable	Operate within the	Objectives and work to

			mandate of mother organization with new objectives	be performed are identified by the university
Quality	No information available	No information available	No information available	Quality of service is maintained through on the spot evaluation at seminars and workshops
IP concerns	Not yet thought about	Not concerned as commercial applications are performed	Not concerned as work on existing technologies	Not yet thought about
Communication	Concerned to keep personal contacts with partners despite lack of facilities	Regular meetings keeps members informed	Through mass media and public relations	Regular visits and other activities of the faculty keep counterparts informed
Policy direction	Limited impact as no participation in policy making process	Lobby for policy change	Keep policy makers aware of the required changes in policy directions (consider as a duty of the centre)	Limited impact as no participation in policy making process

The above table shows that these new forms of organizations encompass remedial measures against the weaknesses perceived by the counterpart partner.

This shows that the new forms of organizations are capable of shaping the processes related innovation process compared to the traditional organisations. This suggests that the public policy needs to encourage the establishment of such organizations.

## **6.0 Conclusions & Policy recommendations**

The findings concluded that personal contacts are the prominent type of URI relationship in Sri Lanka. This agrees with observations by OECD (1992) and observations of many other researchers such as Sutz (1998) who emphasized the importance of personal (informal) relationships. The similar observations related to coordination and communication patterns of relationships suggest the non-existence of a proper systemic mechanisms to promote relationships in the URI system in Sri Lanka.

### **6.1 Framework conditions**

With respect to framework conditions, inadequate funding, limited facilities in the S&T base, and lack of communication between the sites have been identified as the major structural drawbacks in the Sri Lankan context. Limitations of the existing mandates of universities and research institutions, and lack of understanding on quality and IP rights, retard research oriented structural relationships. What is evident in the promotional literature, specially with respect to the need for making available new targeted schemes to support the industrial innovations are corroborated by these findings.

The above weaknesses in the structure have prevailed in the system for many years and still no signals can be seen for the formulation of adequate instruments to overcome them. The capabilities of individual institutions are limited to address these issues individually. This calls for policy interventions by the Government at framework conditions. The policy recommendations propose by the author is given in the annexure one.

### **6.2 Micro level conditions**

The investigation into micro level process related conditions, propose opportunity driven self-adaptive policy initiatives at organizational level legitimized by the National Policy framework. For example, establishment and functions of Industry Interaction Units in Universities and research institutions, need legitimate existence while the unit itself need

to seek opportunity and orient itself to perform its functions. Similarly, administrative circulars on human mobility can set the stage for mobility of human resource between knowledge users and producers, but the actual implementation would rest on individual organizational initiative. However, some policy initiatives need less authorization in terms of legal perspectives. For example incentive based systemic changes should have been implemented within the organizational regimes that can promote interactive modes of innovations. The new forms of organizations have provided evidence for such capacity to generate interactive modes of innovation process.

Micro level weaknesses do not confine to universities, industries and research institutes only. It was noted in the findings that those weaknesses can be seen in policy making circles also. The continued nature of these weaknesses is exaggerated by the macro level weakness at the policy making and decision makers compartments. Lack of national level programs and directions connected with passive motivations, ignorance of S&T in the national planning (with an exception in the IT sector), and policy statements limiting to list of wishes and discussions without designing implementation tools, and lack of allocation of resources are seen as major incompetence in policy making circles. Again this calls for the public policy to take remedial measures in terms of policy making process itself.

The education and training and service-based relationships are shaped by the micro level determinants. These determinants vary according to the type of organization. "Self understanding of the weaknesses" and the "opportunity driven learning-adaptive approach" (Chaudhuri, 1986) are evident in all types of organizations. The four examples provide evidence for the initiatives of these organizations to facilitate the evolution of new forms of organization to overcome the weaknesses. Similar experience in the Indian context has been reported by Chaudhuri (1986) who looked at "Technological innovation in a research laboratory in India". This again calls for policy directions towards strengthening micro level dynamics to maximize the benefits, to capture the opportunities through continuous responsive, learning and adaptive process. The policy recommendations by the author based on evidence related micro level conditions are given in the annexure 2.

### **6.3 Policy implications**

Polt (2001) indicates that "in all countries, science and technology policy aims at fostering industry science relations through promotion programmes and in recent years, most countries have put increasing attention on such programmes and have extended their scope and size, addressing more or less the full range of channels". The need for extensive set of policy initiatives imply that the Government still has to play a major role in the industrial development in the country. In other words, it provides evidence for the existence of linear (plus) model. The initiatives taken in the recent past are worthwhile to note as it provides evidence for the existence of the linear (plus) model. The industrial Master Plan (Rainbow plan) provides similar evidence for linear model approach. For example, the Master Plan recommends compartmentalization of research, development and design functions at universities, research institutes and industrial enterprises respectively, where very little interactions can be expected between academia and "enterprises". Although the plan seems to have identified the deficiencies in the policy making and implementation instruments such as isolated policy dialogues by various affiliated policy making bodies in different ministries, weak interface among these affiliates and ministries, fragmented nature of policies, and duplication of functions in different ministries, the plan itself seems to have ignored the existence of micro level deficiencies, to some extent. The plan does not provide recommendations or instruments to bring universities and research institutes to act within the R&D circle for common benefit.

### **6.4 Concluding remarks**

The study shows that relationships in Sri Lanka are based on lower end of the spectrum which are characterized by short-term orientation such as education & training and service based relationships. The micro-level constraints and weaknesses are wide spread in all three types organizations in addition to the weaknesses related to the framework. Within these weaknesses of the framework conditions, the URI relationships contain a vast potential of opportunity while micro-level issues prevent them from exploiting the opportunities for mutual benefits. It also concludes that in addition to removing weaknesses in the framework, it is imperative to understand micro-level conditions to

propose public policy interventions, that are needed to promote URI relationships. The author has proposed two sets of policy initiatives (see annexures 1 & 2) that could be taken by the Government, universities, research institutes, industry and various other actors in relation to promote URI relationships by overcoming framework and micro level weaknesses.

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Annexure 1- Policy recommendations for framework conditions

Issue	Requirement	Policy initiative(s)	Tool(s) <sup>1</sup>	Implementing Agency					
				Government	Industry	Universities	Research Institutes	Foreign donor agencies	Other
Funding	Provide financial assistance for industrial innovations	Establish funding schemes and loan schemes for encouraging industrial innovations	Venture capital, Loans for industrial innovations	x				x	x
		Promotion of consortia for pre-competitive research	Grants for research for pre-competitive research	x	x	x	x	x	
		Modernization of existing research grants schemes	Research grants for industrial research with active industry participation	x	x				
		Provide venture capital for funding industrial innovations	Establish venture capital fund	x				x	x
		Provide financial support for structured mechanisms for industrial research	S&T parks, incubators, Collaborative research centres	x	x	x	x		
Incentives	Encourage innovations at all levels	Provide special incentives for products based on local technologies	<i>Tax holidays, tax concessions, incentives for up gradation</i>	x	x	x	x		
	Maintain uniformity of existing incentives for all industries		Extend the existing incentives for SMEs	x	x				

<sup>1</sup> Already established tools are given in italic letters

Incentives ...ctd	Make incentive compatible to the national economic objectives	Review existing incentives regularly	Incentive review committee	x						x
	Motivate the actors of the S&T base	Provide productivity based incentives	Institutional level incentive schemes (financial or kind) based on performance evaluation. Appreciation of achievements	x						
Systems	Monitoring, coordination, evaluation & facilitation of interactions	Establish coordination, evaluation and monitoring mechanism at national level	S&T cell in the National Planning Department	x						
		Establish coordination, evaluation & monitoring mechanism, specially for interactions, at institutional level	<i>Liaison office, Industry institute cells, Centres of excellence, S&amp;T marketing units, Business centres with business out look</i>		x	x	x			
Skills	Develop technical skills in the labour force	Modernize technical education through review of existing curricula and incorporate modern courses according to the needs of the country	Modern technical education system	x	x					x
	Capitalize the existing knowledge base of the universities	Commercialisation of knowledge base	Commercial arms, Marketing units, Incubators, Spin off companies, <i>Centres of excellence</i>	x		x	x			
	Industry orientation of education & training programs	Formalize interactions with industries towards development of education and training programs	<i>Industry consultative Boards, Industrial training for students, Members from the industry for councils and Boards of managements</i>	x	x	x	x			

Rules & regulation	Minimize rigidity of financial & administrative controls	Relaxation of financial & administrative regulations on R&D activities	More autonomy to councils & Boards of management with performance based accountability	x		x	x		
	Promote marketing approach	Retain generated income for institutional development	Development fund/ account for institutions without strings attached to the General Treasury	x			x		
Facilities	Organize and strengthen public sector testing and service facilities for industrial requirements	Establish central testing & service facilities with market oriented and industry based management approach	Central testing & service facilities with market oriented and industry based management approach	x	x	x	x		
		Network with national & foreign laboratories	Formalization of the concept in policy agendas of global and regional organizations	x	x	x	x	x	
		Maximize the productivity of the existing facilities with market oriented approach	Service arms in research institutes with private sector outlook	x		x	x		
Mandate	Legalize commercial activities and modernization of universities and public R&D institutions	Encourage commercial activities in public S&T sector institutions by providing legal coverage	Joint venture, Commercial arm, Service centres, Spin off companies	x		x	x		
Quality	Accreditation of products and services	Encourage accreditation of products and services	Declare standards, Incentives for laboratory accreditation	x	x		x		

IP	Promote and establish IP systems/culture	Promote IPR issues	<i>Awareness programs, training on IP rights process, bring in IP issues and protection mechanisms to the organizational structures. National IP facilitation cell</i>	x	x	x	x	x	
Communication	Facilitate the information flow between industry and the universities & research institutions	Information system to brokerage resources, capabilities of the universities and research institutions with the technological problems of the industry	<i>Information system with demand oriented out look</i>	x	x	x	x		
		Allocate adequate resources and make flexible arrangements for human mobility to and from counterpart	Regular visits, Communication facilities, Sabbatical leave in industry, Contract appointments		x	x	x		
Policy direction	Ensure consistency	De-politicisation of policymaking bodies	Independent commission for policy planning	x					
	Enhance role of S&T in the decision making process	Economic development missions to couple with inputs from S&T	S&T cell in the National Planning Department	x					
	Enhance policy analysis capabilities of the Government	Enhance policy analysis capabilities of the Government	Recruit scientists to the S&T cell of the National Planning Department	x					

Annexure 2.- Policy recommendations for micro level conditions

Issue	Requirement	Policy initiative	Tool(s) <sup>2</sup>	Implementing Agency					
				Government	Industry	Universities	Research Institutes	Foreign donor agencies	Other
Access to know how	Provide technological information to industries	Establish unit to facilitate search and dissemination of useful technological information to the Industry	<i>Technology information centre</i> established in close relation to industrial organizations	x	x	x	x		
	Make industries accessible to locally developed technologies	Publicize proven local technologies	Commercial arms, Marketing units	x		x	x		x
	Develop national programs on specific technologies suitable to the resources, capabilities and needs of the country	Encourage national initiatives on development of local technologies	National technology development program	x	x	x	x	x	
Characteristics of Market	Assist promotion of locally produced export quality products in the export market	Formalize aggressive export marketing	<i>Exhibitions, trade shows in potential market niches</i>	x	x				
	Facilitate sub-contracting by local firms for multinational/foreign companies	Provide flexible arrangements, importation of raw material/parts and incentives for sub contracting firms	Incentive review committee for subcontracts	x					
Modernization	Facilitate quality control aspects in SMEs	Encourage establishment of mini scale laboratory facilities in SMEs	Mini-laboratory scheme for SMEs		x	x	x	x	

<sup>2</sup> Already established tools are given in italic letters

Modernization .:ctd	Share human capital between industry and private sector	Facilitate human mobility between industry and public S&T institutions through recruitments and secondments in both directions	<i>Administrative circulars encouraging human mobility</i>	x	x	x	x		
	Share public sector S&T capabilities & resources with the industries	Facilitate maximum utilization of public sector resources & capabilities for industrial development	S&T centre/parks, Mutual agreements, joint venture	x	x	x	x		
	Enhance grass root level skill development (e.g. farmers)	Encourage grassroots level skill development	Subsidized skill development programmes	x		x	x		
Re-orientation	Formalize informal relationships	Develop confidentiality agreements, improve internal efficiency and remove rigidity of regulations of public institutions	Performance based incentive system for re-orientation			x	x		
Perception	Eradicate negative consequences of student industrial training	Formalize industrial training for university students with appropriate management & evaluation	<i>Establishment of industrial training units in universities</i>			x			
	Enhance industry orientation of universities and public research institutes	Recognize and promote industry oriented programmes	Incentives for involvement in industry oriented programmes	x		x	x		
	Change negative attitudes of researchers and academia on industry related programmes	Encourage commercial activities in public S&T sector institutions by providing legal coverage	Joint venture, Commercial arm, Service centres, Spin off companies	x		x	x		
Responsiveness	More university industry research relationships	Encourage URI relationships	Incentives (financial and non-financial) for interactions	x	x	x	x		

Social dynamics	Eradicate culturally bound negative behaviour	Improve productivity orientation of the labour force	Industry automation scheme	x	x				
External influence	Minimize negative influence from external sources	Improve negotiation capabilities of agents and the government	Policy analysis unit at National Planning Department	x					
Technology Culture	Strengthen the in house innovative activities of firms	Encourage in house technology development activities in industries	Consultation scheme for industries to obtain consultations from universities and research institutes	x	x			x	
			Incentives for industries for adaptation of technologies for low cost but quality operations	x	x				
	Utilization of locally produced technologies	Enhance commercialisation of locally produced/adapted technologies	Special incentives for spin off companies			x	x		
Systemic failure	Make available all the assistance to universities and research institutes to promote interactions with industry	Promote formation of separate units to deal with interaction	Industry interaction units in universities and research institutes			x	x		
	Create demand for interaction	Recognize interaction oriented course and activities	Promotion schemes with adequate recognition for interaction oriented activities, job opportunity schemes	x	x	x	x		
	Develop market oriented management and administration style	Inculcate market orientation to the management of public S&T institution	Schemes to promote competition among public institutions and with private sector	x	x	x	x		
Functional failure	To improve management of research institutes and universities	Enhance management capabilities of research institutes and universities	Training programmes for managers, De-politicisation of appointments to the top positions	x		x	x		

Functional failure.. cid	To minimize brain drain	Provide incentive based encouragement to retain key personnel	Incentive schemes for key personnel	x		x	x		
	Develop skills of staff	Enhance skills to match modern requirements	Training schemes			x	x		
Opportunity	Utilize knowledge base in universities	Enhance utilization of university intellectual resources	Spin off companies, S&T parks, Interaction cells	x		x			
	Capitalize on capabilities of research institutes	Restructure & support research institute in order to market it's capabilities	Marketing/commercial arm, Service centres	x			x		
Industrial dynamics	To improve quality and knowledge base of industry	Enhance technical capabilities of industries	<i>Technology promotion scheme for industries</i>	x	x				
Research	Effective R&D work done in research institutes	Improve research culture in research institutes	Vision oriented research funding for research institutes	x			x		
	University to manage R&D	Improve research culture in universities	Structure research management function in universities			x			
	Enhance exposure to industry culture	Minimize cultural gap between industry and research institutes and universities	Short term/long term exchange programs, Sabbatical leave to be spent in industries			x			
	Change attitudes of researchers and academia on industry	Develop conducive attitudinal changes for interactions	Incentive based systemic changes			x			
	Minimize mismatch of expectations of partners (cultural differences)	Regular dialogue between partners on technical problems and R&D	Forum as a meeting place		x	x	x		

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