Abstract

Universities play very important role in economic development of any country. In fact, it is said that universities are central players in an economic system. Countries are putting their efforts to make their economy technology/knowledge-based to achieve desired levels of economic growth. Economic growth based on technology is directed by a number of factors and their integration in the economy. It has become an important issue in the national agenda how to get the universities to better contribute industrial sector. Outcome of university research may be transferred to industry in several forms like i.e. seminars, training, patenting, licensing, start-up companies and spin-off firms etc. Transferring of academic research results to industry is considered as a vital factor for the industrial growth. Being highly educated segment of society, responsibility of creating awareness and then fostering these linkages rest with the universities. Therefore, in this thesis research an effort is made is to analyze/identify the characteristics and forms of the existing industrial linkages in our universities and barriers inhibiting these linkages and suggest viable measures to enhance and foster its effectiveness.

An exploratory research technique was adopted to conduct this research. A survey questionnaire having three parts pertaining to existing industrial linkages, barriers and improvements was structured to seek primary data. Both close and open ended questions were incorporated in the questionnaire. Secondary data was obtained from journals, annual reports and web sites. A survey of 69 departments (engineering disciplines) of 15 institutes of higher education was conducted.

An overall stock of our higher education, economy and university industry linkages is taken. In 60 years history of Pakistan, it was only last eight years when higher education of Pakistan took a number initiatives and made significant achievements. Through Medium Term Development Framework HEC evolved a sustainable vision and strategy to pursue its future plans. HEIs has increased from 59 in year 2000 to 124 in year 2008 and student enrolment has grown from 135,123 in year 2001-02 to 316,278 in year 2007-08. Research publications has increased from 815 in year 2002 to 3,640 in year 2008, which is a significant improvement. On economic front there is long history of failures mainly due to political instability, weak institutions and poor governance. Our exports always, except few times, remained lower than imports resulting in to trade deficit thereby causing burden on already weak economy. HEC

took few measures to link higher education with economy as an engine of economic growth. However, Initiatives like University Industry Technology Support Programme (UITSP), University-Industry Interaction Project and Collaborative Research Projects with CSF did not produce any significant results. In world context, Pakistan's performance remained on extreme lower side of curve by obtaining 101 places out of 134 countries in Global Competitiveness Report 2009.

Literature provides an evidence of the fact that with out strong university industry linkages dream of innovation, competitiveness and sustained economic growth can not be fulfilled. To have effective university industry linkages a through understanding of mechanisms like consultancy, contract research, collaborative research, spin offs, science parks and technology incubation centers is essential. In this regard role of Industrial Liaison Office or Technology Transfer Office is vital. Research results indicated that only 21% interaction with industry was made by industrial liaison offices and 53% interactions were made by individuals. Only 28% departments had formal collaboration agreements with industry. Informal interactions with the industry were quite significant in the form of workshops and seminars with a score of 73% and 78% respectively. Adequacy of lab equipment for teaching purpose was 80% where as its adequacy for research was only 58%. Factors like lack of entrepreneurship spirit, time constraint due to heavy teaching and administrative work load, existing university norms and procedures and lack of interest on part of industry to collaborate with universities were rated as severe barriers to university-industry linkages

To establish and foster university industry collaboration, a number of recommendations have been made for all stake holders. Measures like setting up of effective and functional university liaison offices, encouragement of industrial visits by academics and students, giving publicity to university activities relevant to industry, tax concessions for companies collaborating with universities, revision of curriculum in consultation with industry professionals and making university policies and procedure which encourages entrepreneurship could be very effective.

DEDICATED

TO

MY BELOVED PARENTS

WHO AT EVERY STAGE OF THEIR LIFE SACRIFICED

AND ENCOURAGED ME FOR MY WELL-BEING AND PROGRESS

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CHAPTER 1

INTRODUCTION

1.1 General

In globalization perspective, both knowledge and technology modernization are acknowledged as basis of economic development and growth. Universities play increasingly important role in economic development of societies and nations. In fact, it is argued that universities are central players in an economic system [1]. In recent times, their direct involvement with industry has increased and policies have been designed to promote University-Industry (U-I) networking [2]. Governments are increasingly aware of the importance of higher education institutions as strategic actors in both national and regional economic development, given their potential to upgrade skills and knowledge of the labour force and contribute towards producing and processing innovation through technology transfer [3]. Also, scholars have promoted the idea that universities should go beyond their traditional teaching and research activities, and undertake a 'third mission', aimed at a more direct interaction and contribution to the industry [4].

Every higher education institution needs enormous financial resources that, in our system, are typically provided through public funding. The state demands a return on its investment beyond traditional manpower development. Thus, increasingly, universities bear the responsibility of interacting with the entire society to demonstrate positive gains. Currently, public sector higher education institutions in Pakistan get reasonable levels of state funding, but this state of affairs will not last forever. The time is approaching when these institutions will be pressed to generate their own funding beyond the usual increase of the fees charged to students. Under these demanding circumstances, the only recourse for our universities will be industrial funding, especially in the pure and applied sciences. Academia-industry collaborations, which are common in developed countries but non-existent in Pakistan, are a win-win prospect for both universities and industries. By developing workable industrial linkages, universities can not only raise money to function, but also can acquire a good deal of skill and knowledge. This is probably the best way to contribute towards society as well. The modus operandi for establishing a university-industry liaison should be framed by universities and they should not wait for industries and other related organizations to initiate such relationships. The universities must be willing to work and solve practical problems, even without any grants from industries, to gain the confidence of industrial collaborators by delivering good results. This is the key to successful industrial liaisons [5]. Universities and industries are main stake holders in the context of these linkages, therefore it provides rational to study profile of both.

1.2 Higher Education in Pakistan

Today, more than ever before in human history, the wealth or poverty of nations depends on the quality of higher education. Those with a larger repertoire of skills and a greater capacity for learning can look forward to lifetimes of unprecedented economic fulfillment. But in the coming decades the poorly educated face little better than the dreary prospects of lives of quiet desperation [6]. Higher education is no longer a luxury, it is essential to national social and economic development [7].

Higher education in Pakistan has gone through many ups and downs, mainly dominated by long wave of crests. The University Grants Commission (UGC), the predecessor of the Higher Education Commission of Pakistan, was established, in 1974. It was mandated that the UGC will maintain the standards of education and establish a uniform policy aimed at bringing about national unity and cohesion. Assessment of the financial needs of universities, disbursement of grants, and building institutional capacity were also placed under the preview of the Commission. UGC was able to meet its mandate to some extend however, it did not made any significant achievements towards growth and uplift of higher education standards in Pakistan. The quality and relevance of higher education continued to deteriorate and access remained one of the lowest in the world in terms of the percentage of the population attending university at the age cohort [8]. The Education Policies of 1979, 1992 and 1998 and the eight Five Year Plans, all set unrealistic targets without providing the funds and the required political will to ensure their successful implementation. The Pakistan Economic Survey 2001-2002 concluded that one of the factors in the slow improvement of education indicators has been the low level of public expenditure in education.

Due to ineffectiveness of the University Grants Commission (UGC) in overcoming the general decline in higher education over many years and its inability to foster change [8], HEC was established on September 11, 2002.

1.2.1 The Medium Term Development Framework (MTDF)

HEC managed to evolve a Medium Term Development Framework (MTDF). The MTDF – a five year action plan identified major issues faced by higher education sector and offered a sustainable vision and a strategy to resolve them. This strategic framework was built around four cores, and three cross cutting aims.

Core aims:

- **a.** Faculty Development
- **b.** Improving Access and Learning
- **c.** Excellence in Research
- **d.** Relevance to National Priorities.

Supporting aims:

- **a.** Leadership, Governance and Management
- **b.** Quality Assessment, Standards and Accreditation and
- **c.** Infrastructure Development: Physical and Technological.

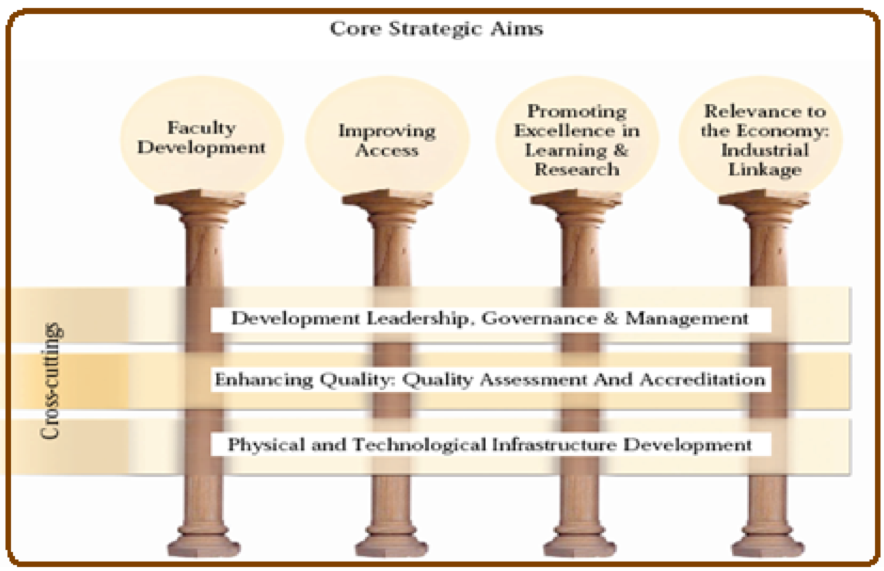

Figure1.1: Strategic Frame work
Source: The Medium Term Development Framework 2005 [9]

MTDF was structured in such a manner that each core and supporting aim had its own strategy and programme of interventions. Targets measurable in terms of qualitative and quantitative performance indicators were clearly laid down. The targets set out in MTDF for each strategic aim were made compatible to the international best practices. The structure of MTDF permitted ongoing review and lesson learning for enhanced effectiveness. The subsequent chapters of this report present an in-detail deliberation on the implementation of these concepts.

1.2.2 Increased Number of Universities

The HEC, at its advent, inherited a higher education system with inadequate infrastructure to serve the higher education requirements of a population of 170 million people. The system, before the inception of the HEC, could only afford to set up 59 HEIs in the country during the 55 years of its history. The HEC through its sound planning and pragmatic implementation has increased that number to 124 in a period of only six years. This represents a more than 100 percent increase. The data in Figure 1.2 highlights this amazing achievement. Location wise distribution of HEIs is shown in figure 1.3.

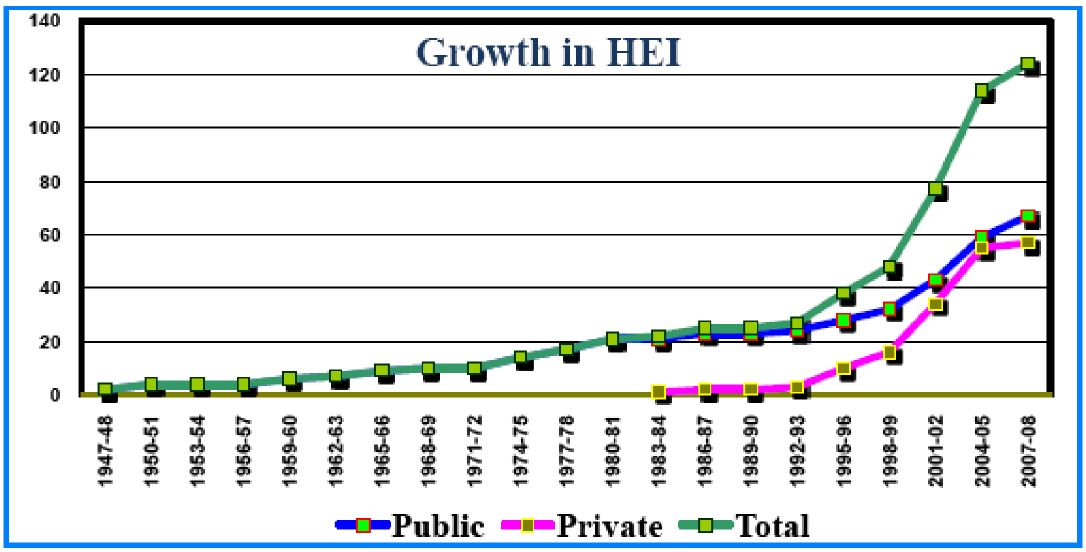

Figure1.2: Increase in the Number of HEIs in Pakistan
Source: HEC Annual Report 2007-2008 [10]

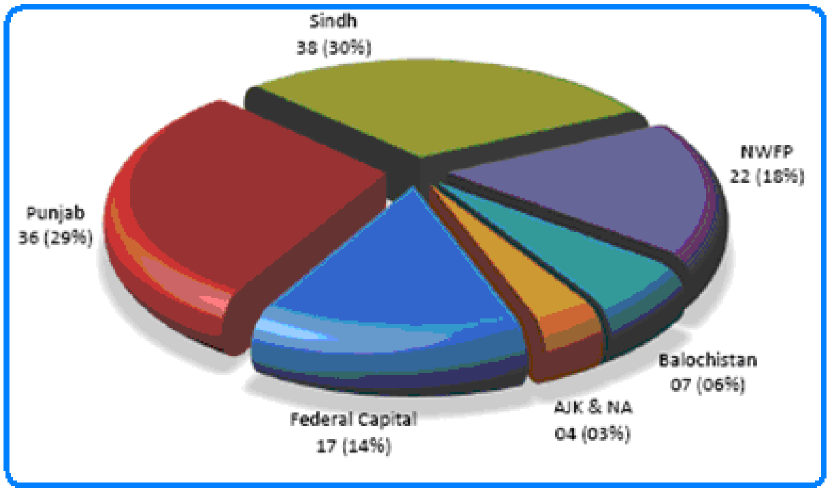

Figure1.3: Distribution of Higher Education Institutions by Location
Source: www.hec.gov.pk [11]

1.2.3 Increased Enrolment

Enrolment levels in higher education are the most obvious indicator of improved access to higher education. The HEC's efforts to improve access to higher education have borne fruit. Because of the different initiatives taken by the HEC overall enrolment, in the HEIs, increased 2.34 times (135,123 to 316,278) excluding distance education during the period from 2002 to 2008. Figure3 shows the year-wise increase in higher education enrolment between 2002 and 2008.

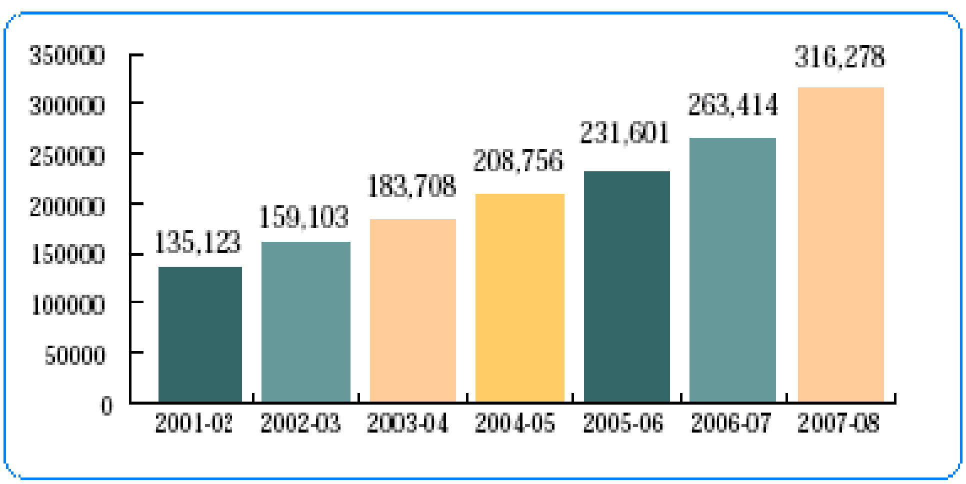

Figure1.4: Enrolment in Universities (Excluding distance learning)
Source: HEC Statistics 2009

The data on total enrolments by type of HEI during 2007-08 is presented in Table1.1 These data show the large share of student enrolment in distance learning programmes. Within the mainstream universities, a larger proportion of students are enrolled in general universities, while a relatively smaller proportion of students are enrolled in the medical, engineering and agriculture universities.

Table1.1: Total Enrolment by Type of HEI 2007-08

	Total Enrolment of Students		Enrolment of MPhil & PhD Students			
	Number	% of Total	MPhil	PhD	Number MPhil & PhD	% of Total
General Universities	220,733	25.2	7,504	4,121	11,625	63.8
Agriculture Universities	27,881	3.2	1,087	1,302	2,389	13.1
Engineering Universities	30,766	3.5	154	227	381	2.1
Medical Universities	11,924	1.4	116	630	746	4.1
DAIs	18,588	2.1	700	130	830	4.6
Other Institutes	4,107	0.5	486	242	728	4
Centres	2,015	0.2	514	277	791	4.3
AIOU & VU	559,289	63.9	673	58	731	4
Grand Total	875,303	100	11,234	6,987	18,221	100

Source: HEC Statistics 2009

1.2.4 The National Research Programme for Universities (NRPU)

The National Research Programme for Universities (NRPU) is a mega recurring grant programme designed for faculty members and researchers who want ordinary financial help for research projects. The programme targets the strengthening of indigenous capacity and the reduction of the exodus of talent from the country. The research grant programme provides assistance for research in all disciplines and has also been extended to 15 private sector universities in addition to all the public sector universities.

The HEC, after peer review and scrutiny, awards research grants of Rs. one to six million. However, if the proposed research budget exceeds Rs. 6 million, the potential Impact Factor of the research output is brought into consideration to decide the award. Thus, depending upon the Impact Factor, a maximum of up to Rs. 15 million may be awarded. Year-wise details of projects received and approved under this scheme are shown in Table 1.2.

Table1.2: Financial Year-wise Status of NRPU (2002-03 to 2007-08) (Rs. million)

Years	Received Projects	Approved Projects	Rejected Projects	Annual Allocation	Expenditure Amount	Projects Carried Forward Next F.Y.
2002-03	319	34	18		14.89	267
2003-04	138	58	169	100	57.56	178
2004-05	191	74	108	90	90.6	188
2005-06	218	128	155	*200	**301.61	123
2006-07	284	196	94	445	449.659	117
2007-08	227	154	79	350	327	111

Note: 1.* Budget was Rs. 200 million plus additional amount of Rs.101 million was allotted

Figure 1.5 shows the discipline-wise grants for research awarded under NRPU. It shows that 31% is consumed by basic sciences followed by engineering disciplines which is 16%.

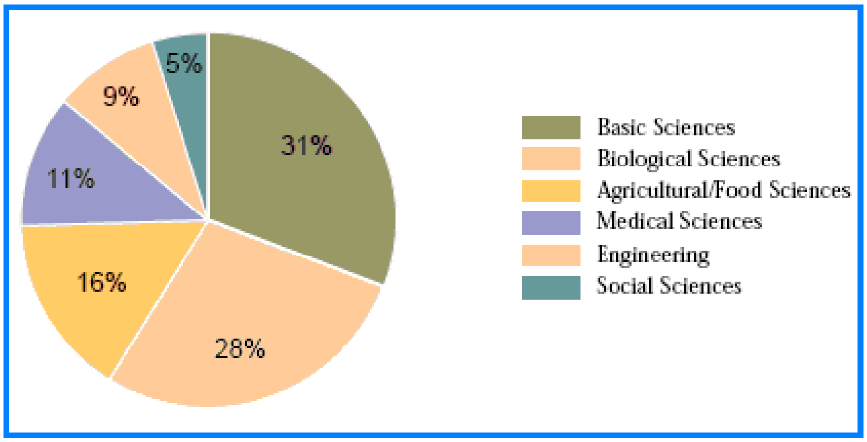

Figure1.5: Discipline-wise Research Grant under NRPU
Source: HEC Statistics 2009

1.2.5 Research Publications

The success of the strategies adopted by HEC for the improvement of research in Pakistan can be benchmarked against the research output which has emanated from the institutes of higher learning in the last six years (2002-2008).

A comparison of research output before and after the HEC shows that, in the five years prior to its inception, 3,260 articles were published. During the six-year after its inception a total of 10,824 articles have been published in leading academic journals (Figure 1.6).

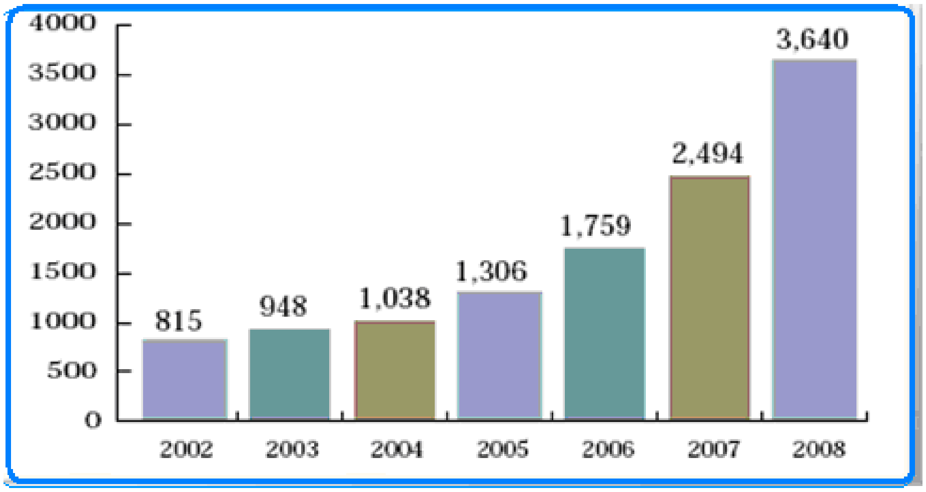

Figure1.6: Increase in Number of Research Publications
Source: HEC Statistics 2009

This more than 300 percent increase in a period of six years is a good indicator of quantitative performance. However, this achievement is even more remarkable in light of the fact that the post HEC publications are all in peer reviewed and HEC recognized and approved journals. There is thus remarkable progress in terms of quantity and quality of the research output under the HEC.

1.3 S&T and R&D Expenditure

S&T expenditures of any country indicate its will and desire to acquire and utilize technology for socioeconomic development. Figure 1.7 shows Pakistan's S&T expenditures as percentage of GDP over the last 18 years, which is of course not encouraging at all. Also our R&D expenditures are not very healthy; detail is shown in figure 1.8.

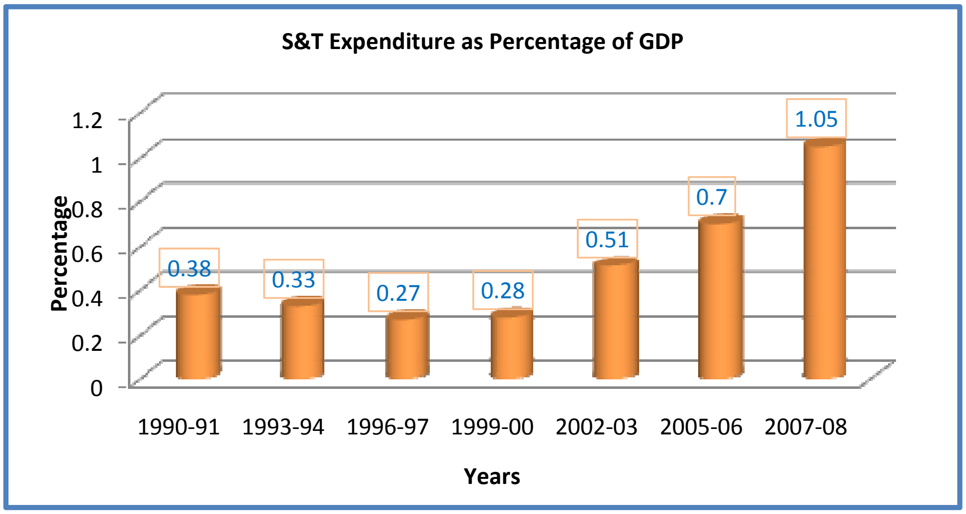

Figure1.7: S&T Expenditure as Percentage of GDP
Source: PCST Survey 2008-09 [12]

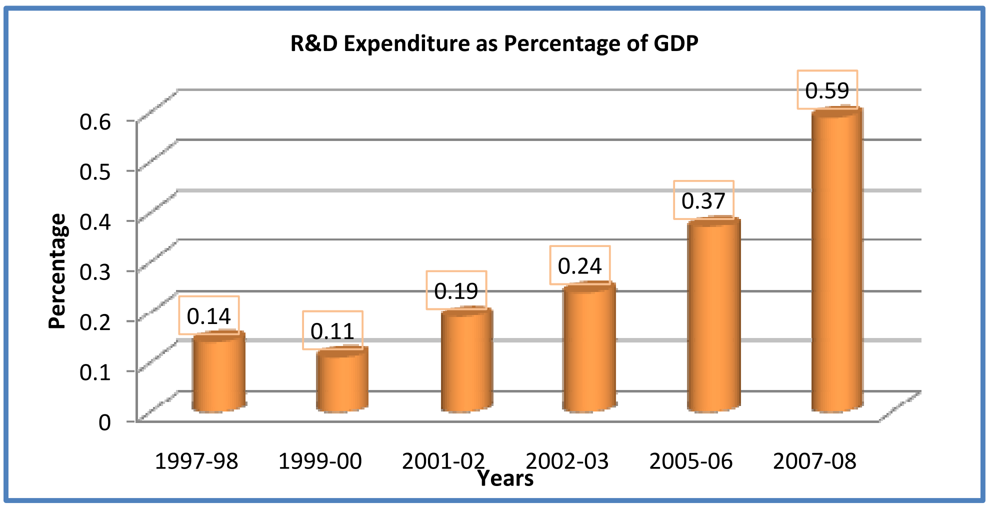

Figure1.8: R&D Expenditure as Percentage of GDP
Source: PCST Survey 2008-09 [12]

1.4 An Overview of Economy and Industry

Engineering sector accounts for around 63 percent share in world trade. Achieving any significant share of this market will require concerted efforts by Pakistan in gearing up our universities, poly-techniques and factories for the kind of manufacturing prowess and design capabilities required by the world market [13]. Increasing efficiency of the industrial sector is a critical aspect of economic development. Industry's role for the economy is crucial not only to safeguard local industry, but also to benefit from increased trade opportunities in the global market, subsequently strengthening Pakistan 'economic performance. The strength of

Pakistan's economy depends on the dynamism of businesses that can respond to opportunities as they emerge, and that can restructure and adapt to market demands [14]. Pakistan's Rear GDP growth fluctuated between 8 and 2 in a span of six years(2004-2009), highest in year2005 and lowest in year 2009 [15]. The manufacturing being the second largest sector of the economy bears significant importance contributes to 18.4 in GDP [16]. The industrial sector showed worst performance by posing a negative growth of -3% in year 2009.

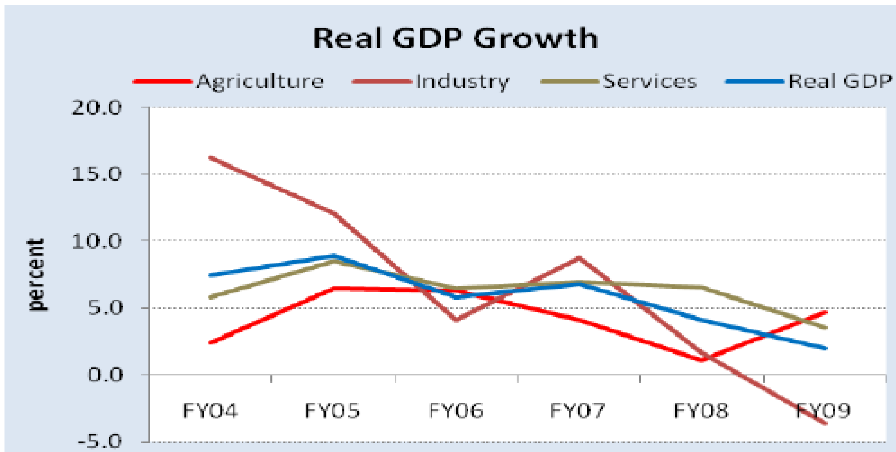

Figure1.9: GDP growth of last six years
Source: State Bank of Pakistan Annual Report 2009

A complete picture of contribution in GDP by each sector is shown in Table 1.3. Services sector contributes almost 53% in GDP where as agriculture sector contributes 47% and industrial sector contribution is almost 25%15.

Table1.3: Sector wise Share in GDP and Growth Rates

	FY08		FY 09	
	Growth	Percent	Growth	Percent
Commodity producing	**1.4**	**47.0**	**0.2**	**46.2**
Agriculture	1.1	21.3	4.7	21.8
Crops	-2.2	9.5	6.6	9.9
Major crops	-6.4	6.9	7.7	7.3
Minor crops	10.9	2.6	3.6	2.6
Livestock	4.2	11.1	3.7	11.3
Fishing	9.2	0.4	2.3	0.4
Forestry	-11.5	0.3	-15.7	0.2
Industry	1.7	25.7	-3.6	24.3
Manufacturing	4.8	19.2	-3.3	18.2
Large-scale	4.0	13.4	-7.7	12.1
Small-scale	7.5	4.4	7.5	4.7
Slaughtering	4.2	1.3	4.2	1.4
Mining and quarrying	4.4	2.6	1.3	2.5
Construction	-3.9	2.4	-10.8	2.1
Electricity & gas distribution	-22.0	1.6	-3.7	1.5
Services sector	**6.6**	**53.0**	**3.6**	**53.8**
Wholesale & retail trade	5.3	17.3	3.1	17.5
Transport storage &	5.7	10.2	2.9	10.3
Finance and insurance	12.9	6.4	-1.2	6.2
Ownership of dwellings	3.5	2.7	3.5	2.7
Public admin. & defence	1.2	5.9	5.0	6.1
Community, social & personal services	10.0	10.6	7.3	11.1
Gross domestic product	**4.1**	**100.0**	**2.0**	**100.0**

Source: State Bank of Pakistan Annual Report 2009

In Pakistan's history of last nine years(table 1.4), its exports touched a peak of US$ 19.2 billon in year 2007-2008 and lowest of US$ 9.1 billon in year 2001-2002, showing almost over 100% rise in our exports [17].

Table1.4: Export figure of last nine years

Year	Value (FOB $ Billion)	Change (%age)
2000-01	9.2	-
2001-02	9.1	-0.7
2002-03	11.2	22.2
2003-04	12.3	10.3
2004-05	14.4	16.9
2005-06	16.5	14.3
2006-07	17.0	3.2
2007-08	19.2	13.2
2008-09 (P)	17.8	- 6.7

Source: Ministry of Commerce Statistics 2009

On the other hand over imports(table1.5), which remain always subject of great concern, touched its peak of US$ 40 billon in year 2007-2008.Balance of trade (table 1.7) never remain in favour of Pakistan, making a strong case to bring innovation in our product.

Table1.5: Import figures of last nine years

Year	Value (C&F US$ Billion)	Change (%age)
2000-01	10.7	
2001-02	10.3	- 3.6
2002-03	12.2	18.2
2003-04	15.6	27.6
2004-05	20.6	32.1
2005-06	28.6	38.8
2006-07	30.5	6.9
2007-08	40.0	30.9
2008-09(P)	34.8	- 13.0

Source: Ministry of Commerce Statistics 2009

Table1.6: Difference of balance of trade

Year	Export (US $ in Billion)	Import (US $ in Billion)	Difference of balance of trade
2003-04	12.3	15.6	-3.3
2004-05	14.4	20.6	-6.2
2005-06	16.5	28.6	-12.1
2006-07	17.0	30.5	-13.5
2007-08	19.2	40.0	-20.8
2008-09	17.8	34.8	-17.0

Source: Ministry of Commerce Statistics 2009

1.4.1 Industrial Classification

An establishment is classified in a particular industry on the basis of value of major products & byproducts or services rendered, falling within the scope of manufacturing activity according to Pakistan Standard Industrial Classification (PSIC-2007). PSIC has classified manufacturing industries in to 22 major groups (table1.4) [18]. Federal Bureau of Statistics (FBS) conducted latest Census of Large-Scale Manufacturing Industries (CMI) in 2005-2006.

Table1.7: Classification of Manufacturing Industries

S / No.	Description		S/No.	Description
1	Food & Beverages		12	Other non-metallic mineral
2	Tobacco		13	Basic metals
3	Textiles		14	Fabricated metals
4	Wearing apparel		15	Machinery & equipment
5	Leather		16	Electrical machinery &
6	Wood products		17	Radio, TV &
7	Paper products		18	Medical & optical
8	Printing & publishing		19	Motor vehicles & trailers
9	Petroleum		20	Other transport equipment
10	Chemical products		21	Furniture
11	Rubber & Plastics		22	Recycling

Source: Pakistan Standard Industrial Classification (PSIC-2007)

A total of 6417 industries in all the four provinces of Pakistan including Islamabad have been recorded. The number of industries has risen to 6,417 in 2005-06 from 4,792 in 1990-91. Distribution of these industries in four provinces and Islamabad is shown in table 1.7 and figure1.10

Table1.8: Number of Manufacturing Establishments covered in Latest CMIs

Region	1990-91	1995-96	2000-01	2005-06
Pakistan	4,792	4,474	4,528	6,417
Punjab	2,452	2,364	2,357	3,590
Sindh	1,751	1,528	1,768	1,825
NWFP	425	468	236	673
Balochistan	110	69	93	212
Islamabad	54	45	74	117

Source: CMI 2005, Federal Bureau of Statistics (FBS)

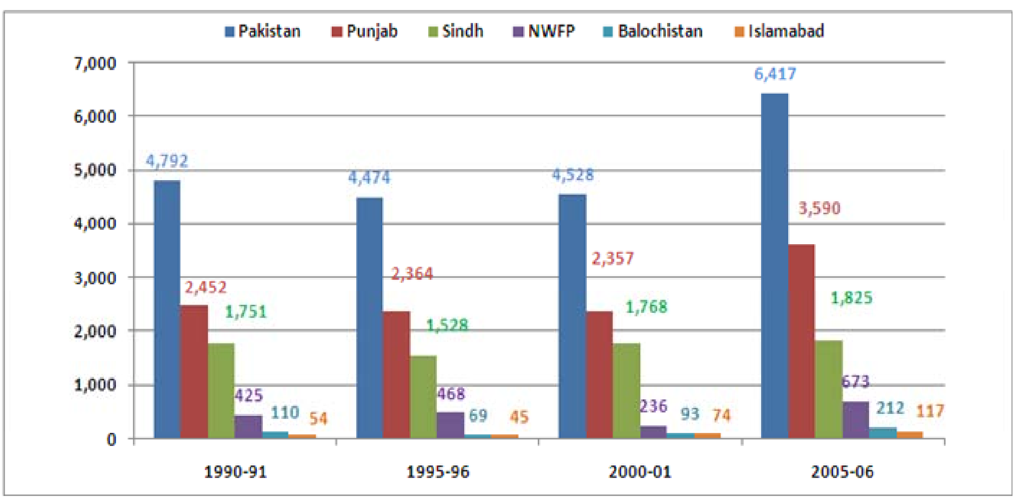

Figure1.10: Growth in number of Manufacturing Establishments
Source: CMI 2005, Federal Bureau of Statistics (FBS)

1.4.2 Role of SMEs

Small and medium-seized enterprises (SMEs) are seen as a key to economic growth, innovation and employment growth, significant employment potential, revenue generation and technological advancement in most advanced economies. In recent years developing/emergent economies have also started to focus on the crucial role that SMEs can play in their development [19]. Internationally SME's are very significant in numbers. Globally 90% of the business belongs to SME's and contribute between 40% to 50% of GDP. In the EU SME's comprise of about 99% of all firms and account for employment of 65 million people. SME's in India account for 39% of the manufacturing output and 33% of exports [20].

According to the recent Census of Establishments conducted by the Federal Bureau of Statistics (FBS), there are about 3.2 million economic establishments in Pakistan [21]. There are 72 districts in Pakistan and more than 50 percent of SMEs in the country are in the following ten districts, namely: Karachi, Lahore, Faisalabad, Multan, Hyderabad, Sialkot, Gujrat, Shiekhupura, Gujranwala and Quetta. Furthermore, 25 percent of SMEs in the country are in Karachi, Lahore and Faisalabad districts. Out of these small and medium size enterprises, with employment base up to 99, constitute about 90% of all private enterprises employing approximately 78% of nonagricultural labor force. It contributes 30% to GDP and generates export proceeds of Rs. 140 Billion and contributes 25% of export of manufactured goods [20], [22].

1.5 University-Industry Linkages in Pakistan

In the late 1980's, USAID in collaboration with HEC (then UGC) financed around 20 projects to promote university-industry partnership. Every project had an industry partner (without any financial contribution) who was associated with it throughout its execution and was supposed to take up the project to commercial levels after completion in the university. Regrettably, no project reached the industrial arena. Since, there is no tradition in this country to analyze the failures to find out the causes to avoid their repetition, a thorough analysis has not been done and a compilation of progress reports of all projects is lying somewhere in the files under the title "**projects completed**".

1.5.1 University-Industry Technology Support Programme (UITSP)

UITSP support is awarded on a competitive merit based evaluation of research projects which are of direct importance to the current needs of industry. HEC mandates that the project proposals should pertain to products and processes needing improvement in the priority areas relevant to the socio-economic development needs of the country and be implemented by professionals from local industry. Fourteen projects were funded through this programme.

1.5.2 University-Industry Interaction Project

This is an umbrella project that aims to create awareness regarding science and technology and to establish stronger connections between academia and industries of Pakistan for the uplift of the industrial sector through research. The major goals of this project are to educate the people regarding refined scientific results; and, build broad consciousness between students, the ordinary people, lawmakers and industrialists about new inventions in frontier technologies. The project aims to emphasize the socio-economic difficulties of the state and their likely scientific answers.

The major activities under this project have included outreach through several channels, including workshops and seminars, meetings with Chambers of Commerce and Industry, and the setting up of a data base on experts for promoting academia industry linkages.

1.5.3 Competitiveness Support Fund (CSF)

The HEC signed a Memorandum of Understanding in August 2006, with the CSF to support joint projects for the promotion of the knowledge-based enterprise sector to ensure long-term economic growth in Pakistan. The HEC/CSF joint initiatives complement the existing projects that USAID is supporting with the HEC.

1.5.4 Collaborative Research Projects with CSF

The CSF/HEC scheme for promotion of relevant research is operated under stringent criteria. Projects are included if they have:

- high potential to generate investments, jobs, income and exports
- high potential to improve quality of products and services
- appropriate environmental, health and social impact

- participation of the “triple-helix” actors, specifically private sector involvement in financing 20% of the total project costs

Projects can range between US$20,000 to US$250,000. The CSF contributes 50 percent, the HEC 30 percent, and industry 20 percent. As with all HEC programmes, a well defined and transparent procedure is laid down for the project submission, vetting and approval processes. Information about these processes is widely disseminated to ensure a level playing field.

1.6 Standing in Global Competitiveness Index

The GCI measures competitiveness of a country by taking various social and economic indicators into consideration and assigning weights to each indicator. Though it is not a direct measure of any particular socio-economic indicator, it is an indicator of economic, social and institutional stability of a country. The GCI uses twelve indicators called the twelve pillars including institutions, infrastructure, macroeconomic stability, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market sophistication, technological readiness, market size, business sophistication, and innovation. The higher the GCI number, the lower the country’s competitiveness profile as compared to other nations [23].

The GCI is used by big businesses and international investors as an indicator of economy’s investment openness. Weak macroeconomic indicators and institutional infrastructure have led Pakistan to lag behind other South Asian neighbors in the GCI Index. A consistent and sustainable economic outlook will be required in coming years for Pakistan to be at a better position in the GCR Index [23].

1.6.1 Stages of development

There are three main groups of pillars at each stage of development [24], as shown in figure1.11 while table1.8 shows list of selected countries in each stage of development.

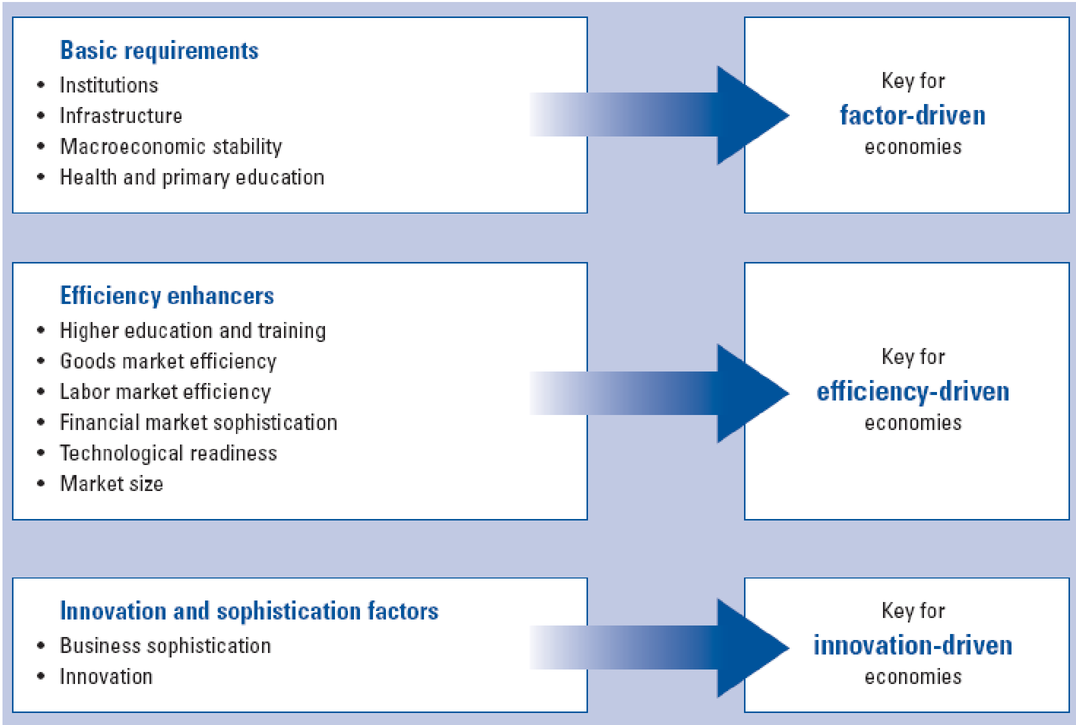

Figure1.11: The 12 pillars of competitiveness
Source: GCR 2008-2009

- ***Factor-Driven Stage.*** In the first stage, the economy is *factor-driven* and countries compete based on their factor endowments, primarily unskilled labor and natural resources. Companies compete on the basis of price and sell basic products or commodities, with their low productivity reflected in low wages. Maintaining competitiveness at this stage of development hinges primarily on well-functioning public and private institutions (pillar 1), well-developed infrastructure (pillar 2), a stable macroeconomic framework (pillar 3), and a healthy and literate workforce (pillar 4) [25].
- ***Efficiency-Driven Stage.*** As wages rise with advancing development, countries move into the *efficiency-driven* stage of development, when they must begin to develop more efficient production processes and increase product quality. At this point, competitiveness is increasingly driven by higher education and training (pillar 5), efficient goods markets (pillar 6), well-functioning labor markets (pillar 7), sophisticated financial markets (pillar 8), a large domestic or foreign market (pillar 10), and the ability to harness the benefits of existing technologies [26].

- ***Innovation-Driven* Stage.** Finally, as countries move into the *innovation-driven* stage, they are able to sustain higher wages and the associated standard of living only if their businesses are able to compete with new and unique products. At this stage, companies must compete through innovation (pillar 12); producing new and different goods using the most sophisticated production processes (pillar 11) [27].

Table1.9: List of countries/economies at each stage of development

Stage 1	Transition from 1 to 2	Stage 2	Transition from 2 to 3	Stage 3
Bangladesh	Armenia	Algeria	Bahrain	Australia
Egypt	Azerbaijan	Argentina	Barbados	Belgium
Ethiopia	China	Brazil	Chile	Canada
India	Iran	Malaysia	Croatia	Denmark
Indonesia	Jordan	Mauritius	Estonia	France
Kenya	Kazakhstan	Mexico	Hungary	Germany
Malawi	Kuwait	Namibia	Latvia	Italy
Mali	Libya	Panama	Lithuania	Japan
Mauritania	Morocco	Romania	Poland	Korea, Rep
Moldova	Oman	Serbia	Qatar	New Zealand
Nepal	Saudi Arabia	South Africa	Russian Federation	Norway
Nicaragua	Venezuela	Thailand	Slovak Republic	Singapore
Nigeria		Tunisia	Taiwan, China	Spain
Pakistan		Ukraine	Turkey	Sweden
Paraguay		Uruguay		Switzerland
Philippines				UAE
Senegal				United Kingdom
Sri Lanka				United States

Source: GCR 2008-2009

1.6.2 Pakistan's Ranking

As shown in table1.10, Pakistan's ranking in the Global Competitiveness Index (GCI) has dropped by 18 positions since 2006, to 101st place this year [24]. Pakistan's economy falls in stage1 of development which is a factor driven economy, wherein 60% weight age goes to basic requirements 35% to efficiency enhancers and 5% to innovation factors. Pakistan's ranking in basic requirements, efficiency enhancers and innovation factors is 110, 89 and 85 respectively which is not a healthy sign for our economic growth. Spider graph in figure1.13 shows our relative position against a standard factor driven economy.

Table1.10: Pakistan's Ranking

Indicators(Pillars)	Rank (out of 134)	Score(1-7)
GCI 2009–2010	101	3.7
GCI 2006–2007	83	3.8
Basic requirements	110	3.7
1st pillar: Institutions	95	3.5
2nd pillar: Infrastructure	85	3.0
3rd pillar: Macroeconomic stability	116	4.2
4th pillar: Health and primary education	116	4.0
Efficiency enhancers	89	3.7
5th pillar: Higher education and training	123	2.7
6th pillar: Goods market efficiency	100	3.8
7th pillar: Labor market efficiency	121	3.8
8th pillar: Financial market sophistication	71	4.2
9th pillar: Technological readiness	100	2.7
10th pillar: Market size	29	4.6
Innovation and sophistication factors	85	3.4
11th pillar: Business sophistication	87	3.8
12th pillar: Innovation	82	3.0

Source: GCR 2009-2010

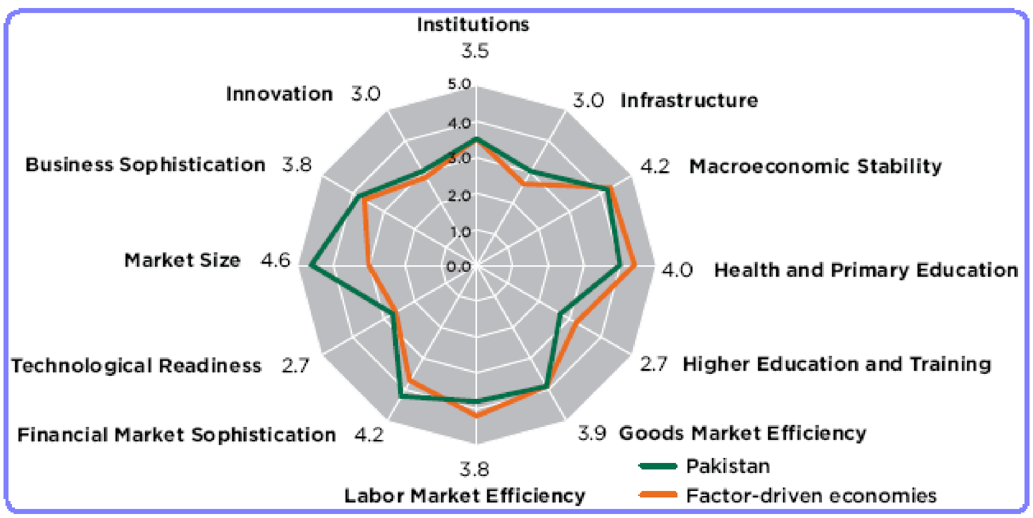

Figure1.12: Pakistan's score in GCI
Source: GCR 2009-2010

Out of twelve pillars of GCI, two pillars, higher education and innovation, directly relates to our area of research. Detailed breakdown of these two pillars is shown in table 2.0 and 2.1 respectively.

Table1.11: Ranking and score of higher educating and training

5th pillar: Higher education and training	**Ranking**	**Score**
Secondary enrollment	121	
Tertiary enrollment	118	
Quality of the educational system	104	2.9
Quality of math and science education	109	3.1
Quality of management schools	94	3.7
Internet access in schools	81	3.2
Local availability of research and training services	103	3.3
Extent of staff training	119	3.0

Source: GCI 2009-2010

Table1.12: Ranking and score of innovation

12th pillar: Innovation	Ranking	
Capacity for innovation	73	3.0
Quality of scientific research institutions	80	3.7
Company spending on R&D	86	2.8
University-industry research collaboration	82	3.0
Govt procurement of advanced tech products	91	3.4
Availability of scientists and engineers	89	3.9
Utility patents	87	-

Source: GCI 2009-2010

1.7 Knowledge Assessment Methodology

In order to facilitate countries trying to make the transition to the knowledge economy, the *Knowledge Assessment Methodology* (KAM) was developed. KAM is a simple knowledge economy benchmarking tool, which was developed by the World Bank Institute. It is designed to provide a basic assessment of countries' readiness for the knowledge economy, and identifies sectors or specific areas where policymakers may need to focus more attention or future investments. The KAM is currently being widely used both internally and externally to the World Bank, and frequently facilitates engagements and policy discussions with government officials from client countries [28].

1.7.1 An Effective Innovation System

An innovation system refers to the network of institutions, rules and procedures that influences the way by which a country acquires, creates, disseminates and uses knowledge. Institutions in the innovation system include universities, public and private research centers and policy think tanks. Non-governmental organizations and the government are also part of the innovation system to the extent that they also produce new knowledge. An effective innovation system is one that provides an environment that nurtures research and development (R&D), which results in new goods, new processes and new knowledge, and hence is a major source of technical progress [29].

Number of studies that show that innovation or the generation of technical knowledge has substantial positive effects on economic growth or productivity growth. For example, Lederman and Maloney (2003), using regressions with data panels of five-year averages between 1975 to 2000 over 53 countries, finds that a one-percentage point increase in the ratio of total R&D expenditure to GDP increases the growth rate of GDP by 0.78 percentage points [30]. There are twelve variables of innovation system in KAM [31].

- **a.** FDI Inflows as % of GDP
- **b.** Researchers in R&D / Mil. People
- **c.** Total Expenditure for R&D as % of GDP
- **d.** Manufacturing. Trade as % of GDP
- **e.** University-Company Research Collaboration
- **f.** S&E Journal Articles / Mil. People
- **g.** Availability of Venture Capital
- **h.** Patents Granted by USPTO / Mil. People
- **i.** High-Tech Exports as % of Manufacturing. Exports
- **j.** Private Sector Spending on R&D
- **k.** Firm-Level Technology Absorption
- **l.** Value Chain Presence

1.7.2 Pakistan's Standing in World Perspective

All twelve variables of innovation system in context of Pakistan are shown in table1.12. In "actual" column hard data is presented, where as in "normalized" column the variables are normalized from 0 (weakest) to 10 (strongest).This data reflects that Pakistan has a weak innovation system once it is measured in world context. The spider graph, shown in figure1.13, gives another view of data shown in table1.12.

Table1.13: Pakistan's standing in World perspective

Variables	Pakistan (Group: All Countries) actual	normalized
FDI Inflows as % of GDP, 2003-07	2.08	3.12
Researchers in R&D / Mil. People, 2006	80.27	2.12
Total Expenditure for R&D as % of GDP, 2006	0.44	4.41
Manuf. Trade as % of GDP, 2007	22.41	2.44
University-Company Research Collaboration (1-7), 2008	3	4
S&E Journal Articles / Mil. People, 2005	3.17	2.85
Availability of Venture Capital (1-7), 2008	2.7	3.52
Patents Granted by USPTO / Mil. People, avg 2003-2007	0.02	3.36
High-Tech Exports as % of Manuf. Exports, 2007	1	2.06
Private Sector Spending on R&D (1-7), 2008	2.8	3.44
Firm-Level Technology Absorption (1-7), 2008	4.4	3.6
Value Chain Presence (1-7), 2008	3.4	4.08

Source: Data Extracted from KAM 2009, World Bank

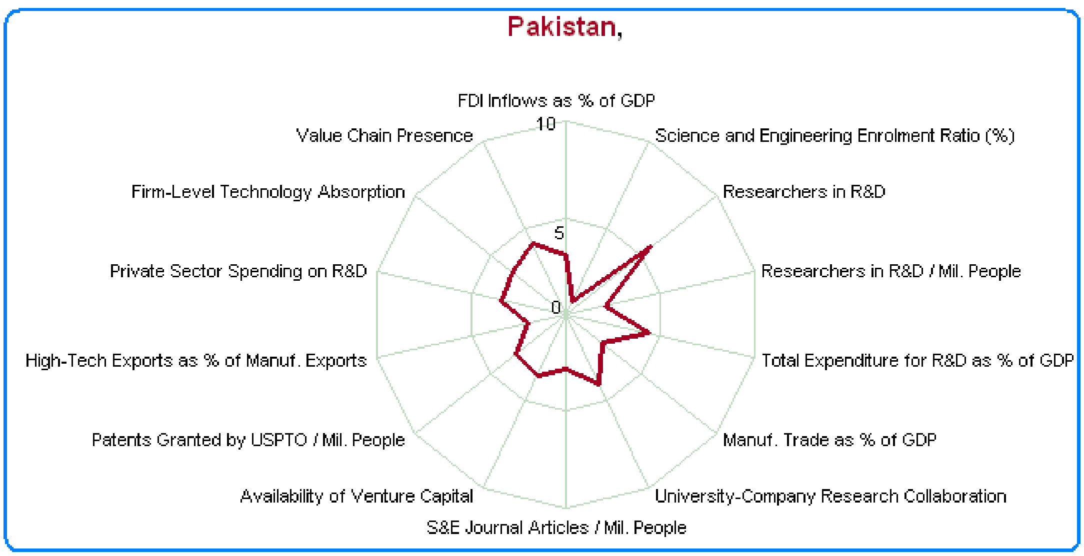

Figure1.13: Pakistan's comparison with world in innovation system
Source: Data Extracted from KAM 2009, World Bank

1.7.3 Pakistan's Standing in South Asian Perspective

In table1.13 and figure 1.14, comparison of Pakistan has been drawn with South Asian countries. Pakistan's FDI inflows score is highest amongst all other innovation variables. Science and engineering enrolment ratio is lowest with a score of 3.33.

Table1.14: Pakistan's comparison with South Asian countries

Variables	(Group: South Asia)	
	actual	normalized
FDI Inflows as % of GDP, 2003-07	2.08	10
Science and Engineering Enrolment Ratio (%), 2007	10.21	3.33
Researchers in R&D, 2006	12,689.00	7.5
Researchers in R&D / Mil. People, 2006	80.27	5
Total Expenditure for R&D as % of GDP, 2006	0.44	6.67
Manuf. Trade as % of GDP, 2007	22.41	5
University-Company Research Collaboration (1-7), 2008	3	6
S&E Journal Articles / Mil. People, 2005	3.17	6
Availability of Venture Capital (1-7), 2008	2.7	6
Patents Granted by USPTO / Mil. People, avg 2003-2007	0.02	6
High-Tech Exports as % of Manuf. Exports, 2007	1	5
Private Sector Spending on R&D (1-7), 2008	2.8	6
Firm-Level Technology Absorption (1-7), 2008	4.4	6
Value Chain Presence (1-7), 2008	3.4	6

Source: Data Extracted from KAM 2009, World Bank

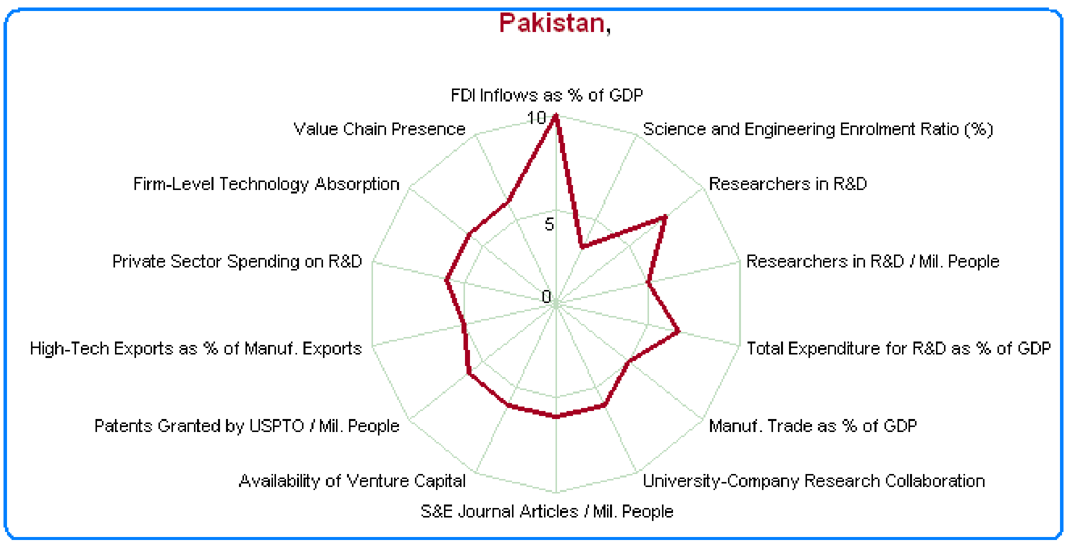

Figure1.14: Pakistan's comparison with South Asian countries
Source: Data Extracted from KAM 2009, World Bank

1.7.4 Pakistan's Comparison with other countries

In figure 1.15, comparison of Pakistan with India and Sri Lanka in South Asian context has been drawn. Generally, Pakistan stands behind these two countries, especially in area of university industry collaboration. Figure 1.17 shows Pakistan's standing in relation to these two countries in the context of world.

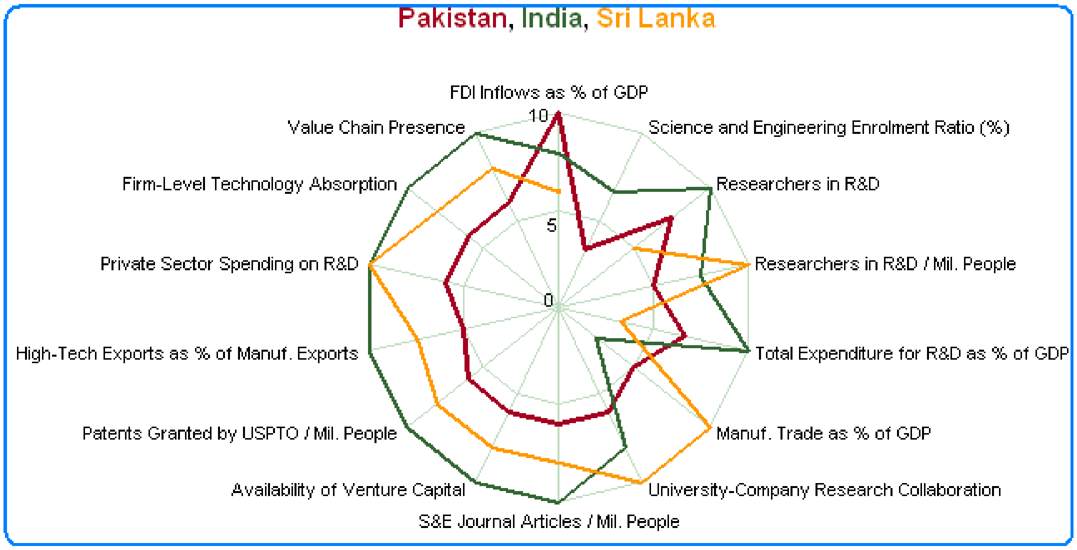

Figure1.15: Comparison of Pakistan, India and Sri Lanka in Context of South Asia
Source: Data Extracted from KAM 2009, World Bank

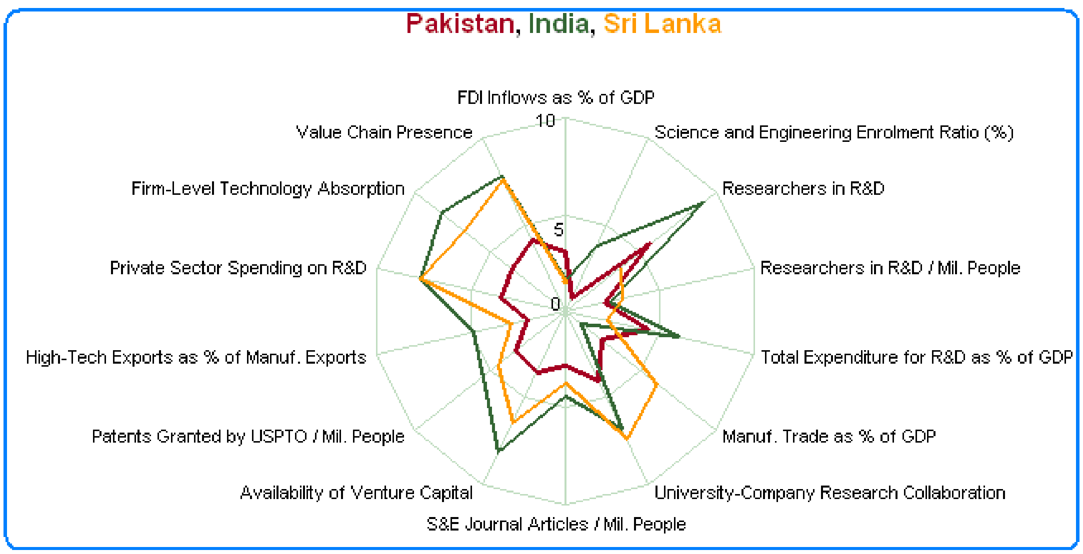

Figure1.16: Comparison of Pakistan, India and Sri Lanka in Context of World
Source: Data Extracted from KAM 2009, World Bank

Figure 1.17 provides comparison of Pakistan with other two Muslim countries which are economically and technologically better placed. Pakistan is far behind in every aspect from these two countries. Malaysia is head of Turkey in all areas except for researchers in R&D and S&E journal articles. In figure 1.18 comparison of Pakistan has been drawn with India and China.

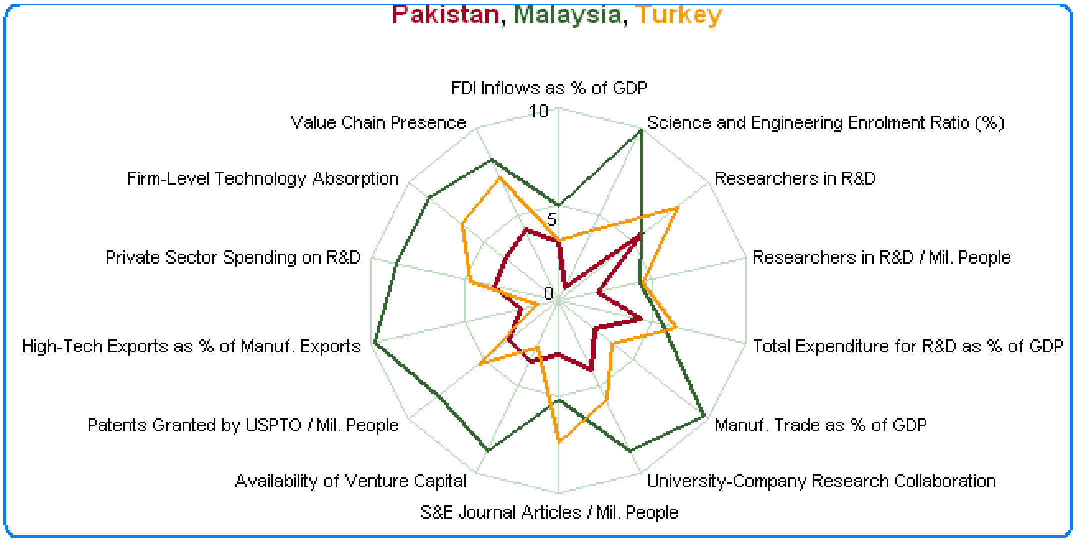

Figure1.17: Comparison of Pakistan, Malaysia and Turkey in context of World
Source: Data Extracted from KAM, World Bank

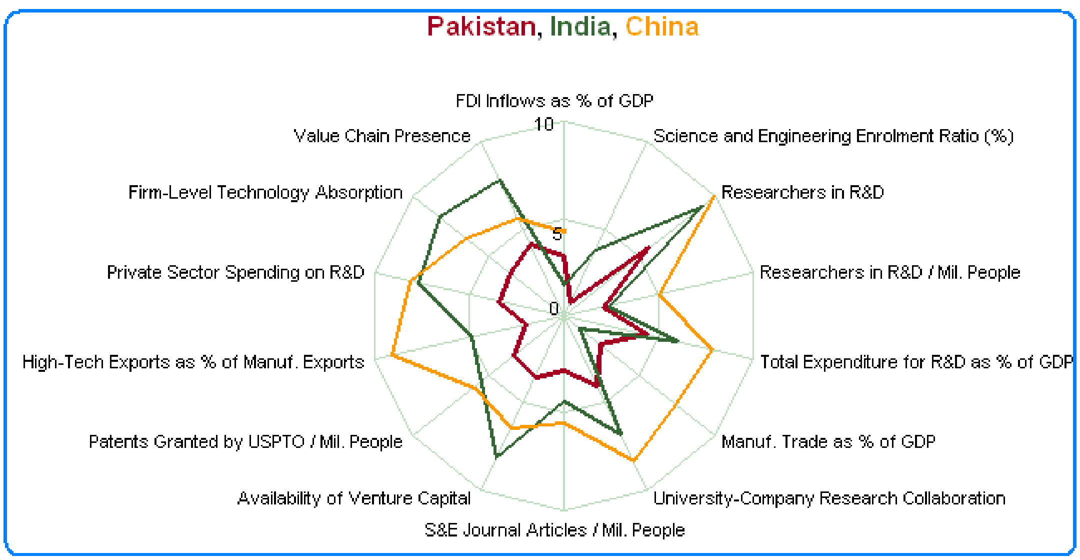

Figure1.18: Comparison of Pakistan, India and China in context of World
Source: Data Extracted from KAM, World Bank

CHAPTER 2

RESEARCH DESIGN AND METHODOLOGY

2.1 Problem Statement

In recent past there has been substantial growth in HEIs of Pakistan and presently there are 124 HEIs both in public and private sector which are being regulated by HEC to promote and maintain highest standards of education and research. HEC has spent billions of rupees to upgrade / uplift these HEIs in terms of civil infrastructure, lab equipment, provision of internet and free access to digital libraries. Also government expending on S&T and R&D has significantly improved from 0.51% of GDP in 2002-03 to 1.05% in year 2007-08 and from 0.9% in year 2001-02 to 0.59% of GDP in year 2007-08 respectively. However, these positive steps taken by HEC and government are unable to push the universities to move beyond their conventional responsibility of teaching and adopt an entrepreneur attitude for economic uplift of the country. As far as industrial sector is concerned, that is assumed as engine of economic development in any country, we are confronted with weak industrial base. In spite of having weak industrial base, according to latest figures of Federal Bureau of Statistics, there are 6417 large scale manufacturing units and 3.2 million SMEs which have the potential of absorbing university research if proper guidance and support is provided to them. Mainly, these businesses are family owned and are run with a typical mind set of following old traditional orthodox methods. They are reluctant to welcome innovative ideas, processes and new technologies may be due ignorance, negligence or some fear.

This wide Gulf between our universities and industries needs to be bridged in order to have effective university-industry linkages. Both of them need to come out of their shells and enter in to win-win situation; however responsibility of initiating this process rest with university. Universities must make access to industry to create awareness of their potentials for the industry. My research question ***"Identification of barriers affecting university-industry linkages and suggest measures for its improvement"*** is based on the assumption that universities have not been able to adopt pro-active approach to initiate process of establishing industrial linkages in the era of knowledge and technology based economy.

2.2 Research Aim

To carry out research to determine existing level of industrial linkages and identification of barriers constraining these linkages in institutes of higher education and suggest measures for improvement and elimination of these barriers in the light of literature and good practices on the subject.

2.3 Research Objectives

In order to analyze university- industry linkages, literature review on the subject and a comprehensive survey of institutes of higher education was carried out. The broad objectives of this research are as under:-

- **a.** To carry out study of higher education in Pakistan and achievements made by HEC during the last 9 years
- **b.** To carry out brief study of Pakistan's economy and its industrial sector, role of SMEs in economic development of the country
- **c.** To carry out study of university-industry linkages in Pakistan
- **d.** Examine the characteristics and operational structure of existing university-industry interactions
- **e.** Examine the potentials and constraints in establishing sustainable university-industry interactions
- **f.** Based on finding suggest measures to enhance effectiveness of these linkages

2.4 Significance of Research

It is thought that knowledge is the driver of a country's socio-economic growth. The academia industry linkage is essential not only to ensure that our knowledge base has relevance to our needs but also to provide opportunity for industry to benefit from efforts of the academia. The relevance of university education being imparted in building high level skills and creating cadre of enterprising innovators in industry is crucial for this socio-economic growth.

Few key motives, which encourage the industry to establish and enhance university industry collaboration, are:

- **a.** Access to manpower, including well-trained graduates and knowledgeable faculty;
- **b.** Access to basic and applied research results from which new products and processes will evolve;

- **c.** Solutions to specific problems or professional expertise, not usually found in an individual firm;
- **d.** Access to university facilities, not available in the company;
- **e.** Acquiring reputation and improving the firm's image

On the other hand, the reasons for universities to seek cooperation with industry appear to be relatively simple. Several reasons for this interaction are [32]:

- **a.** Industry provides a new source of money for university;
- **b.** Industrial money involves less "red tape" than government money;
- **c.** Industrially sponsored research provides student with exposure to real world research problems and
- **d.** Industrially sponsored research provides university researchers a chance to work on an intellectually challenging research programs

Keeping in view the above it is considered imperative to conduct research on university –industry linkages so that a clear picture of existing level is identified and measures are suggested to enhance its effectiveness so that both the stake holders enter in to win-win situation.

2.5 Research Technique

There are several techniques which could be used to carry out the research based on research problem area. Exploratory research technique was used to undertake this research. It allows the researcher to gather the information as much as possible concerning a specific problem. Exploratory research helps determine the best research design, data collection method and selection of subjects.

2.6 Research Approach

Research approach is a general plan which shows that how this research will go on, and how researcher will answers the question that has been set by the researcher. It contains clear objectives, derived from research question. A logical research approach has been adopted starting from exploring the background of subject, thorough literature review, analysis of data collected and finally establishing the recommendations and conclusions. The detail of research approach is shown in figure 2.1, and described as follows:

- **a.** Past and present state of higher education in Pakistan and achievements made by HEC during the last 9 years.

b. Brief introduction of Pakistan's economy and its industrial sector. Role of SMEs in economic development of the country.

c. History of university-industry linkages in Pakistan

d. Design of research question its objectives and significance

e. Study of existing literature on university-industry linkages

f. Study of Tipple Helix Model of university-industry-government relation

g. Identification of barriers constraining industrial linkages as perceived by university academics

h. Identification of improvements which could be effective for enhancing collaborative activities with industry and elimination ob barriers

i. Design of survey questionnaire and its pretest

j. Collection of primary data through a survey of 69 departments of 15 institutes of higher education all over the Pakistan

k. Compilation and analysis of data by using statistical tools to measure means , percentages and develop their graphs

l. Draw results based on the analysis

m. Give suitable recommendations for improvement of industrial linkages so that our universities can effectively with the industry.

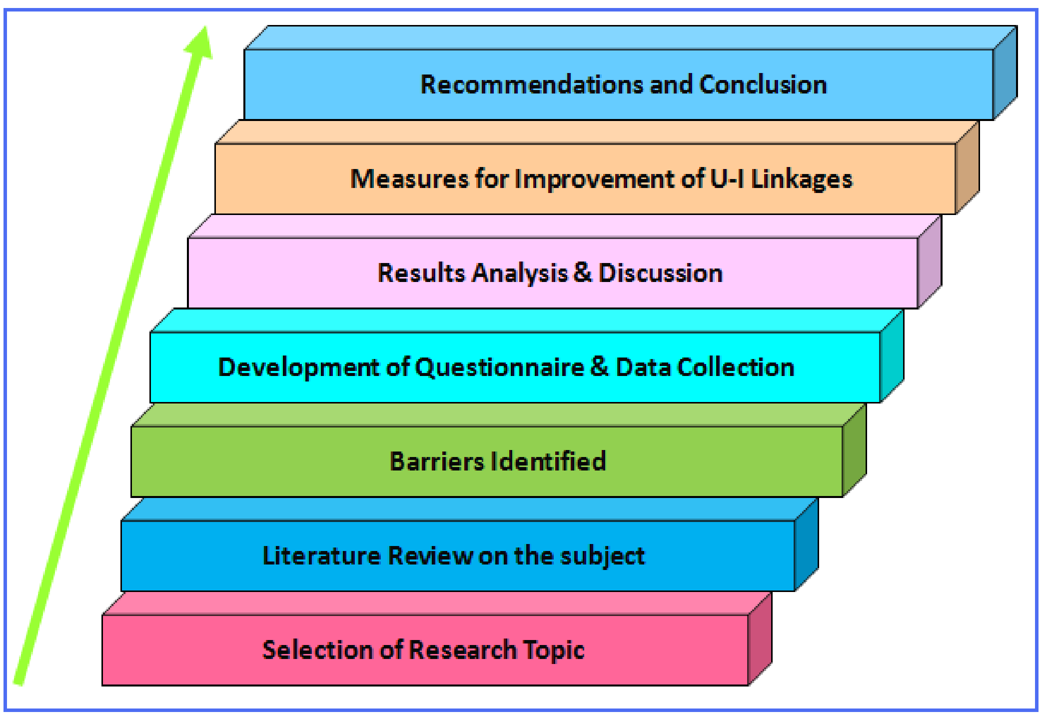

Figure2. 1: Research Approach

2.7 Data Collection Methods

As data collection method is highly influenced by the methodology, which is chosen, survey questionnaire was used to collect the primary data while secondary data was collected from literature review, annual reports, periodicals and journals for this research. As this research's main concern is examining the issues in industrial linkages in higher education institutes, the questionnaire is designed to explore present level of linkages and constraints in establishing these linkages.

2.8 Questionnaire

The questionnaire consists of two pages containing three parts (Appendix A).

a. **Part I.** The first part of the questionnaire was structured to know about the characteristics of university departments and their industrial collaboration activities undertaken during the last three years.

b. **Part II.** In part II of questionnaire respondents assessed 13 barriers on 4 point Likert scale varying from great extent to not at all. These barriers are related to universities which they are likely to confront while interacting with the industry.

c. **Part III.** Part III pertains to suggestion for improvement of industrial linkages. Respondents assessed 11 suggestions on 4 point Likert scale varying from very effective to not at all effective.

2.9 Thesis Structure

The structure of the thesis has been developed in a very logical and interwoven pattern for an easy understanding of the research study. The format of thesis is in accordance with the "Guidelines for the Preparation of B.E. Project Report / MS Thesis", issue by the National University of Science & Technology (NUST), Islamabad, Pakistan.

- **Chapter 1.** It provides an overview of state of higher education in Pakistan, history of higher in Pakistan, increase in HEIs and student enrolment, scholarships. S&T and R&D expenditure as percentage of GDP.A brief of large scale manufacturing industries and SMEs is also covered. An over view of Pakistan's standing in global competitiveness index and comparison of knowledge efficiency index with other countries like India, Srilanka, Turkey and Malaysia is given.

- **Chapter 2.** It is regarding research designed and methodology followed for completing this thesis.
- **Chapter 3.** It deals with comprehensive literature review on university-industry linkages, types of linkages, factors affecting the formation of university industry linkages and its reasons, commercialization of university knowledge, role of intermediaries, entrepreneurial university, open and close innovation systems, mechanisms of technology transfer, triple helix model, and management of university- industry linkages.
- **Chapter 4.** It covers details of questionnaire and data collection through survey.. Existing level of industrial linkages, factors constraining industrial linkages and suggestions for improvement of linkages is covered in this chapter.
- **Chapter 5.** It covers results analysis and discussion. It gives summary of results obtained through analysis and it is followed by individual results and their analysis. Statistical and graphical tools have been used to show the results.
- **Chapter 6.** Models and measures for improvement of university-industry linkages have been discussed in detail in this chapter.
- **Chapter 7.** In this chapter comprehensive recommendation for government, industry and university has been made.

CHAPTER3

LITERATURE REVIEW

3.1 Background

In the context of globalization market place is undergoing rapid changes in competition, technological advancement and a shift to knowledge based economies. New trends in globalization and rising competition have led to crucial challenges to overcome such as rapid technological changes, shortened product lifecycle, downsizing, highly market volatility, political instability [33]. During the last decade, the world economy has expanded at an unprecedented rate; world trade has tripled while the number of patents reached a record of 5.6 million [34]. Policy markers and researchers commonly agreed on the necessity of establishing knowledge flow between academia and industry as one of the most promising factors to strengthen economic development and to foster innovation capability [35].

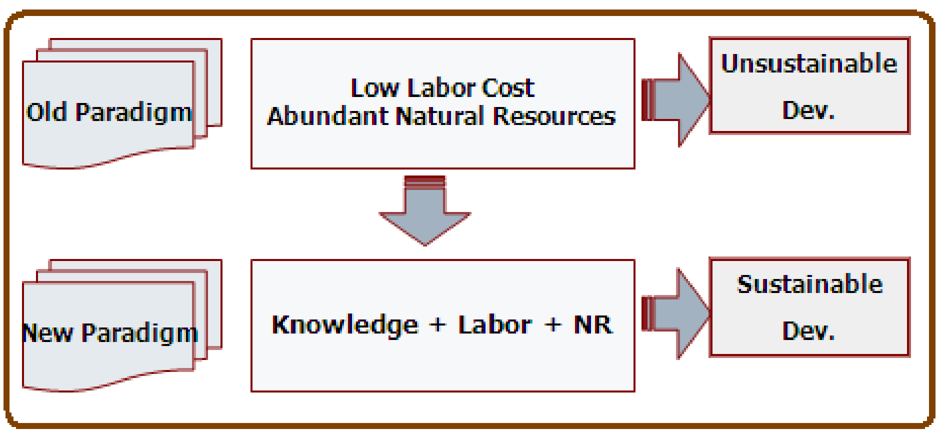

Figure 3. 1: Development Paradigm
Source: Arocena, R. & Sutz, J. (2001) [36]

On the one hand, codified output of academic research like publications and patents seem to be the most important input to industrial innovation [37]. On the other, collaborative and contracted research activities appear to be a much more important form of knowledge transfer [38].

3.2 University Industry Linkages

The university, as an institution, came into being in the 12th century with the educational mission of transmitting knowledge from teachers to pupils. Since then it has evolved from its ivory tower (that is, institutions where scientific knowledge is deposited and which are isolated from society) to a new position within socioeconomic environment, where it acts as an agent to further national and regional development [39]. The development of universities over the years has led them to undertake missions that are increasingly more committed to the society around them [40,41]:

a. Teaching, conservation and dissemination of knowledge (from their early days until the late 19th century)

b. Teaching and research. Research was incorporated as another mission of the university in the first academic revolution (from the late 19th century)

c. Teaching, research and direct contribution to social and economic development, or the so-called Third Mission. Incorporating the Third Mission as another mission is known as the second academic revolution (from the end of the 20th century).

Industry academia interactions have become more formal, frequent and planned mainly since the 1970s [42]. One of the most notable pioneers of U-I interactions was the Massachusetts Institute of Technology (MIT), which led the establishment of faculty-formed firms[43]. It is argued that closer interaction between universities and industries may not only generate mutual benefits but also contribute to industrial competitiveness. Figure 3.2 captures a wide range of modes of interaction. It identifies that a wide range of formal and informal interactions can occur which in turn may shape and lead to activities in terms of problem solving and increasing the stock of codified and non-codified knowledge [44].

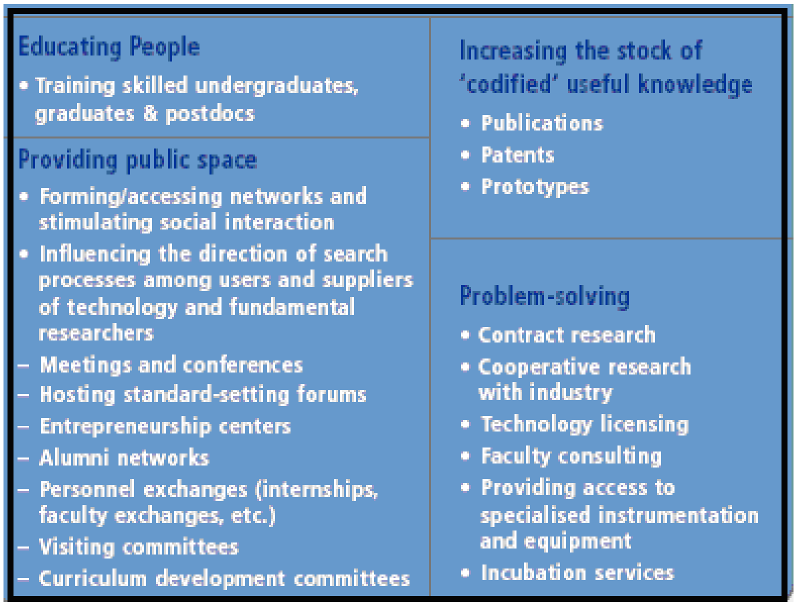

Figure3. 2: Multi-faceted role of University
Source: Cosh, A., Hughes A., and Lester R. K. (2006)

It has been argued that, in transferring technology from the universities to entrepreneurs, the former should not lose sight of the fact that their primary task lies in the field of fundamental research and scientific education [45]. Universities must strike a balance in their activities. It is a fact that universities and industries have different cultures which often results in a conflict of interests. Industries are mainly concerned with the provision of goods and services and its related profit, universities are more concerned with dissemination of knowledge.

It has been found that university research in a particular geographical area substantially increases both the quantity and productivity of industrial R&D in the same geographical region [45]. An understanding of the above has made the issue of collaboration between higher education institutions and industry a focus for politicians, academics and industrialists [46].

University-industry co-operation in developing economies cannot be expected to work in the same way as in developed economies. Co-operation may be hampered by technological constraints on the part of both partners. In many cases, universities will not have the ability to supply knowledge that is new to their partners and companies cannot be expected to be willing and/or able to pay universities for their services. The stimulation for absorbing and applying new ideas can be contributed by both partners as universities may be technologically not more or even less advanced than some of their industry partners. Universities in developing countries find themselves in a different position from their peer institutions in industrialized countries. They tend to be under-funded and unable to purchase and apply the latest research equipment. Their faculty and staff tend to be less qualified on average. Thus, developing countries' universities are usually far below the academic standards set by universities in industrialized countries. Consequently, they put more emphasis on undergraduate teaching, which is a very important function in many developing countries that strive to improve the skills of their population. Graduate education and research do not belong to the core activities of many universities in developing countries [46].

3.3 Development of University and Industry Linkages

University-industry linkages take place in the form of workshops, conferences, seminars, joint R&D, consultancy, contract research, start-ups and spin-offs.

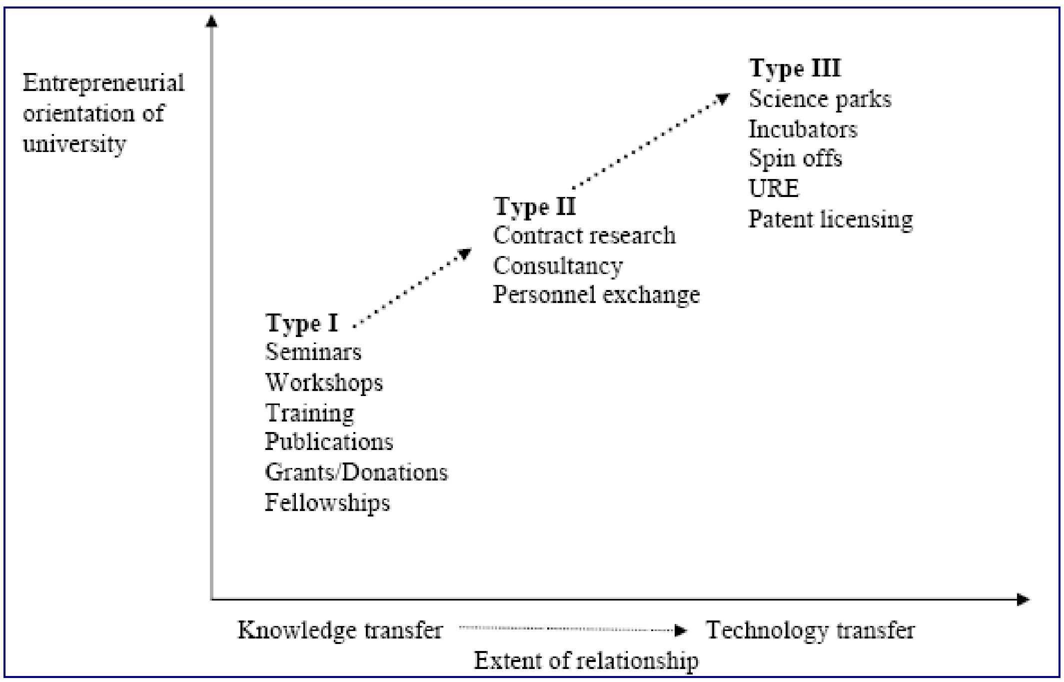

Figure3. 3: Typology of University-Industry Interactions
Source: Dr. M. Esham (2008) Research Studies on Tertiary Education Sector

As shown in Figure3.3, on horizontal axis there is extent of relationship and on vertical axis there is entrepreneurial role of the university. The first types of interactions are seminars, workshops and publications. As the orientation of university changes interactions takes place in the shape of contract research and consultancy. When university takes the role of entrepreneurial university then activities like spin-offs and new start ups take place.

3.4 Types of University Industry Linkages

Basic diagram of U-I knowledge flow is shown in figure 3.4. There are different ways and means by which university-industry interaction can take place. Detail of some of these mechanisms is mentioned below:-

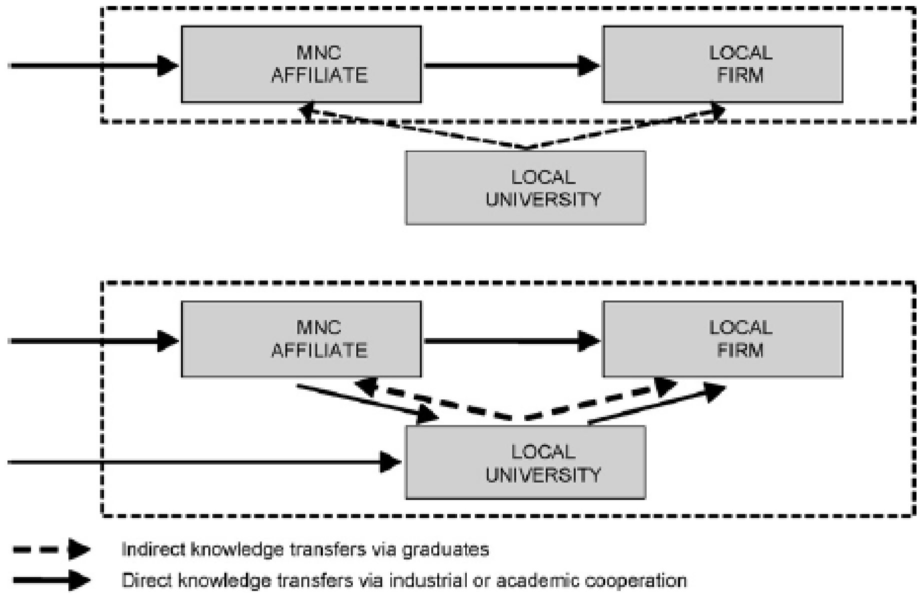

Figure3.4: Flow of knowledge/technology between university and industry
Source: Ingo Liefner et al (2008) [47]

3.4.1 Collegial Interchange, Conference and Publication

This is informal and free exchange of information among colleagues, which includes presentation at professional and technical conferences and publication in professional magazines. It is widely used and the first step of linkage between academic institutes, their research centers and industry [48].

3.4.2 Exchange program

A transfer of personnel can be used to exchange expertise and information either from industry to laboratory or from laboratory to industry. In this mechanism, conflicts of each party’s interest must be avoided and laboratory must approve of the lab personnel consulting arrangements [48].

3.4.3 Joint Venture in R&D

A contract is drawn between university research center and a contractor in which costs associated with the work are shared as specified in the contract. The two parties can work together from the stage of R&D to commercialization. It must be of mutual benefit to industry and the research centers, and commercially valuable data may be protected for a limited period of time. It provides some assurance that the best brain in the business will be brought together to bear on the problem, and that there will be a balance between long term, high risk research and short-term work which can be promptly commercialized [48].

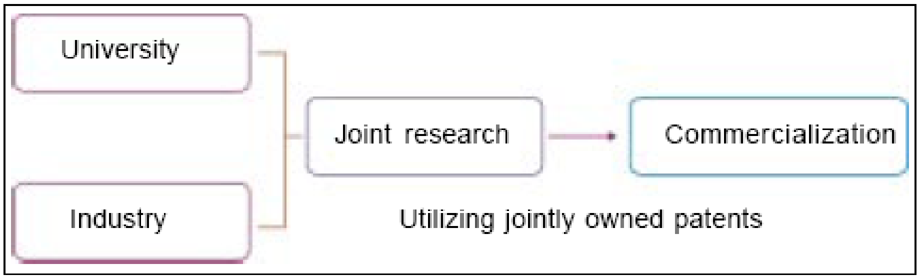

Figure3.5: Typical scheme of commercialization of joint research results
Source: Source: Toshiya Watanabe 2009 [49]

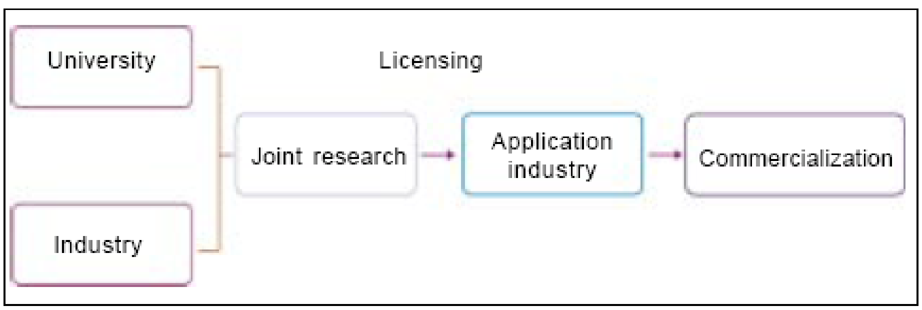

Figure3.6: Joint licensing of joint research results
Source: Toshiya Watanabe 2009

3.4.4 Licensing

Licensing is the transfer of less-than-ownership rights in intellectual property to a third party, to permit the third party to use intellectual property. It can be exclusive or non-exclusive and is preferred by small business. The industry as a potential licensee must present plans to commercialize the invention. Licensing has traditionally been the most popular mode of university technology transfer [50].

3.4.5 Contract Research

It is a contract between a research center and a firm for contract R&D to be performed by the research center. Industry usually provides funds and the university provides brains with the time frame ranging from a few months to years. Through contract research, the industry wants to utilize the unique capability of the research centers that works for commercial benefit [48].

3.4.6 Spin-offs

University spin-offs are defined as new ventures that are dependent upon licensing or assignment of the institution's intellectual property for initiation. In contrast, start-ups are companies where the university has been involved in some way in forming the company but where it does not have any formal intellectual property agreement with the company's founder i.e. the knowledge is tacit (or not formally protect able) [51].

3.4.7 Science Park, Research Park or Technology Park

These are installations on a given site area, normally close to a university and collaborate with a member of high-tech firms that receive official assistance in the early stage. The main fund providers would be the commercial firms participating and the researchers include both from the university research centers and the industry. This is a kind of form especially adopted by the high-tech firms [52].

3.4.8 Graduate and Researcher mobility

An important way in which knowledge is transferred from the higher education sector into industry is through the skills and experience gained by graduates and researchers [53].Graduate mobility is quite closely related to contract research as graduates from universities might embody the absorptive capacity an industry needs to identify opportunities at universities [51].

3.4.9 Training

Technology transfer through training could be in the form of practical training where students are exposed to the working methods and requirements of jobs at industry or at the institutions. The capability of staff in the particular field is improved by further training. Special training is also useful when potential managers are given lectures on administrative issues and the employees are trained for adoption of a new technology [54].

3.5 Factors affecting the formation of U–I linkages

In line with much of the recent literature, firm-and university-level factors that may be associated with a higher tendency toward U–I linkages are as under:

3.5.1 Firms' knowledge bases

Several studies have explored how firm characteristics affect the formation of different types of linkages to universities and public research organizations [55]. Knowledge is seen as residing in skilled knowledge workers in firms and as being accrued and generated through their experimentation efforts, to both exploit and explore new ways to solve problems. Firms with stronger knowledge bases through their enhanced absorptive capacity have better capabilities for searching and exploiting valuable external knowledge, one source being universities. This view is corroborated by several studies that show that firms with higher R&D intensity have more university collaborations [56].

3.5.2 Scientific quality of university departments

The propensity to form U–I linkages also depends on the characteristics of university departments. Mowery and Sampat [57] suggest that public research organizations vary in structure, size and strategy and, therefore, should not be considered homogeneous entities. Several scholars have explored the degree to which the scientific quality of universities influences the formation of U–I linkages and obtained contradictory results. Some studies find that top tier universities or departments establish more U–I linkages than those with less high quality scientific records.

3.6 Reasons for Establishing University-Industry Linkages

Universities have a number of motivations for reassessing their ties with industry and likewise industry's incentives are also compelling [58]. There are many reasons for these linkages and the list is by no means exhaustive [59]:

- **a.** Universities provide a ready pool of graduate and undergraduate students that industry may access for their work requirements. Students in return receive critical workforce training that supplements coursework. Workforce training is increasingly recognized within the US as a critical component of education in knowledge- based, international economy.
- **b.** Technical opportunities exist in industry for faculty and students that may not exist in institutions of higher education.
- **c.** Materials exist in industry for research and educational purposes that may not exist in institutions of higher education.
- **d.** Collaborations with industry provide research funding to universities, a need that has become increasingly apparent over the past 10 years. Universities

come to rely on the generation of extramural funding as they structure their budgets. A sad reality, though, as money should not drive every decision made within universities.

e. Such collaborations can advance the service mission of universities, an increasing component of universities as they become more involved in their local communities. Such service has also been demanded by local and state governments within which the institutions are located; this could be considered a quid pro quo for tax-exempt status-or at least to forestall political retaliation against universities that are perceived to be 'rich islands' within some communities.

f. Collaborations provide for local and regional economic development. There is evidence to suggest that university industry collaborations contribute to the overall economic development of the United States. This is necessary in a post-industrial, knowledge-based economy.

g. Collaborations between universities and industry often are novel to high technology areas, as opposed to low technology areas (such as basic manufacturing). Nanotechnology and materials science/engineering are examples of such high technology fields. However, the argument is being increasingly made that basic manufacturing is now 'high technology' and hence is important to the overall US economy.

h. Universities often have research infrastructure that industry wants. For many companies, it is simply more cost effective to contract out research to universities that have the research infrastructure in place rather than building from the ground up or renovating existing facilities.

i. .Industry outsourcing to universities, to reduce the costs of doing business and increase profits.

3.7 Role of Technology Transfer Office (TTO)

The role of the TTO is to facilitate commercial knowledge transfers through licensing to industry of inventions or other forms of intellectual property resulting from university research. A dedicated transfer unit allows for specialization in support services, most notably, partner search, management of intellectual property, and business development [60].

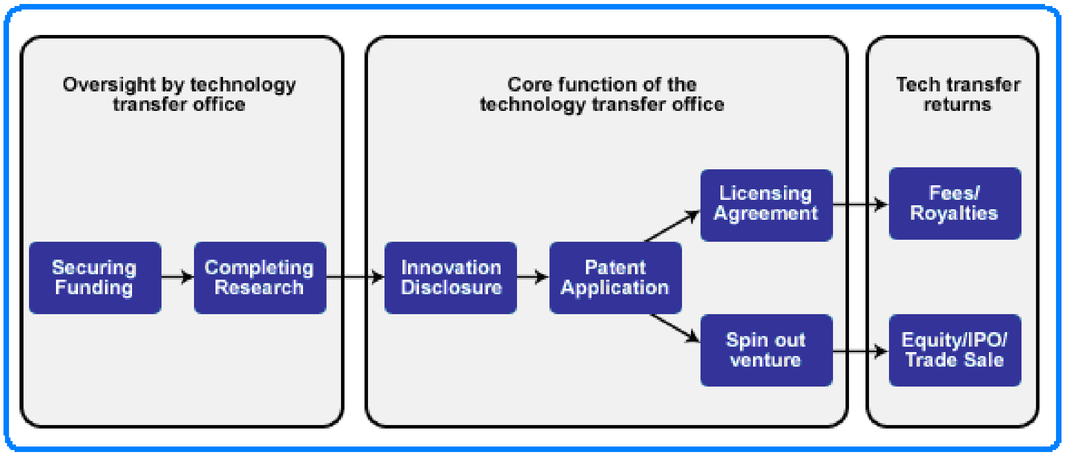

Figure3.7: Technology transfer process
Source: Stadler et al (2007)

TTOs represent an important resource to university research faculty. Professionals who work in university TTOs must understand both the culture and function of the academic research enterprise as well as that of the industry sector, using their expertise to put together licensing deals [61]. The learning curve for new TTO personnel is steep as they may be unfamiliar with the faculty and industrial networks important for finding licensees [62]. The technology transfer literature suggests that institutions with older offices often outperform those with newer offices, perhaps due to the longer time period needed to develop the resource of specific skill sets useful to facilitating technology transfer.

3.8 Advantages of Technology Transfer

The advantages of technology transfer process go both ways, to the research centers as well as to the industry [63].

3.8.1 Advantages to university and its research centers

The advantages could be listed as follows:

- **a.** Opportunity to access the needs of the economy and to develop its activities accordingly through income from the sales of technology
- **b.** Opportunity to place students in industry so that classroom learning can be related to practical experience
- **c.** Access to industry for both fundamental and applied research
- **d.** Access to the protected markets
- **e.** Business stature enhancement

f. Improvement in new technology implementation

g. Creation of goodwill

h. New product development and spin-offs

i. Cost savings (lower production cost)

j. Patenting

3.8.2 Advantages to industry

The following are the advantages to the industry:

a. Supply of better qualified graduates having more relevant training because industry's needs have been identified

b. Access to a variety of post-experience training facilities it has helped to design

c. Access to the university's physical facilities and the expertise of its staff

d. Access to research, consulting and data collection of the university

e. An improved public image in the society in which it operates, which means that more talented students will be attracted to the industrial sector

f. Gained technical knowledge

g. Gained technology services not available before

h. Quality improvement

i. Cost savings

j. New markets

k. Manufacturing and lead time reduction

3.8.3 Challenges

While there are clear benefits for both parties to interact, there are also significant challenges that must be overcome. Elmuti et al. [64] state that although there is evidence to indicate the power of university-industry collaborations, the intensity of these relationships and the tangible outcomes generally lags behind. These challenges include [65]:

a. The differing cultures of the organizations can impede success. The two sectors operate on different timescales, have different objectives to fulfill and often have different value systems. Finding the appropriate balance that satisfies both stakeholders is the biggest challenge to be faced.

b. Another challenge is the conflicting desire of academia to publish and industry to maintain secrecy to secure intellectual property rights and maintain competitive advantage.

c. The issues relating to ownership of IP and the division of revenue amongst the parties is often an area of strong debate among collaborators. Disagreements are common in this area, with industry claiming that IP from universities is often over-priced and ignores the risks industry is exposed to while commercializing it. Universities fear that industry may steal their discoveries and generate revenue streams that rightly belong to the university. Only through defined processes and trust can this challenge be overcome.

d. Organizations must adapt their strategies in response to their external environment. These changes can result in the level of interaction between university and industry either increasing or decreasing in importance. Since much of the academic research is long-term in nature, instability in industry support can result in difficulties for the university in planning for the future.

3.9 Entrepreneurial University

To be an entrepreneurial, a university has to have a considerable degree of independence from the state and the industry, but also a high degree of interaction with these institutional spheres [66]. The difference between academics and entrepreneurial role is shown in table3.2.

Table 3.1: Difference between academics and entrepreneurial role

	Academic	Entrepreneurial
Norms	Universalism Communism Disinterestedness Skepticism	Uniqueness Private property Passion Optimism
Processes	Experimentation Long-term orientation Individualistic/Small group	Focus Short-term orientation Team management
Outputs	Papers Peer recognition/status	Products Profits

Source: Sanjay Jain etal, (2009)

The development of entrepreneurial initiatives in universities implies the intensive participation of different agents such as teachers, students, and the labour force involved, who operate the implementation process. These agents assume a special role in contributing to the development of an entrepreneurial mentality, covering the interface between teaching processes and technology transfer movements [67]. The most important characteristic of the full-fledged entrepreneurial university is that research problem definition comes from outside sources as well as from within the university and scientific disciplines. In its fullest form, the definition of research problems arises from all interaction between university researchers and external sources as a joint project [68].

3.10 University-industry-Government Relations

3.10.1 Triple Helix Model

A group of scholars including Etzkowitz and Leydesdorff [69] states that the university can play an enhanced role in innovation in increasingly knowledge-based societies through forming direct links with industry to maximize “capitalization of knowledge”, and that academia should be closely integrated with the industrial world. This view is referred to as the “triple helix” thesis. The evolution of innovation systems, and the current conflict over which path should be taken in university–industry relations, is reflected in the varying institutional arrangements of university–industry–government relations [70].

3.10.1.1 The Statist Triple Helix

The Triple Helix model of simultaneously competing and cooperating institutional spheres differs from situations in which the state encompasses industry and the university, for example, the former Soviet Union, and some European and Latin American countries, in the era when state-owned industries were predominant. In these countries, government was the dominant institutional sphere [40].

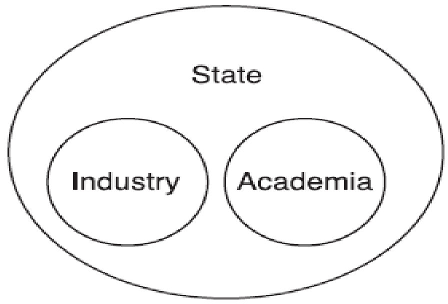

Figure3.8: An etatistic model of university–industry–government
Source: Henry Etzkowitz(2003)

Industry and the university were basically part of the state. When relationships are organized among the institutional spheres, government plays the coordinating role. In this model, government is expected to take the lead in coordinating and provide the resources for new initiatives. Industry and academia are seen to he relatively weak institutional spheres that require strong guidance, if not control. In Brazil examples can he seen in the S&T policies of the 1970s and early 1980s when government organized large-scale technology projects and raised the level of research at universities in order to support the creation of new technological industries such as computers and electronics to affect regional development [71]. The idea of the statist version of the Triple Helix is that the country should keep its local technological industry separate from what is happening in the rest of the world. In this configuration, the role of the university is seen primarily as one of providing trained persons to work in the other spheres. It may conduct research, it is not expected to play role in the creation of new enterprises.

3.10.1.2 The Laissez-faire triple helix

The polar alternative to the statist model is a laissez-faire triple helix of separate institutional spheres, in which people are expected to act competitively rather than cooperatively in their relations with each other. Strict separation leads to narrow definitions of institutional roles, strong boundaries, and high standards for justifying interaction among the institutional spheres. In reality the spheres are often closer together than the model of government. Industry and academia operating in their own areas without close connections [72]. In this laissez-faire model the university is a provider of basic research and trained persons. Its role in connection with industry is to supply knowledge, mainly in the form of publications and graduates, who bring tacit knowledge with them to their new jobs. It is up to industry to find useful knowledge from the universities without expectation of much assistance.

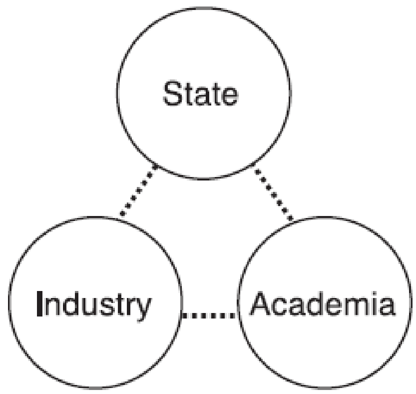

Figure3.9: ‘‘laissez-faire’’ model of university–industry–government relations
Source: Henry Etzkowitz (2003)

Not surprisingly, there is a very strong presumption of individual-ism in the laissez-faire approach. A new enterprise is expected to be initiated by an individual rather than by a group. Enterprises are expected to be run by individuals to whom great prominence and attention are given. Whether or not it is justified, the success of the organization is attributed almost entirely to the person at the top [73].

There is expected to be only limited interaction among university industry government in the laissez-faire Helix. Thus, to the extent that there are relationships, they tended to occur at arm's length.

3.10.1.3 The Triple Helix model of innovation

Once the received models are open to change, a new set of interactions ensues that tends towards convergence of innovation regimes. Innovation begins to take on a new moaning as the spirals of the Triple Helix intertwine, cooperating from a position of relative autonomy to enhance each other's performance of their traditional roles. The increased interaction among university, industry, and government as relatively equal partners, and the new developments in innovation strategies and practices that arise from this cooperation, are the core of the Triple Helix model of economic and social development [74].

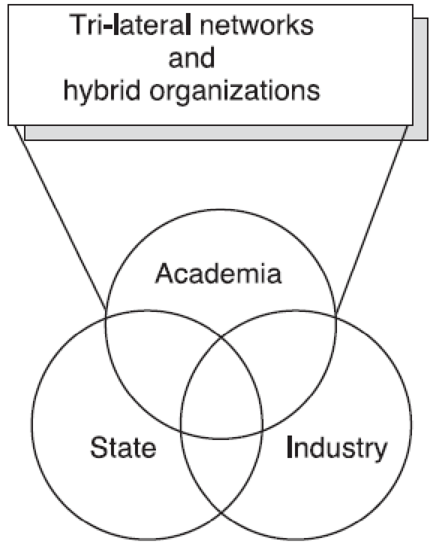

Figure3.10: The Triple Helix Model of University–Industry–Government Relations.
Source: Henry Etzkowitz (2003)

The Triple Helix also becomes a platform for "institution formation" the creation of new organizational formats to promote innovation, such as the incubator, science park, and the venture capital firm. The Triple Helix model of innovation comprises three basic elements [75]:

a. A more prominent role for the university in innovation, on par with industry and government, in a knowledge- based society;

b. A movement toward collaborative relationships among the three major institutional spheres, in which innovation policy is increasingly an outcome of interactions among the spheres rather than a prescription from government or an internal development within industry; and

c. In addition to fulfilling their traditional functions, each institutional sphere also “takes the role of the other” operating on a y-axis of their new role as well as an x-axis of their traditional function. Functional integration, as well as differentiation among institutions, takes place though interaction among the spheres.

3.11 Barriers to University-Industry Linkages

The barriers to university-industry interaction discussed here are certainly not exhaustive; it does represent some of the more frequently cited issues inhibiting a more productive collaboration between universities and industry [76].

3.11.1 Difference between Academic and Industrial Research

There is a lot of difference between university and industry culture because of their varying aims, missions and objectives. These variations (Table3.3) develop resistance between university and industry and reduce their fruitful interactions.

Table 3.2: Difference between Academic and Industrial Research

Typical aspects	University	Industry
Focus of the R&D	Basic research; curiosity-oriented	Applied research
Basic rationale	Advance knowledge	Increase efficiency
Aim	New ideas	Profits
Characteristics	Idea-centered	Practical, product-centered
Framework	Open	Close, confidential
Evaluation	By peers	By the boss
Schedule	Open-ended	Tight, predetermined
Recognition	Scientific honors	Salary increases

Source: Vedovello (1998) [77]

3.11.2 Lack of Communication

Communication is a major barrier to collaboration. Communication skills differ between and within universities and industry. Needs and expectations are often different between the parties and the failure to communicate them compounds the problem. And the unfortunate fact is that university and industry representatives often have stereotypical visions of the other and that hampers communication for effective project finalization and execution. This also includes the lack of multiple levels of communication within organizations, where different offices within each organization must work together to get the partnership cemented so that the work can progress. This also includes the lack of communication between faculty and staff/administration at the university.

3.11.3 Divergent Missions and Goals

In general terms, the mission of universities is to advance science and therefore to advance a public good. Industry's mission on the other hand is to make profit and advance the private good of its stakeholders and shareholders. This conflict in the mission is also present on the level of *goals*. The universities need to produce scientific results that are thoroughly validated in order to advance their scientific reputation. Industry needs products and services which can be sold with profit in the marketplace. Also, universities have mixed missions, particularly when it comes to establishing start up companies. The establishment of start up companies with faculty at the center is, in some people's eyes, a significant departure from education, teaching, service, and research. Reasonable minds can differ on this topic, but in the end, this mixed mission can be problematic in dealing with industry partners.

3.11.4 Cultural Differences

Cultural differences are a major barrier to collaboration. Not only is there the basic legal distinction between both (non-profit educational institutions vs. for profit companies), but there are also cultural differences within universities and industry that have nothing to do with this legal difference.

3.11.5 Secrecy or Public Dissemination of Knowledge

Secrecy or public dissemination of knowledge is a major difference between universities and industry. By their very nature, universities desire to publish and disseminate the results of their work. Faculty demand and cherish the ability to publish. Companies, on the other hand, are often more secretive about the results of research in the search for competitive advantage and ultimately profit. These fundamental differences of opinion are often reconciled in research agreements, but this still remains a major difference.

3.11.6 Fear Factor

Both parties, either through culture, prior experience, or stereotyping, often fear doing work with the other. Perhaps it is the fear of having to divulge information in the partnership, perhaps it is a new partnership. Regardless, fear can be a barrier to collaboration [78].

3.11.7 Universities Overvalue the Value of the Research They Do

Universities overvalue the value of technology or the research they do. This is often a comment made by industry, who feels that faculty often overvalue the work they do on projects. As with many aspects of this partnership, this is to be determined on a case-by-case basis.

3.11.8 Lack of Trust

Lack of trust is another significant barrier that occurs, often in combination with other aspects in this section. This lack of trust occurs within universities and industry and often between these parties. This is particular evident in areas of legal issues and contract negotiation and can be exacerbated by the departure of key personnel in establishing the relationship [79]. This area emphasizes the need for personal, trusting relationships both within the academic institution and with the industry partner.

3.11.9 Financial Risk for Universities

It is financially riskier for universities to work with industry rather than government. The federal government in particular is seen as a stable source of research money as the federal government is not seen as being subject to the vagaries of the marketplace. Obviously, however, budget cuts at the federal levels during periods of fiscal distress do not mean that government is entirely risk free.

3.11.10 Universities Lack Consistency

By their very nature, universities are fluid organisms. Administration and faculty come and go, making long term partnerships difficult. Agendas may change even if personnel are stable. Public universities are subject to the fiscal legislative process, and private universities have their own unique issues to a certain extent. Whether intentionally or inadvertently, universities can be inconsistent when it comes to industrial partnerships.

3.11.11 Exclusive Relationships

As in personal relationships, it is often the case that one party wants an exclusive relationship and the other does not. Some companies want an exclusive relationship and often times universities and their faculty do not.

3.11.12 Too Much Specialization in Contract Negotiations

It has been pointed out by industry that there is often too much specialization in contract negotiation, evidenced by a technology transfer office negotiating the intellectual property/licensing clauses, and the sponsored program office negotiating the rest of the provisions. This can lead to unnecessary delay in finalizing research contracts. In fairness to universities, however, this sort of problem also exists in companies, where different business units are responsible for different parts of a research or intellectual property agreement. This leads to delays on the industry side. This problem can be compounded by personnel turnover, poor communication, and a shift in agendas.

3.11.13 Conflicts of Interest

Conflicts of interest often impede collaboration. At the present time, universities are very much concerned with conflicts of interest (financial and otherwise). How can faculty do research if they are not free of potential conflicts? This concern is particularly important when doing research with industry. No institution, no matter how much money is involved, wants to become embroiled in a controversy that will tarnish the reputation of the institution. And it is not likely that companies would want to tarnish their reputations either.

3.12 Management of university industry linkages

A professional management of university-industry relations is nowadays believed to be a crucial success factor for the development of sustainable collaboration. Professional management of university-industry linkages includes the following aspects [80]:

- **a.** Internal or external interface structures (organizational development) which are in charge of managing university-industry linkages, in particular their organization, staffing, modes of operation and legal status as well as their control through the alma mater;
- **b.** Procedures of financial management: financial autonomy in the deployment and utilization of resources, costing of projects, distribution of generated income, existence of risk capital;
- **c.** Procedures of personnel management: status and salaries of personnel collaborating in projects; development of skills and attitudes in staff for their collaboration in industry, incentives for the motivation of staff to collaborate in projects with industry; policies on the use of staff time in industry-related projects
- **d.** Management of intellectual property: existence of policies and procedures for the development and management of patents and other intellectual properties.

3.12.1 Management of Collaborative R&D Projects

A good practice model for the effective management of collaborative R&D projects should reflect six key areas [81]:

a. The need to evaluate new partners and build a collaborative environment which takes into account any key issues identified.

b. Good project management is essential to success, and particular emphasis should be given to structured objective setting, good progress monitoring, effective communication and deploying only trained, high quality project managers to run the collaboration.

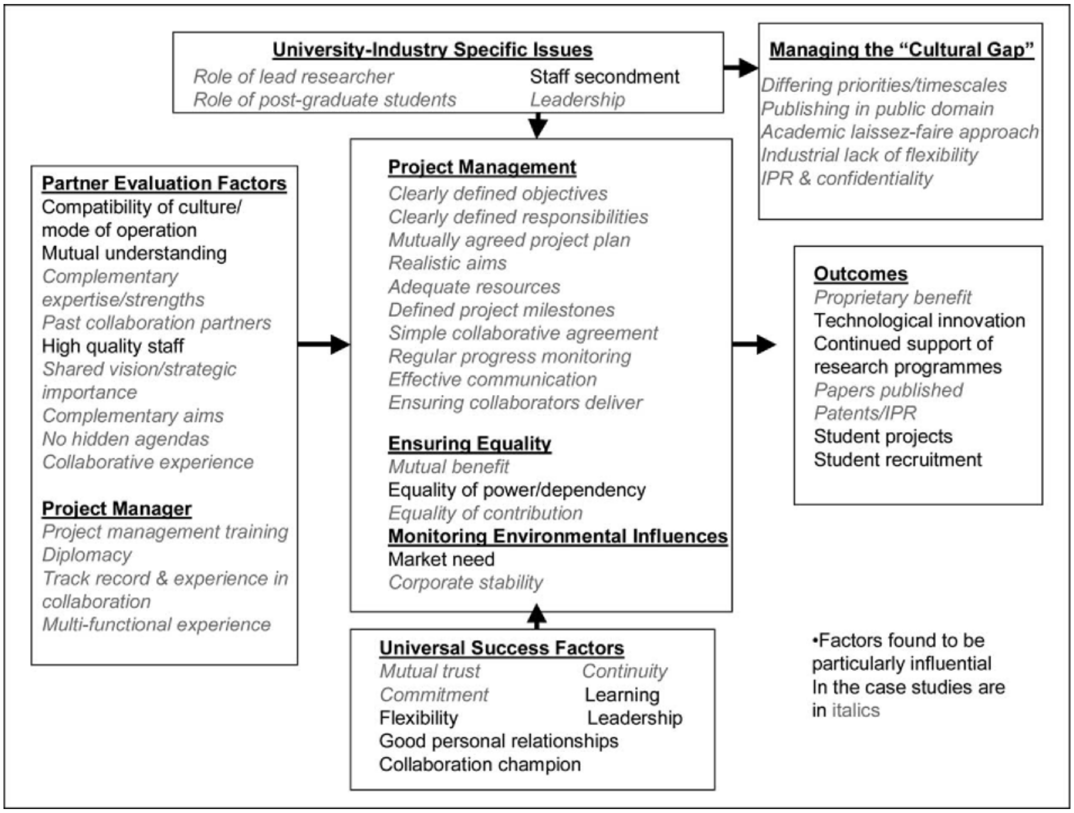

Figure3.11: Good Practice Model for Collaboration Management
Source: Tina Barnes etal, 2002

c. A tendency for collaborations to be influenced by external factors such as corporate instability, indicates that the management processes themselves need to be flexible enough to cope with change.

d. The importance of trust, commitment and continuity was reinforced by this research. Further, important insights were gained into preparing the ground for successful collaboration.

e. Effective management of university–industry interactions must include measures which will help maintain the interest and commitment of the industrial partners. These include attention to proprietary benefit, ensuring benefit at least commensurate with investment, and planning for the achievement of tangible outcomes early in the project.

f. Good university–industry relations require that an appropriate balance be achieved between academic objectives and industrial priorities.

CHAPTER 4
SURVEY QUESTIONNAIRE
AND DATA COLLECTION

4.1 Survey Questionnaire

The questionnaire consisting three parts was designed to determine existing level of university-industry linkages, barriers to these linkages and suggestions for improving these linkages. The detail of each part is as under:

a. **Part I.** The first part of the questionnaire was structured to know about the characteristics of university departments and their industrial collaboration activities undertaken during the last three years. In this part, an effort was made to determine the type and level of existing industrial linkages in our universities. Out of fourteen questions, 4 questions were pertaining about university and department information and remaining 10 were directed towards university-industry linkages.

b. **Part II.** In part II of questionnaire respondents were invited to weigh up 13 diverse barriers on 4 point Likert scale varying from great extent to not at all. These barriers are related to universities which they are likely to confront while interacting with the industry. Although there is non exhaustive list of university-industry barriers, however only most common barriers has been mentioned in this part. All important aspects of university-industry barriers have been covered in this part of questionnaire.

c. **Part III.** Part III pertains to suggestion for improvement of industrial linkages. There were 11 suggestions and respondents were invited to assess them on 4 point Likert scale varying from very effective to not effective. A range of suggestions were covered in this part of questionnaire, focusing on improving university-industry linkages.

Part I

1. University name … ……………….
……………………………………………
2 Department name… ………..
……………………………………………
3. Appointment of Respondent, check one.

Dean	
Head of department/Chairman	
Professor	
Lecturer	

4. Strength of teaching faculty in the department

Professor/associate professor	
Assistant professor/Lecturer	

5.What programmes are offered by you,check all applicable

	Yes/No
UG	
Masters	
M.phil	
PhD	
PGD	
Short Courses	

6. Please indicate from which source your department received funding

	Yes/No	Amount(if possible)
Industry (private)		
Industry (public)		
Private foundations		
GoP		
International agencies		
NGOs		

7. Illustrate position of your laboratory equipment.

	Adequate	Inadequate
Teaching purpose		
Research purpose		

8. Is there any university-industry liaison office?

Yes	No

9. Do you have any formal collaboration agreements with relevant industry?

Yes/No	

10. Please describe what type of services you provided to industry?

	Yes/No	Data of last three years(if possible)
Consultancy		
Contract research		
Training programmes		
Workshops		
Seminars		
University Patents		
Prototypes developed by your faculty		

11. Does your university/department have any Technology Incubation Centre?

Yes/No	

12. Who coordinated collaborative activity with industry?

	Yes/No
Individual Scientist/Professor	
Research team	
Through U-I interaction unit	
Dean/ department head	
NGO	
Third party	

13. Did you take on development and research projects in last three years with?

	Collaborative research	Development project
Industry (private)		
Industry (public)		
Private foundations		
International agencies		
NGOs		
GoP / Ministries / Departments		

Part II

15. Barriers to University –Industry Linkages

	Point out to what extent under mentioned factors affect university-industry linkages:	**Great Extent (4)**	**Moderate Extent (3)**	**Little Extent (2)**	**Not at All (1)**
1	Lack of research capabilities of researcher				
2	Lack of confidence to take on research related to industry				
3	Lack of enthusiasm and entrepreneurial attitude among researcher				
4	Time limitation because of intense teaching and managerial work load prevents interacting with industry				
5	Lack of awareness to seek consultancy and contract research				
6	Making linkages with industry has a depressing impact on educational mission of academia				
7	Lack of interest on part of industry to engage in collaboration with university				
8	Collaboration with industry restricts the option of selecting basic research themes				
9	University infrastructure is insufficient to have U-I collaboration				
10	Laboratory facilities are inadequate to undertake research relevant to industry				
11	Lack of adaptation of university structure to the requirements of collaboration with industry				
12	University rules, regulations and procedures impede collaboration process with industry				
13	Inappropriate geographical site of the university reduces chances of collaboration with industry				

Part III

16. Suggestions for Improving University-Industry (U-I) Linkages

	Point out to what extent following measures are effective for improving University -Industry linkages (check one against each)	**Very Effective (4)**	**Effective (3)**	**Slightly Effective (2)**	**Not at all Effective (1)**
1	Inclusion of internship with industries in curriculum				
2	Encourage visits of students to industry				
3	Encourage visits of faculty to industry				
4	Improvement of laboratory equipment				
5	Involvement of professionals from industrial sector for teaching purpose				
6	Setting up of U-I liaison offices in universities				
7	Publicizing university research to industries and their representative bodies				
8	Conducting seminars, conferences and workshops for professionals from industry				
9	Reduced taxation for those industries which engage in collaborative activities with universities				
10	Making it mandatory for faculty to carry out some kind of collaborative work with industrial sector				
11	Providing increments, awards and promotions related to collaborative work				

4.2 Data Collection

In order to identify barriers affecting university-industry linkages, a survey questionnaire was sent to 138 departments of both public and private universities. A time period of 45 days was allocated to seek response from the departments of universities. Data was collected through E-mail and personnel contact from 69 departments of 15 universities. Detail of departments is as under:

Table 4.1: Detail of respondent departments

Sr. No.	**Name of department**	**No. of Respondents**
1	Computer science and engineering departments	10
2	Electrical engineering departments	9
3	Electronics engineering departments	6
4	Telecom engineering departments	6
5	Mechanical engineering departments	8
6	Industrial & mfr engineering departments	6
7	Metallurgy engineering departments	5
8	Chemical engineering departments	8
9	Textile engineering departments	5
10	Civil engineering departments	6
	Total	69

4.2.1 Departments characteristics

Sixty nine departments of engineering disciplines of 15 institutes of higher education were analyzed in this research. Bachelor of engineering (BE), Masters and PhD engineering programmes are being run by 69 departments of these universities. Summary of the same is given in table 4.2.

Table 4.2: Type of programmes being run

Type of Programme	No. of Departments
UG	64
Masters	60
PhD	39

Table 4.3: Funding Source for University Departments (2006-2009)

Source of funding	No. of departments received funding
GoP	69
Industry(Private)	19
Industry(Public)	2
International agencies	15

Table 4.4: Position of Laboratory Equipment

Item	No. of departments
Sufficient for teaching purpose	55
Insufficient for teaching purpose	14
Sufficient for research purpose	40
Insufficient for research purpose	29

4.2.2 Interaction with Industry

Table 4.5: Interaction of departments with industry

Item	No. of departments
Consultancy	29
Contract research	6
Training programmes	13
Workshops	51
Seminars	54
University Patents	6
Protype developed	24

Table 4.6: Coordination of University-Industry Interactions

Coordinator	Number of coordination made
Individually	96
Research team	23
Industrial liaison office	27
HOD	16

4.2.3 Barriers to University-Industry Interaction

Respondents were asked to assess 13 barriers on four point Liker scale varying from great extent to not at all. The barriers which inhabit university-industry linkages as supposed by faculty are shown as under.

Table 4.7: **Barriers to University –Industry Linkages**

Sr. No.	**Point out to what extent under mentioned factors affect university-industry linkages**	**Great extent(4)**	**Moderate Extent(3)**	**Little Extent(2)**	**Not at All(1)**
1	Lack of research capabilities of researcher	1	11	41	16
2	Lack of confidence to take on research related to industry	0	4	17	48
3	Lack of enthusiasm and entrepreneurial attitude among researcher	31	18	9	11
4	Time limitation because of intense teaching and managerial work load prevents interacting with industry	27	26	12	4
5	Lack of awareness to seek consultancy and contract research	12	36	15	6
6	Making linkages with industry has a depressing impact on educational mission of academia	0	0	16	53
7	Lack of interest on part of industry to engage in collaboration with university	34	20	11	4
8	Collaboration with industry restricts the option of selecting basic research themes	0	14	30	25
9	University infrastructure is insufficient to have U-I collaboration	1	9	22	37
10	Laboratory facilities are inadequate to undertake research relevant to industry	32	13	12	12
11	Lack of adaptation of university structure to the requirements of collaboration with industry	26	25	14	4
12	University rules, regulations and procedures impede collaboration process with industry	35	18	15	1
13	Inappropriate geographical site of the university reduces chances of collaboration with industry	30	32	7	0

4.2.4 Measures for Improvement of University-Industry Interaction

Effectiveness of suggested measures had been assessed by university faculty to ascertain its importance. In table 4.8 view point of university faculty academics on measures for improvement on four point Likert scale varying from very effective not to not at all effective.

Table 4.8: Promotional Measures for University-Industry Interaction

Sr. No.	**Point out to what extent following measures are effective for improving University - Industry linkages (check one against each)**	**Very Effective (4)**	**Effective (3)**	**Slightly Effective (2)**	**Not at all Effective (1)**
1	Inclusion of internship with industries in curriculum	46	20	3	0
2	Encourage visits of students to industry	40	20	9	0
3	Encourage visits of faculty to industry	36	25	8	0
4	Improvement of laboratory equipment	35	22	12	0
5	Involvement of professionals from industrial sector for teaching purpose	10	24	27	8
6	Setting up of U-I liaison offices in universities	35	20	14	0
7	Publicizing university research to industries and their representative bodies	39	20	10	0
8	Conducting seminars, conferences and workshops for professionals from industry	37	22	10	0
9	Reduced taxation for those industries which engage in collaborative activities with universities	42	19	8	0
10	Making it mandatory for faculty to carry out some kind of collaborative work with industrial sector	31	28	10	0
11	Providing increments, awards and promotions related to collaborative work	20	21	25	3

CHAPTER 5

RESULTS, ANALYSIS AND DISCUSSION

5.1 General

Results and analysis of collected data is carried out in two phases. In phase one, results and their analysis is done in a summarized form to give an overall picture of the research. In phase two detail results and analysis of all the three parts of the questionnaire is carried out to give a detail picture of research.

5.2 Summary of Analysis and Discussion

5.2.1 Departments characteristics

Sixty nine departments of engineering disciplines of 15 institutes of higher education were analyzed in this research. Bachelor of engineering (BE), Masters and PhD engineering programmes are being run by 69 departments of these universities. Summary of the same is given in table 5.1.

Table 5.1: Type of programmes being run

Type of Programme	No. of Departments	% of Departments
UG	64	92.7%
Masters	60	86.7%
PhD	39	56.5%

Highest number of under graduate programmes are being run which is followed by Masters and PhD programmes.

Almost hundered percent departments received funding from government of Pakistan (Table 5.3). However, 27.5% departments stated that they had received support from private industry while 22% received funding from international agencies. Only 2% departments received funding from public industry.

Table 5.2: Funding Source for University Departments (2006-2009)

Source of funding	No. of departments received funding	% of departments received funding
GoP	69	100%
Industry(Private)	19	27.5%
Industry(Public)	2	3%
International agencies	15	22%

It is important to look at the ability of university departments critically from the point of view of university-industry linkages. Eighty percent faculty opined that lab equipment is sufficient for teaching (table5.4). However, 42% respondents stated that their lab facilities are inadequate for research purpose. This state may have serious implications and universities may not be able to collaborate effectively with industry.

Table 5. 3: Adequacy of Laboratory Equipments

Item	No. of departments	% of departments
Sufficient for teaching purpose	55	80%
Insufficient for teaching purpose	14	20%
Sufficient for research purpose	40	58%
Insufficient for research purpose	29	42%

5.2.2 Interaction with Industry

Out of 69 departments only 20 (28%) had formal collaboration agreements with industry. Whereas informal interaction with the industry is quite significant, mainly in the form of consultancy, training, seminars and workshops. Only 8% departments conducted contract research which is lowest amongst all, while 78% departments conducted seminars, highest amongst all (Table 5.4).

Table 5. 4: Types of interaction with industry

Item	No. of departments	% of departments
Consultancy	29	42
Contract research	6	8
Training programmes	13	18
Workshops	51	73
Seminars	54	78
University Patents	6	8
Prototype developed	24	34

Table 5.5 indicates that the management of interaction between university and industry are made by individuals (53%) and 21% of the linkages are made by industrial liaison offices.

Table 5. 5: Coordination of University-Industry Interactions

Coordinator	Number of coordination made	% of coordination made
Individually	96	53
Research team	23	13
Industrial liaison office	27	21
HOD	16	13

5.2.3 Barriers to University-Industry Interaction

Respondents assessed 13 diverse barriers on a four point Liker scale with varying weights. As the mean value of Likert scale is 2.5, any results having mean value more than 2.5 are treated as severe constraints and less than 2.5 as mild constraints. The barriers which prevent university-industry interaction according to university faculty is shown in Table 5.6

Table 5. 6: Barriers to university-industry Linkages

Sr. No.	**Point out to what extent under mentioned factors affect university-industry linkages:**	Mean Score
1	Lack of research capabilities of researcher	1.96
2	Lack of confidence to take on research related to industry	1.36
3	Lack of enthusiasm and entrepreneurial attitude among researcher	3.4
4	Time limitation because of intense teaching and managerial work load prevents interacting with industry	3.1
5	Lack of awareness to seek consultancy and contract research	2.78
6	Making linkages with industry has a depressing impact on educational mission of academia	1.23
7	Lack of interest on part of industry to engage in collaboration with university	3.21
8	Collaboration with industry restricts the option of selecting basic research themes	1.84
9	University infrastructure is insufficient to have U-I collaboration	1.62
10	Laboratory facilities are inadequate to undertake research relevant to industry	2.62
11	Lack of adaptation of university structure to the requirements of collaboration with industry	3.5
12	University rules, regulations and procedures impede collaboration process with industry	3.26
13	Inappropriate geographical site of the university reduces chances of collaboration with industry	1.69

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Impact value of each factor is calculated by following simple formula:-

$$I = \Sigma (F)/N$$

Where

I = Severity Impact of each factor

F = Factor Severity

N = Total number of responses

Severity impact of each factor is defined as under

- Factors having impact value between 1-2 are mild factors
- Factors having impact value between >2-3 are moderate factors
- Factors having impact value between >3-4 are severe factors

Factors1,2, 6, 8 and 9 are mild one as their value ranges from 1-2. Factor number 3, 5 and 10 are moderate one and finally factors 4, 7, 11, 12 and 13 are severe factors for university-industry linkages.

5.2.4 Measures for Improvement of University-Industry Interaction

In order to seek view point of university faculty with regard to measures for improvement of university- industry linkages, 11 suggestions were required to be assessed by them. Except for factor 5 all other factors are very effective for improving university-industry interaction.

Table 5. 7: . Suggestions for Improving University-Industry (U-I) Linkages

Sr. No.	Point out to what extent following measures are effective for improving University -Industry linkages (check one against each)	Mean value
3	Inclusion of internship with industries in curriculum	3.5
4	Encourage visits of students to industry	3.6
5	Encourage visits of faculty to industry	2.3
6	Improvement of laboratory equipment	3.3
7	Involvement of professionals from industrial sector for teaching purpose	3.7
8	Setting up of U-I liaison offices in universities	3.2
9	Publicizing university research to industries and their representative bodies	3
10	Conducting seminars, conferences and workshops for professionals from industry	2.1
11	Reduced taxation for those industries which engage in collaborative activities with universities	2

5.3 Individual Results and Analysis

5.3.1 Present State of University-Industry Linkages

A number of close ended questions were asked from the respondents to determine present state of university-industry linkages. In pre-testing phase of questionnaire it was advised by the respondents not to ask hard data because they consider it university secret which may expose their weaknesses. Deliberately minimum hard data was asked mainly due to the said reasons.

5.3.1.1 Engineering Programmes

During the last eight years our engineering universities have upgraded their engineering programmes ranging from undergraduate to doctorate level. Quality of these programmes has also been improved considerably. Intake criteria of both undergraduate and postgraduate students have been standardized by HEC, thereby improving intake quality. A question was asked "what programmes are being offered by your department". Detail of programmes being offered by surveyed engineering discipline is shown in table 5.8 and figure 5.1(absolute numbers).

Table 5. 8: Programmes offered in each discipline

Type of Discipline	No. of Respondents	UG		Masters		PhD	
		#	%	#	%	#	%
Computer Engg	10	10	100	9	90	5	50
Electrical Engg	8	9	100	9	100	8	89
Electronics engg	6	6	100	5	83	3	50
Telecom Engg	6	6	100	4	67	2	33
Mechanical Engg	8	8	100	7	88	6	75
Industrial & Mfr Engg	6	4	67	5	83	2	33
Metallurgy Engg	5	5	100	4	80	1	20
Chemical Engg	8	6	75	6	75	4	50
Textile Engg	5	4	80	5	100	2	40
Civil Engg	6	6	100	6	100	6	100

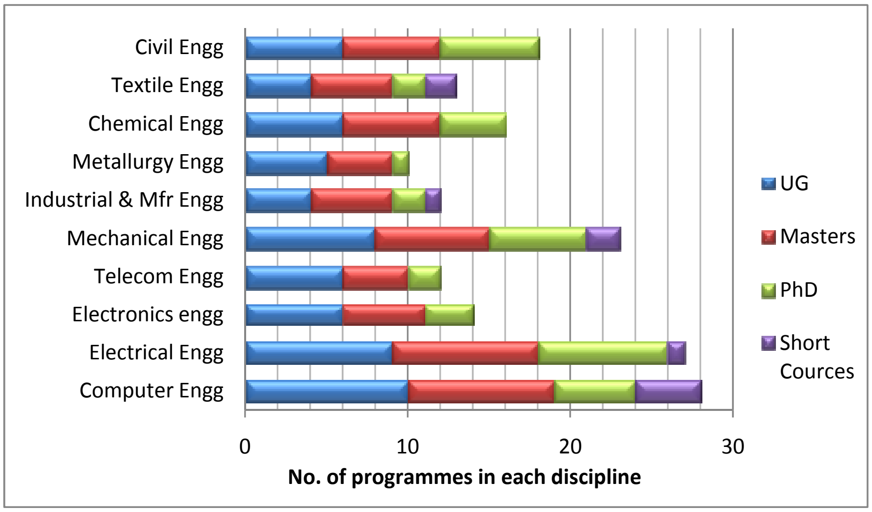

Figure 5. 1: Type and no. of programmes offered in each discipline

In all ten disciplines of engineering ,most of departments are offering UG, Masters and PhD programmes .Only in civil engineering discipline,100% departments are offering UG, Masters and PhD programmes, whereas in telecom discipline only 33% departments are offering PhD programmes. Overall, highest number of programmes is being offered in UG which is followed by masters and PhD.

4.3.1.2 Source of Funding

Respondents were asked "did their department receive any fund from private industry, public industry, private foundations, GoP and international agencies during the last three years" .Table 5.9 shows that 100% departments received funding from GoP. With exception of textile and chemical engineering departments, industrial funding remained very poor for all other departments. Same is the case with funding from international agencies. There has been no funding to any department from private foundations. Government cannot keep on providing funding to universities for extended period of time, universities need to build relations with industries and get funding from them to meet their requirements in times to come. Universities must take initiative and make access to industry in order to convince them for solving their problems, improving their process and enhancing their productivity. That is the only way forward for attracting funds from industry.

Table 5. 9: Funding sources for universities departments (2006-2009)

Type of Discipline	Total no. of departments	Number of departments received funds from				
		Industry (private)	Industry (public)	Private foundations	GoP	International agencies
Computer Engg	10	2	0	0	10	2
Electrical Engg	9	3	0	0	9	1
Electronics engg	6	0	0	0	6	0
Telecom Engg	6	2	0	0	6	0
Mechanical Engg	8	2	1	0	8	1
Industrial Engg	6	1	0	0	6	0
Metallurgy Engg	5	0	1	0	5	0
Chemical Engg	8	5	0	0	8	3
Textile Engg	5	4	0	0	5	2
Civil Engg	6	0	0	0	6	1

5.3.1.3 Adequacy of Laboratory Facilities

Universities which are having well equipped laboratories are in better position to provide research and consultancy services to relevant industry and solve their problems.

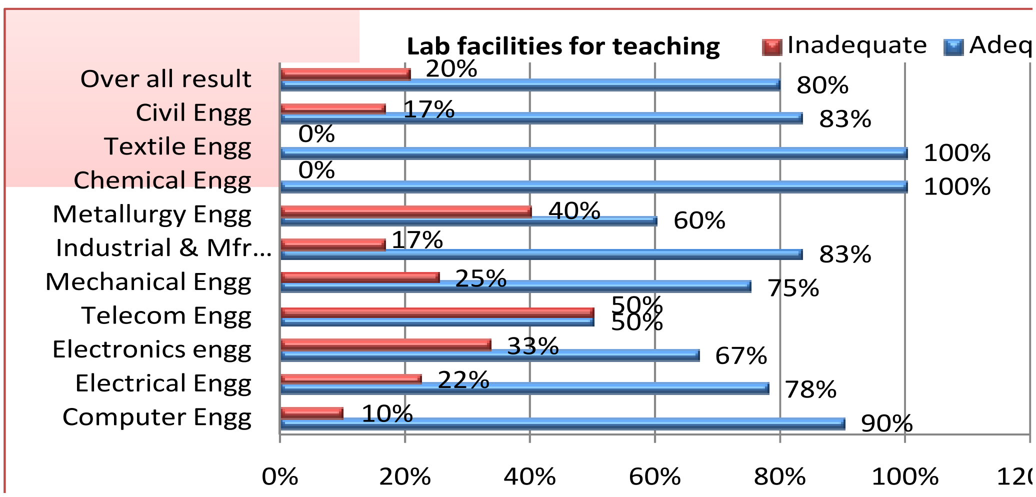

Figure 5. 2: Adequacy of lab facilities for teaching purpose

Figure 5.2 shows that most of respondents are of the view that their lab facilities are adequate for teaching purpose. Hundred percent respondents of chemical and textile engineering departments mentioned that their lab facilities are adequate for teaching purpose. Fifty percent telecom engineering respondents said that their lab facilities are inadequate for teaching purpose. This concern needs to be addressed.

Figure 5.3 shows that for research purpose lab facilities of textile, chemical and computer engineering department are extremely good. Eighty percent respondents of metallurgy and 67% of telecom engineering departments mentioned that their facilities are in adequate for research.

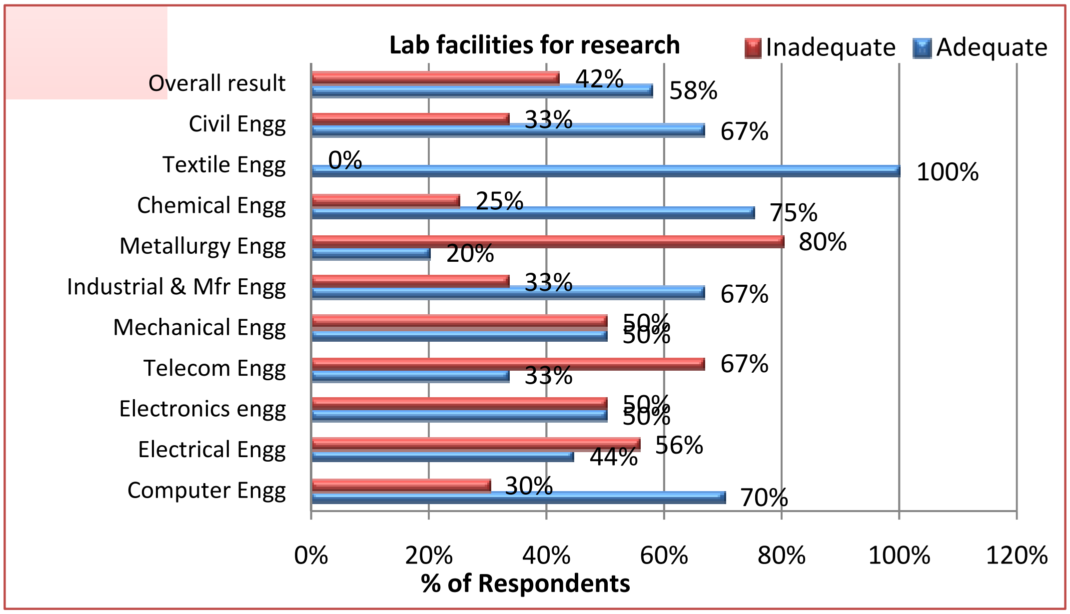

Figure 5. 3: Adequacy of lab facilities for research purpose

5.3.1.4 Formal Collaboration Agreements with Industry

Formal collaboration agreements with industry are one of the yardsticks to measure university- industry linkages in any country. Departments were asked "did they have any formal collaboration agreements with industry". Table 5.10 shows very dim picture of formal collaboration agreements with industry. Only chemical and textile engineering disciplines are having significant formal collaboration agreements with industry. Computer engineering discipline, with good teaching and research capabilities, needs to follow foot steps of chemical and textile engineering disciplines. Other than chemical and textile engineering discipline all other discipline needs to make dedicated effort for having meaningful and effective formal industrial collaborations.

Table 5. 10: Formal collaborations with industry

Type of Discipline	Total no of departments	Formal collaboration	
		Yes	No
Computer Engg	10	30%	70%
Electrical Engg	9	22%	78%
Electronics engg	6	17%	83%
Telecom Engg	6	33%	67%
Mechanical Engg	8	25%	63%
Industrial & Mfr Engg	6	17%	83%
Metallurgy Engg	5	20%	80%
Chemical Engg	8	63%	38%
Textile Engg	5	80%	20%
Civil Engg	6	33%	67%
Overall	69	33%	65%

4.3.1.5 Existence of Industry Liaison Offices

Universities around the world have industry liaison offices to professionally manage university industry linkages. Well trained staff must be placed in these offices which can provide guidance to researchers as well as industrialists. Our survey shows that 73% universities have industrial liaison offices, which is very healthy percentage.

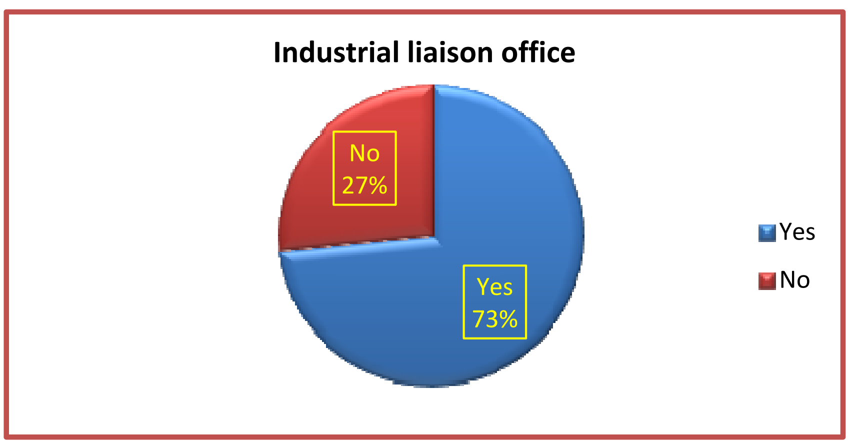

Figure 5. 4: Existence of industrial liaison offices in universities

5.3.1.6 Services Offered to Industry

Respondents were asked what services have been provided by your departments to industry. Table 5.11 shows result of feedback received from respondents. It is revealed that consultancy services were provided by all engineering disciplines, textile engineering discipline with highest figure of 80 percent. Contact research was undertaken by four disciplines, while six disciplines have no contribution in this area. Workshops and seminars is the only area where maximum activity is shown by the departments. Patent activity is extremely weak only three disciplines are visible in this important area. Patents are direct reflection of university research which has commercial value. In USA 75% patents are filed by universities that show the significance of university research. With exception of three disciplines all other developed prototypes, computer engineering discipline with highest figure of 80 percent.

Table 5. 11: Number of departments offered services to industry (2006- 2009)

Type of Discipline	Consultancy	Contract research	Training programmes	workshops	Seminars	University Patents	Prototypes developed
Computer Engineering	4	1	4	7	9	0	7
Electrical Engineering	3	1	2	6	7	0	2
Electronics Engineering	1	0	0	3	4	1	2
Telecom Engineering	2	0	0	4	5	0	1
Mechanical Engineering	3	1	3	5	6	2	4
Industrial & Mfr Engineering	3	0	0	5	4	0	0
Metallurgy Engineering	1	0	0	4	3	0	0
Chemical Engineering	5	2	0	8	8	3	5
Textile Engineering	4	1	4	5	4	0	3
Civil Engineering	3	0	0	4	4	0	0

5.3.1.7 Coordination of Interaction with Industry

Respondents were asked how their interaction with industry was coordinated. Although 73% of surveyed universities have industrial liaison office, but figure 5.5 shows that majority of interaction with industry was coordinated by individuals. This data reveals that industrial liaison offices are not functioning efficiently. However, the activity made by industrial liaison office is higher than that of HODs and individual research teams.

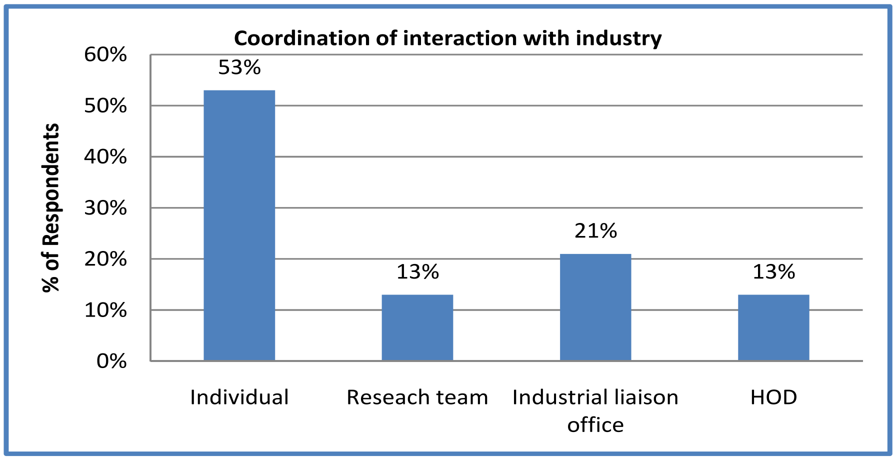

Figure 5. 5: Coordination of interaction with industry

5.3.1.8 Research Proposals

A question was asked to determine whether or not departments submitted research proposals to any agency. Table 5.12 shows that maximum proposal were submitted to GoP/Ministries/Departments followed by private industry.

Table 5. 12: Number of departments submitted research proposals (2006-2009)

Type of Discipline	Total no. of departments	Number of departments received funds from				
		Industry (private)	Industry (public)	Private foundations	International agencies	GoP/Ministries/ Departments
Computer Engg	10	4	0	0	2	5
Electrical Engg	9	3	0	0	4	6
Electronics engg	6	1	0	0	0	5
Telecom Engg	6	2	0	0	0	4
Mechanical Engg	8	3	2	0	3	6
Industrial & Mfr Engg	6	1	0	0	0	3
Metallurgy Engg	5	1	0	0	0	4
Chemical Engg	8	5	0	0	3	7
Textile Engg	5	3	0	0	2	2
Civil Engg	6	4	1	0	1	4

5.3.2 Constraints to University- Industry Collaboration

University-Industry collaboration is vital for sustained economic growth and socioeconomic development of the nation. Developed countries are having strong collaboration and are reaping its fruit however countries like Pakistan are very weak in this area. A survey was carried out to ascertain what factors prevent our universities to interact with industry. View point of respondents was obtained on most relevant and important questions. Detail of factors and respondent's opinion is given in succeeding paragraphs.

5.3.2.1 Lack of Research Capabilities of Researcher

Research capability is fundamental to creation of new knowledge, development of new products and addressing problems. Universities having excellent research capabilities are better positioned to interact with relevant industry. Research capabilities include professional education and experience of researcher and availability of relevant material. Detail of respondents view on "to what extent our research capabilities are relevant to the industry" is shown in figure 5.6.

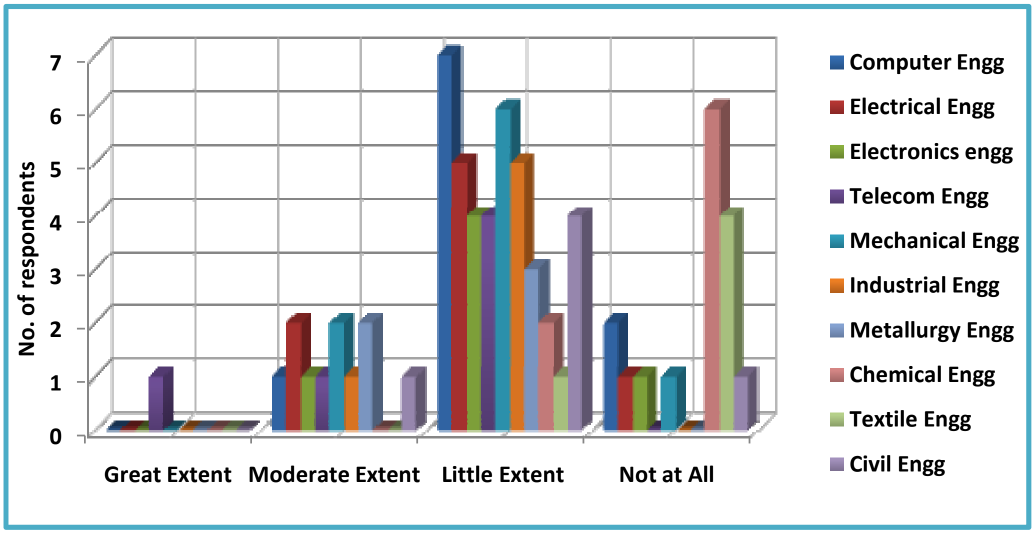

Figure 5. 6: Lack of research capabilities of researcher

Once the detail results are consolidated a clear picture emerges of respondent's views on "to what extent our research capabilities are relevant to the industry" .Results of consolidated response is shown in figure 5.7.

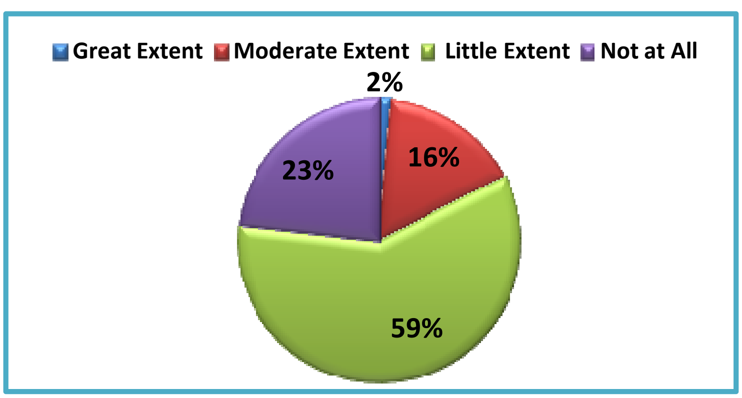

Figure 5. 7: Consolidated result of respondents view

Results and analysis of respondent's views is as under:

a. Overall 2% respondents are of the opinion that to **great extent** there is lack of research capabilities of researcher.

b. Fifty nine percent (59%) respondents opined that to little extent there is lack of research capabilities of researcher, which is quite a high percentage In this shade(moderate extent), highest 83% and lowest 20% respondents belong to industrial and chemical engineering disciplines respectively.

c. Sixteen percent (16%) respondents opined that to moderate extent there is lack of research capabilities of researcher. In this shade (moderate extent), highest 40% respondents of metallurgy engineering discipline are prominent amongst others.

d. 23% respondents opined that our researcher do not lack of research capabilities at all.

e. Above mentioned analysis suggests that by enlarge research capabilities of our academics are good enough to under take industry related research, but its practical demonstration is weak

5.3.2.2 Lack of Confidence to Undertake Industrial Research

Alone capabilities with out confidence or alone confidence with out capabilities cannot produce realistic desired results. In fact, confidence comes through a mix blend of competence, education, knowledge and experience. Academics confidence is prerequisite for making things to happen and putting plans into action. Academics that possess desired level of confidence are better equipped to undertake industrial research than those which don't have confidence. Respondent's views were solicited on "to what extent lack of confidence to undertake industry oriented research affects university-industry linkages". Graphical representation of respondent's views is shown in figure 5.8.

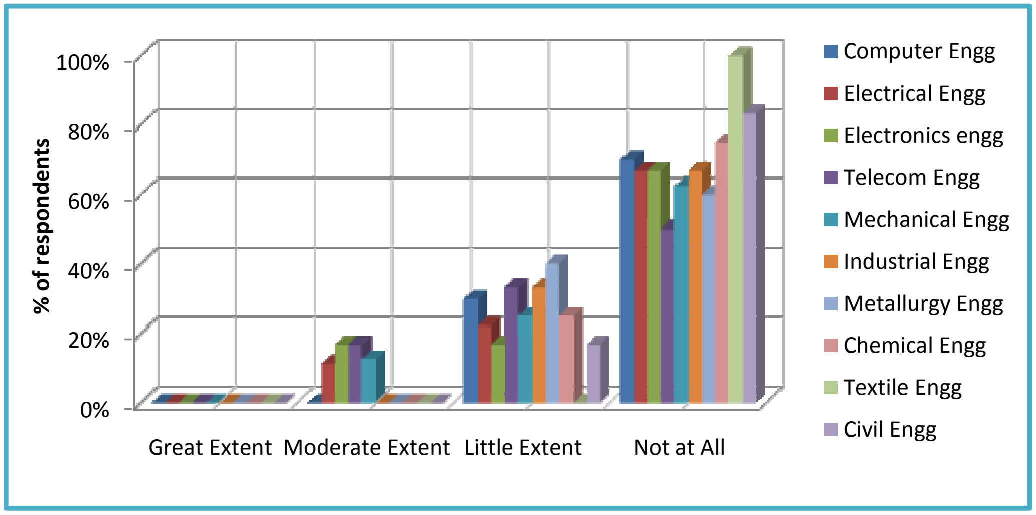

Figure 5. 8: Lack of confidence to undertake industry oriented research

Results and analysis of respondent's views is as under:

a. Overall 69 % respondent opined that there is no lack of confidence at all to undertake industry oriented research. Hundred percent (100%) respondents of textile engineering departments and 83% of civil engineering departments are fully confident to undertake industrial research. However, only 50% telecom engineering respondents are fully confident and this is the minimum score in this group. These results indicate high level confidence of our academics to under take industry related research.

b. Twenty five percent (25%) respondents are of the view that to **little extent** they lack of confidence to undertake industry oriented research. In this shade, highest 40% and lowest 17% respondents belong to metallurgy and electronics engineering disciplines respectively.

c. Only 6% respondents opined that to moderate extent they lack of confidence to undertake industry oriented research. Reasons could be; fresh entrants, weak knowledge of industry, lack of requisite professional qualification.

d. No respondents are noted who passed their opinion in shade 1(great extent) of the scale.

5.3.2.3 Lack of Enthusiasm and Entrepreneurial Attitude

Entrepreneurial spirit is the urge and desire to interact with industry and engage in commercialization of research knowledge. Entrepreneurship gives birth to spinning off firms and new start up firms. It brings funds to the university as well as to the faculty engaged in this activity. Academics in Europe and USA are highly committed in entrepreneurial activities to make their industry competitive through innovation and generate funds for universities. In Asia, National University of Singapore has shifted its focus towards an enterprise university.

In our survey, respondents were asked to give their view on "lack of motivation and entrepreneurial spirit among faculty". Views of respondents are shown in figure 5.9.

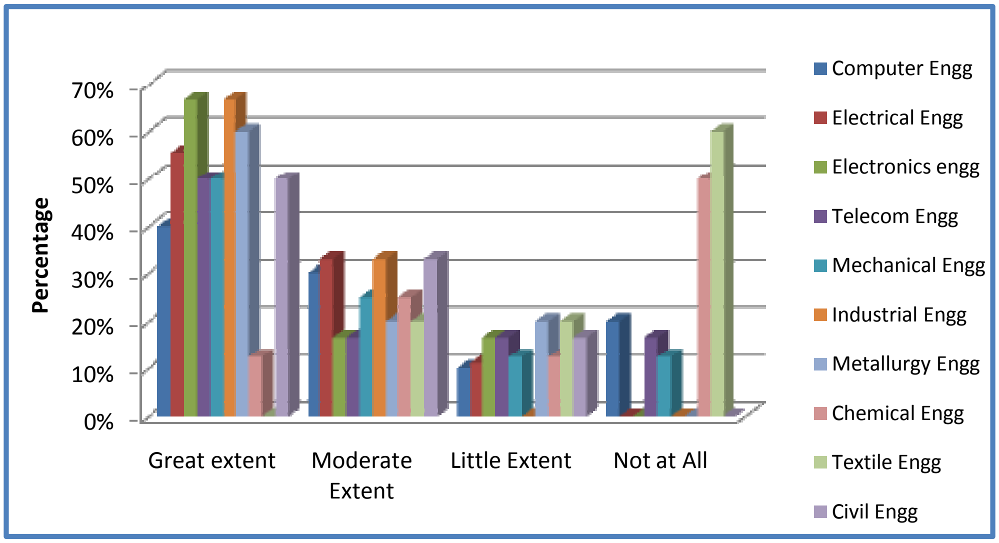

Figure 5. 9: Lack of enthusiasm and entrepreneurial attitude

Once the detail results are consolidated a clear picture emerges of respondent's views on "lack of motivation and entrepreneurial spirit among faculty". Results of consolidated response are shown in figure 5.10.

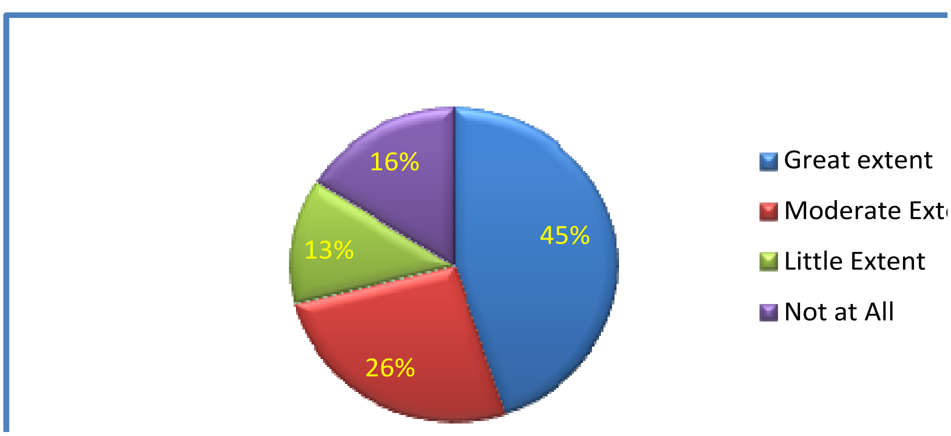

Figure 5. 10: Consolidated result of lack of motivation and entrepreneurial spirit

Results and analysis of respondent's views is as under:

a. Overall 45% respondent of all departments opined that to great extent Lack of enthusiasm and entrepreneurial attitude among researcher affects university-industry collaboration. Electronics and industrial engineering discipline respondents score is highest amongst all others, which is 67%.It implies that lack of motivation and entrepreneurial spirit is major barrier.

b. Twenty five percent respondents opined that to a moderate extent they lack of motivation and entrepreneurial spirit. Computer, industrial and civil engineering discipline respondents score is highest (33%) while lowest score of 10% is observed in textile engineering group.

c. Overall thirteen percent opinion of respondents is noted in third shade (very little extent) of scale, showing this aspect as a constraint to little extent.

d. Only 16% respondents opined that they do not lack motivation and entrepreneurial spirit. Score of textile engineering discipline is highest (60%) which is followed by chemical engineering discipline (50%).

e. These results reflect that there is dire need to motivate and encourage entrepreneurial spirit amongst the faculty.

5.3.2.4 Time limitation because of intense work load

Teaching and research are the basic function of any traditional university, no matter the research out put carries any commercial value. Teaching activities involve preparation and delivering of lectures, setting up of exam papers and conducting exams. Academic are also engaged in conducting research themselves and assisting students in carrying out their research work. Apart from this commitment, academics are also loaded with administrative responsibilities of the departments. If all these activities are not efficiently managed, problem of time constraint will always be faced. Respondents view on “time constraint due to heavy teaching and administrative work load” is shown in figure 5.11.

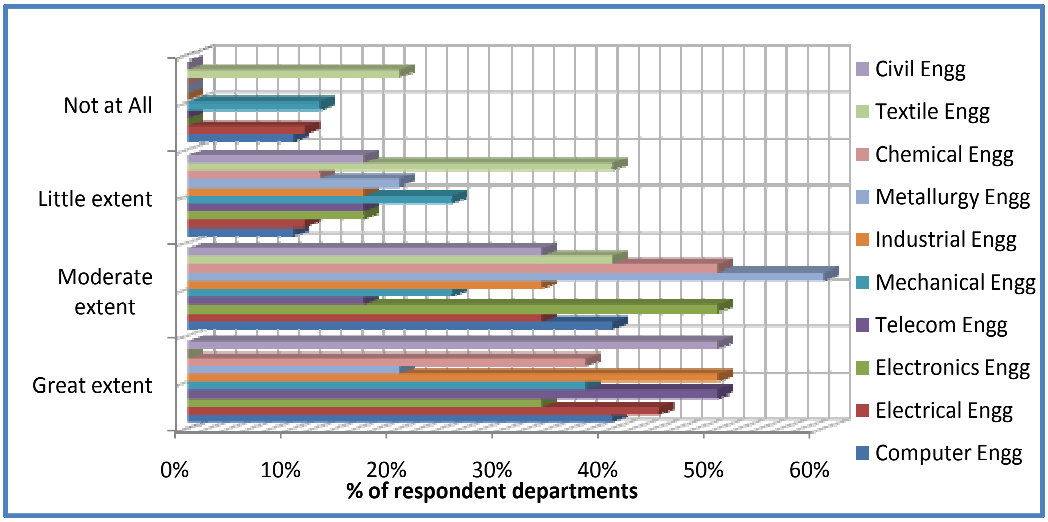

Figure 5. 11: Time limitation because of intense work load
Results and analysis of respondent's views is as under:

a. Overall 39% respondent of all disciplines opined that to a **great extent** heavy teaching and administrative work load prevented them from interacting with industry**.** In this shade highest score of 50% is noted in industrial and civil engineering disciplines.

b. Thirty eight percent respondents of all ten disciplines are of the view that heavy teaching and administrative work load prevented them from interacting with industry to a **moderate extent.** Highest response (68%) of metallurgy engineering and lowest response (17%) of telecom engineering is observed in this shade.

c. Overall 17% respondents mentioned that to little extent this aspect affects them. Respondent of textile engineering discipline with highest score of 40% are prominent in this shade of the scale.

d. Respondents of only four disciplines with an average score of 15% feel that heavy work load does not prevent interaction with industry at all. Here again textile engineering respondents score is highest (20%).

e. Consolidated results (figure 5.12) suggest that majority of academics (39%) feel that heavy teaching and administrative work load poses time constraint to great extent. While an almost same percentage (38%) of academics feels that to a moderate extent heavy work load hinders their interaction with industry. Seventeen percent respondents think that to little extent heavy work load affects their interaction with industry. Only 6% respondents do not consider it a constraint at all. It can be concluded that academics are heavily loaded with responsibilities of teaching and administrative works. Deans must follow a balanced approach to shed away unnecessary work load of researchers.

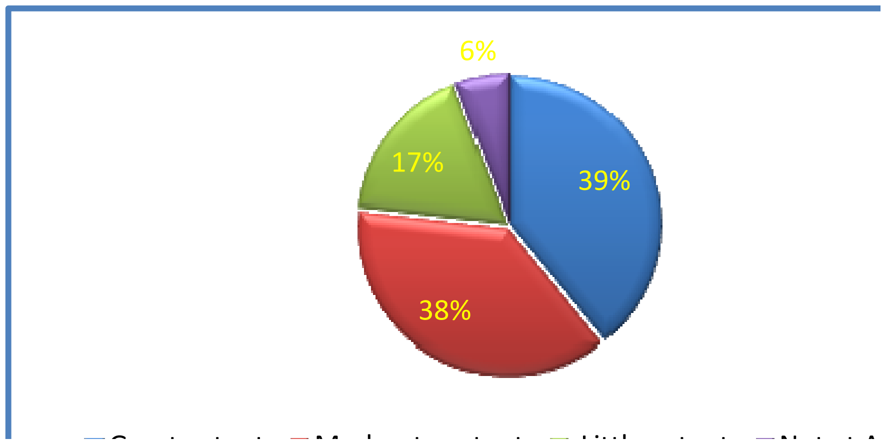

Figure 5. 12: Consolidated response of all respondents

5.3.2.5 Lack of Awareness for Getting Sponsored Research

Consultancy is one of the simplest ways for business to interact with universities and draw on their research. Increasing consultancy may be one way to bring more companies into contact with universities. It may increase the volume of research collaboration, with many contracts originating from consulting relationships.

It is important for academics to know how and from where to get consultancy and other sponsored assignments . These channels may include local industry both public and private, government departments, NGOs and international agencies. In industrialized and developed countries bulk of sponsored research and consultancy assignment come from their industry side.

Same is not the case in Pakistan. Our industry is not yet geared up to collaborate with academia. Academics must take initiative and convince industrialists of their great potential of providing cost effective solutions, improving industrial processes and enhancing productivity. So academics must know all possible channels and ways of accessing those channels for securing consultancy and research assignments. In our survey respondents views were invited on "academics are not aware of the possible channels for getting sponsored research and consultancy assignments". Figure 5.13 gives a detail picture of respondents view on this issue.

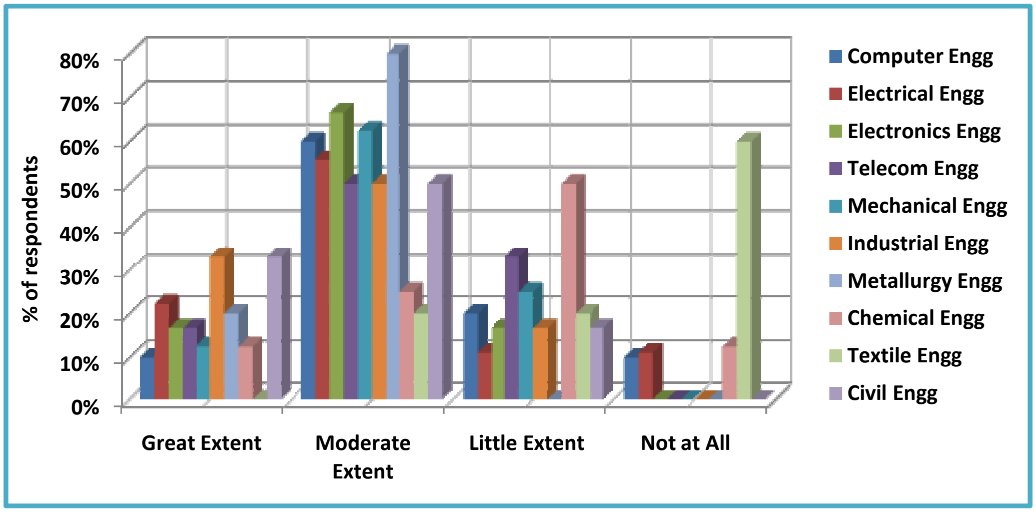

Figure 5. 13: Lack of awareness for getting sponsored research

Results and analysis of respondent's views is as under:

a. Seven teen percent (17%) respondents opined that to great extent they Lack of awareness to seek consultancy and contract research. Civil engineering respondents with a highest score of 33% and computer engineering respondents with lowest score of 10 % are prominent in this shade of scale.

b. Fifty two percent (52%) respondents opined that to moderate extent they Lack of awareness to seek consultancy and contract research. Metallurgy engineering respondents with a highest score of 80% and textile engineering respondents with lowest score of 20 % are prominent in this shade of scale.

c. Twenty two percent (22%) respondents opined that to little extent that Lack of awareness to seek consultancy and contract research. Chemical engineering respondent's score is highest (50%) and that of electrical is lowest (11%) in this shade of scale.

d. Only 9 % respondents opined that they do not lack of awareness to seek consultancy and contract research. In this shade, textile engineering respondents are prominent with highest score of 60%.

e. Results of figure 5.14 shows majority of our academics lack of awareness to seek consultancy and contract research. This constraint needs to be reversed by overcoming following reasons:

- Inefficient working of industrial liaison offices.

- Lack of initiative of academics.
- Lack of proper guidance.
- Lack of interest of academics.

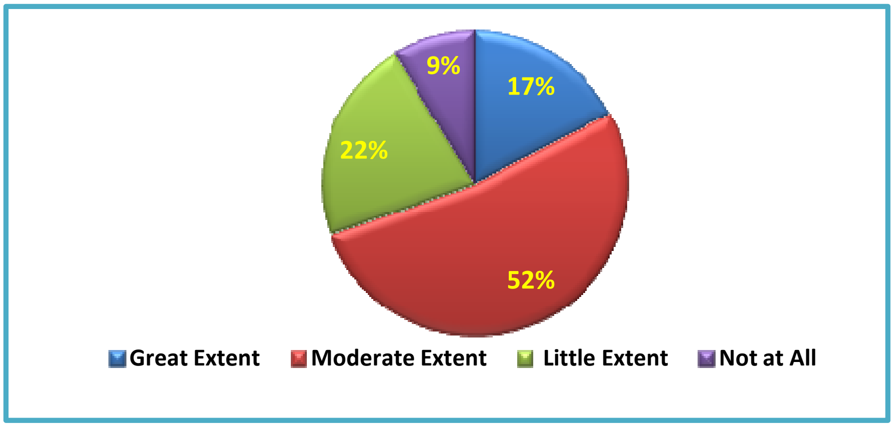

Figure 5. 14: Consolidated response of all respondents

5.3.2.6 Influence of Collaboration on the Educational Mission of University

In today's world of competitiveness and innovation, collaboration with industry is one of highest priority on the agenda of university policy makers. The same concern, to some extent, also exists in our universities at least in papers. This argument is supported by the fact that 73% of surveyed universities have industrial liaison offices. Generally it is considered that benefits of industrial collaboration are enormous which must be tapped. However, a debate always remains open about the enterprise role of university. Some quarters of academics view this activity is detrimental to the educational mission of the university. Respondent's views were solicited on "collaboration with industry has a negative influence on the educational mission of a university". The outcome of respondent's views is shown in figure 5.15.

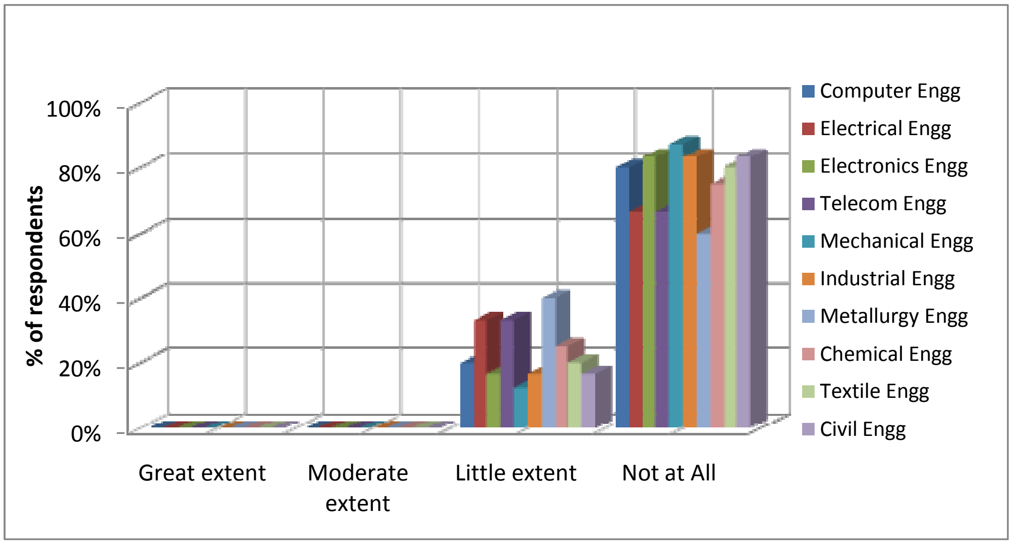

Figure 5. 15: Making linkages with industry has a depressing impact on educational mission of academia

Results and analysis of respondent's views is as under:

a. An over whelming percentage of respondents (77%) consider that making linkages with industry does not has a depressing impact on educational mission of academia university.

b. Only a small percentage of respondents (13%) opined that to little extent making linkages with industry has a depressing impact on educational mission of academia.

c. These result shows that our academics are fully aware of the importance of industrial collaboration, which has a direct relevance to socio-economic development of the country.

5.3.2.7 Industry's Interest to Collaborate with Universities

University-Industry collaboration is like two way traffic which must keep on going for sharing mutual benefits. Internationally it is an accepted fact that companies which use universities and other higher education institutions as a source of information or as a partner tend to be significantly more successful than those that don't.

By enlarge our industrialist are not really keen to interact with academia mainly due to their ignorance regarding university's potential of delivering benefits to industry. There is also a role for government in promoting demand from business for the knowledge and ideas. Individual companies may not have the time or capacity to find out which university is doing research work that is relevant to their needs. Views of respondents were obtained on "Lack of interest on part of industry to collaborate with universities". Opinion of respondents is shown in figure 5.16

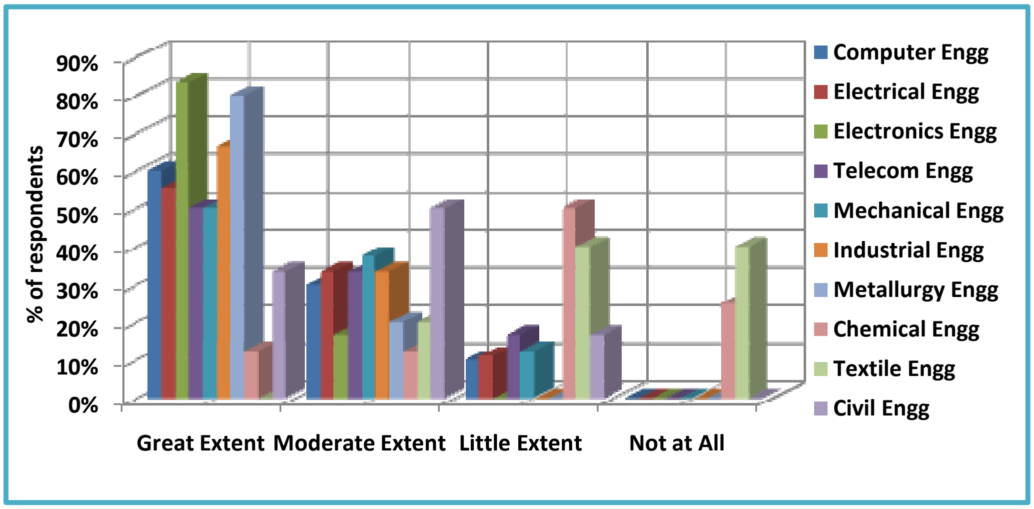

Figure 5. 16: Lack of interest on part of industry to collaborate with universities

Results and analysis of respondent's views is as under:

a. Overall 49% respondent of all disciplines opined that to great extent our industry is not interested to collaborate with university. Highest number of electronics engineering discipline respondents (83%) gave their opinion in this shade.

b. Twenty nine percent (29%) respondents used the second shade of scale (moderate extent) to express their opinion. Civil engineering discipline respondents with a highest score of 50% and chemical engineering respondents with lowest sore of 13% are prominent in expressing their views.

c. Sixteen percent (16%) respondents opined that to little extent there is lack of interest on part of industry to collaborate with universities. Chemical engineering discipline respondents with a highest score of 50% and electrical engineering respondents with lowest sore of 11% are prominent in this shade of scale.

d. Only 6% respondents opined that industry is willing to collaborate with university. Textile engineering respondents are prominent in this shade.

5.3.2.8 Collaboration with industry restricts the option of selecting basic research themes

Creation of new knowledge takes place through continuous research process of universities. Applied research has direct relevance to industry in one or the other form and basic research provides foundation for applied research. In an entrepreneurial university, focus of research is biased towards commercialization of knowledge and its industrial application. There is a perception that collaboration with industry restricts the option of selecting basic research themes. Respondents were asked to give their opinion on "to what extent collaboration with industry limits free choice of research topics". Detail of results of respondent's views is shown in figure 5.17.

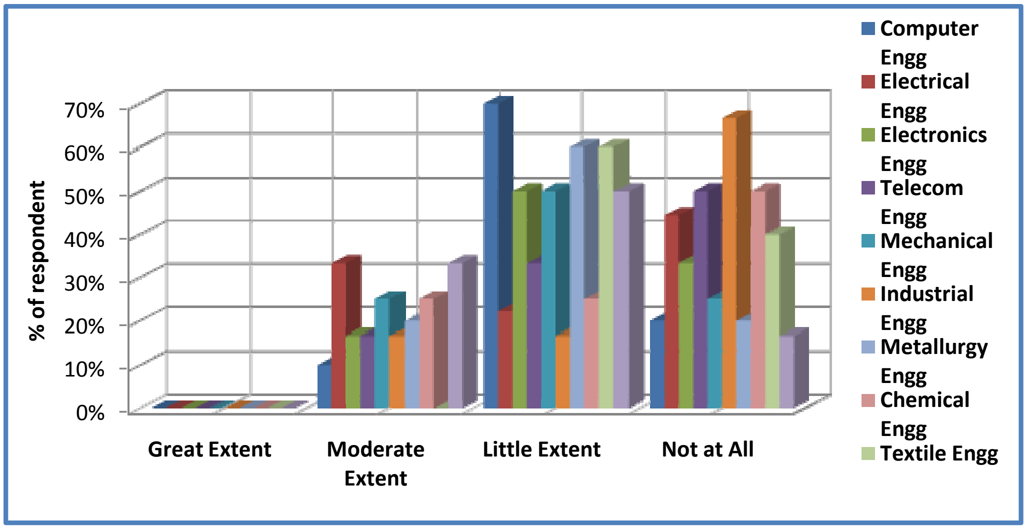

Figure 5. 17: Collaboration with industry restricts the option of selecting basic research themes

Results and analysis of respondent's views is as under:

a. Twenty percent respondents feel that to moderate extent collaboration with industry restricts the option of selecting basic research themes. Thirty three percent respondents of civil engineering discipline are prominent in this shade of scale.

b. A high percentage of respondents (43%) opined that to little extent collaboration with industry restricts the option of selecting basic research themes. This means that majority of academics are desirous to get research topics from industry. Computer engineering respondents are prominent in this shade with highest score of 70%.

c. Remaining 36% respondents feel that collaboration with industry do not restrict the option of selecting basic research themes at all. These academics are dynamic and practical in nature who loves to interact with industry. Highest number, Sixty seven percent, respondents of industrial engineering discipline voiced their opinion in this shade.

5.3.2.9 Adequacy of University Infrastructure

Infrastructure includes building, transport, communication, books, digital libraries and a long list of other items. Most of the academic, research and development problems are linked with root cause of inadequate infrastructure. There is strong evidence that our HEC has injected huge amount of development funds to uplift public sector universities. In this regard, HEC has taken a number of initiatives most prominent is free access to hundreds of journals and books. A good university infrastructure is enabler for university industry collaboration. Respondent's views were solicited on "to what extent university infrastructure is adequate". Results of respondent's views are shown in figure 5.18.

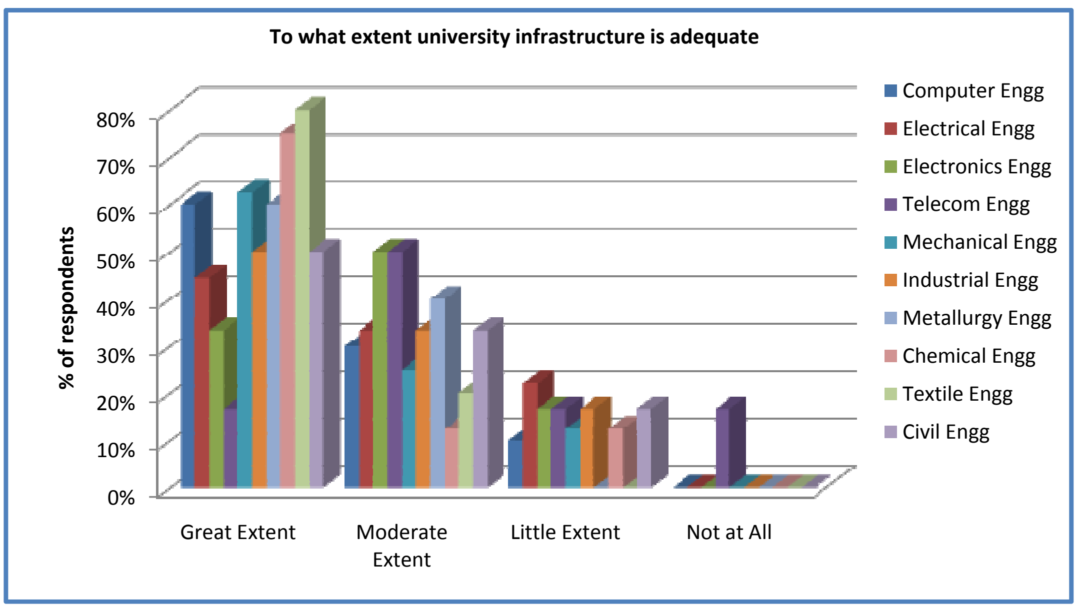

Figure 5. 18: Adequacy of university infrastructure

Results and analysis of respondent's views is as under:

a. A vast majority of respondents (54%) opined that to great extent university infrastructure is adequate. This result is clear reflection of efforts made by HEC to develop and uplift infrastructure of universities.

b. 32% respondents opined that to moderate extent university infrastructure is adequate for both teaching and research activities. Respondents of telecom engineering with highest percentage are prominent in this shade.

c. Only 13% responds are of the view that to little extent university infrastructure is adequate for both teaching and research activities. These respondents are may be comparing adequacy of their departments with that of advance countries.

d. Only very small percentage (1%) opined that university infrastructure is inadequate for both teaching and research activities. Again these respondents belong from UET Kohat, which is in the process of establishing itself.

e. While concluding the analysis it can be said with confidence that university infrastructure is adequate for both teaching and research activities. Since most of surveyed universities have long history of their existence and have developed over a period of time.

5.3.2.10 Adequacy of Lab Facilities

Adequate laboratory facilities are essential for both teaching and research activities to effectively take place in any university. If university labs are not well equipped with necessary specialized equipment, the quality of outgoing graduate students will be seriously challenged in the market place. More over universities will not be able to interact and deliver to the industry. Bulk of researches and developments take place in USA and Europe can be attributed to their strong and well equipped labs. Although some improvement took place in past few years, but still our labs are not adequately equipped to undertake advance research. Respondents were asked to give their opinion on this important aspect "to what extent lab facilities are adequate for undertaking research". Views of respondents are shown graphically in figure 5.19.

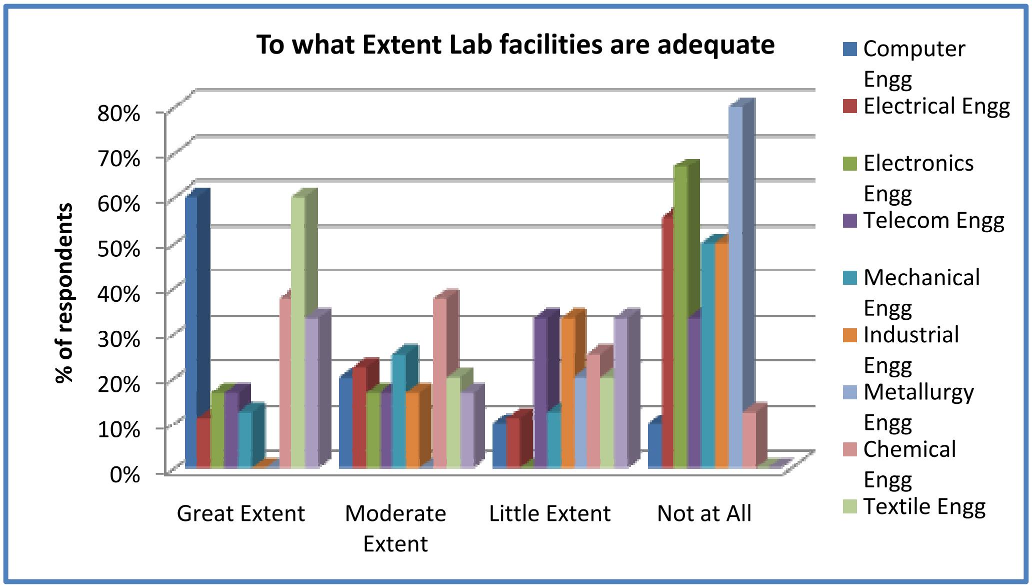

Figure 5. 19: Adequacy of university lab facilities

Results and analysis of respondent's views is as under:

a. Twenty six (26%) respondents are of the opinion that to great extent their lab facilities are adequate for research purpose. Respondents of computer and textile engineering disciplines are most significant with 60% score each in this shade of scale. Most of the NUST colleges/ Schools passed their opinion in this shade.
b. Twenty percentage (20%) of respondents opined that to moderate extent their lab facilities are adequate for research purpose. Respondents of chemical engineering discipline are prominent with 38% in this shade of scale.
c. Nineteen percent (19%) respondents are of the view that to little extent their lab facilities are adequate for research purpose. This shade of scale is area of concern for the academics of respective departments. Efforts must be made to over come this situation.
d. Remaining 35% respondents opined that their lab facilities are not adequate for research purpose. Metallurgy engineering discipline is most prominent (80%) by giving their view in this shade. This situation must cause a concern for academics and they must engage all possible resources to reverse present scenario.

5.3.2.12 Effect of University Norms and Procedures

Generally it is considered that bureaucratic culture prevails in the universities around the world. Intellectual property rights, patents, transfer of technology and other such matters are governed by university rules and regulations, under the umbrella of regional and central government laws. In USA Bayh Dole act was passed in 1980, where intellectual property rights were given to universities from central government. This act changed complete scenario in USA universities, applied research took a new dimension of unprecedented growth.

Policies are there to regulate university matters. Norms and procedures are derived from rules and regulations. Stringent policies and procedures are likely to hamper collaboration with industry. Respondents were asked to give their opinion on "to what extent university norms and procedure hamper collaboration with industry". Views of respondents are shown graphically in figure 5.20.

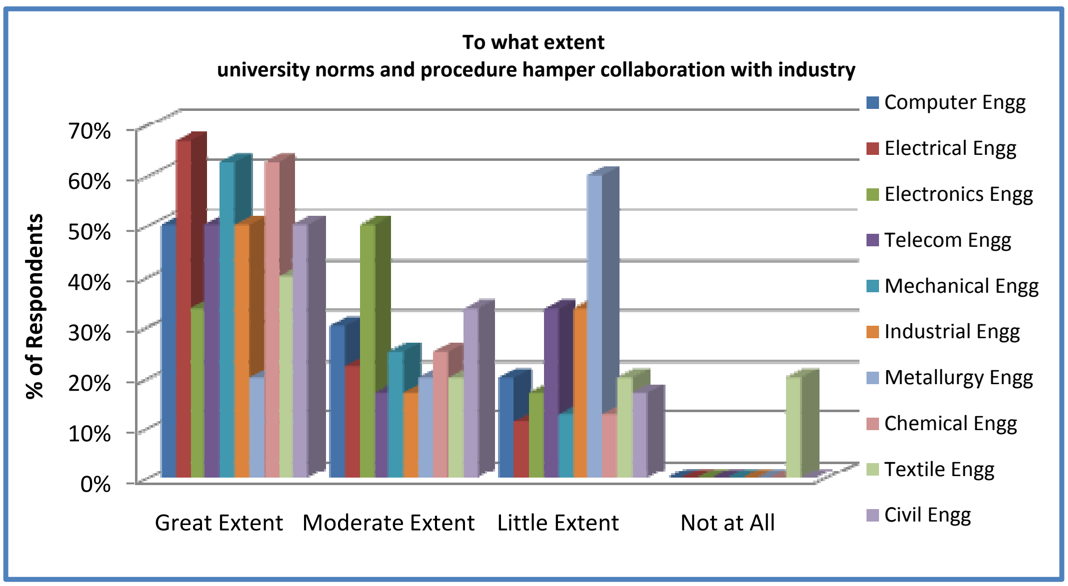

Figure 5. 20: University norms and procedure hampering collaboration with industry

Results and analysis of respondent's views is as under:

a. Over all 51% respondents opined that to great extent university norms and procedure hamper collaboration with industry. This type of response speaks of presence of bureaucratic culture in our higher education institutes. With this kind of approach in our universities, collaboration with industry seems to be a dream. Rectors and voice chancellors of the universities must revisit their policies and take corrective measures based on the input of researchers and industry both.

b. Twenty six percent (26%) respondents were of the view that to moderate extent university norms and procedure hampers collaboration with industry. Opinion in this shade also indicates poor state of university norms and procedures.

c. Twenty two (22%) respondents opined that to little extent university norms and procedure hampers collaboration with industry. Ideally university norms and procedures should facilitate collaboration rather than distraction.

d. Only one respondent of private textile college opined that university norms and procedure do not hamper collaboration with industry at all.

5.3.2.13 Geographical Location of University

Geographical location of university is one of the factors that may facilitate or hamper collaboration with industry. Concept of industrial cluster is developed on the basis of suitable geographical location, where raw material, R&D support and qualified human resource is available. Industrialized countries are reaping fruits of placing universities in industrial clusters. In Pakistan NUST is the only university which is located very close to an industrial sector. Views of respondents were solicited on "to what extent geographical location of university affects collaboration with industry".

Results of respondent's views are shown in figure 5.21.

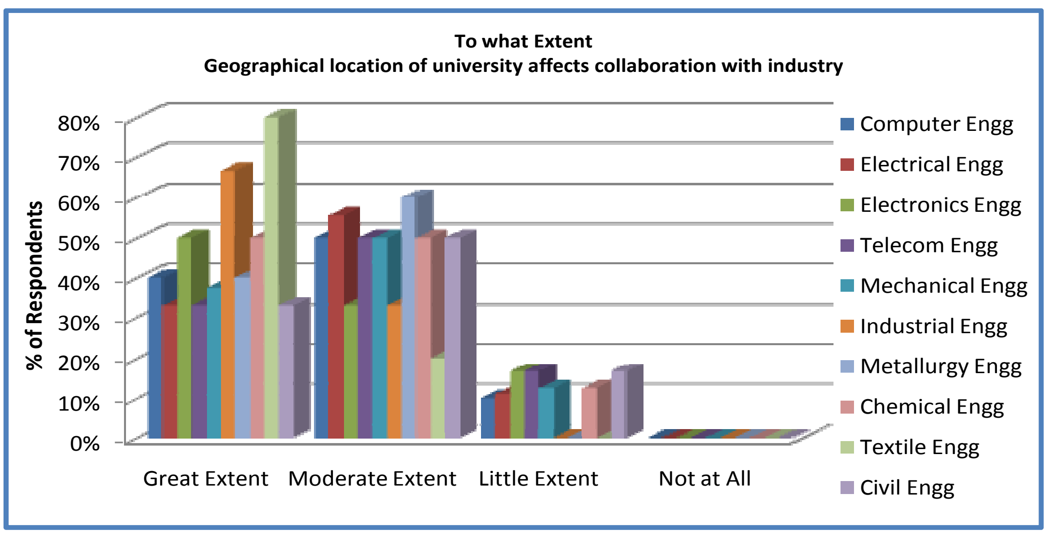

Figure 5. 21: Affect of geographical location of university on industrial collaboration

Results and analysis of respondent's views is as under:

a. Overall 45% respondents opined that to great extent geographical location of university effects collaboration with industry both ways. If the university is located in an area close to industry, positive effect is anticipated. If it is located in a region where industry does not exist, collaboration is severely hampered.

b. Forty six percent respondents are of the view that to moderate extent geographical location of university effects collaboration with industry. It means a vast majority of respondents is of the mind that geographical location of university is very important.

c. Only 10 respondents opined that there is little effect of geographical location of university on collaboration with industry.

5.3.2.14 University Infrastructure and Needs of Industrial Collaboration

This is the most important and at the same times most difficult aspect of university industry collaboration. It demands both policy and cultural change in university to have meaningful collaboration with industry. First step towards this direction is realization of importance of industrial collaboration; to some extent our universities are aware of it. Second step is understanding of industry needs, where we lack significantly. Third step is making action plan for effective collaboration. Fourth and the final step is execution of action plans and their continuous review based on feedback from industry and researchers. Views of respondents were solicited on "to what extent university infrastructure is adapted to the needs of industrial collaboration" Response of respondents is graphically shown in figure 5.22.

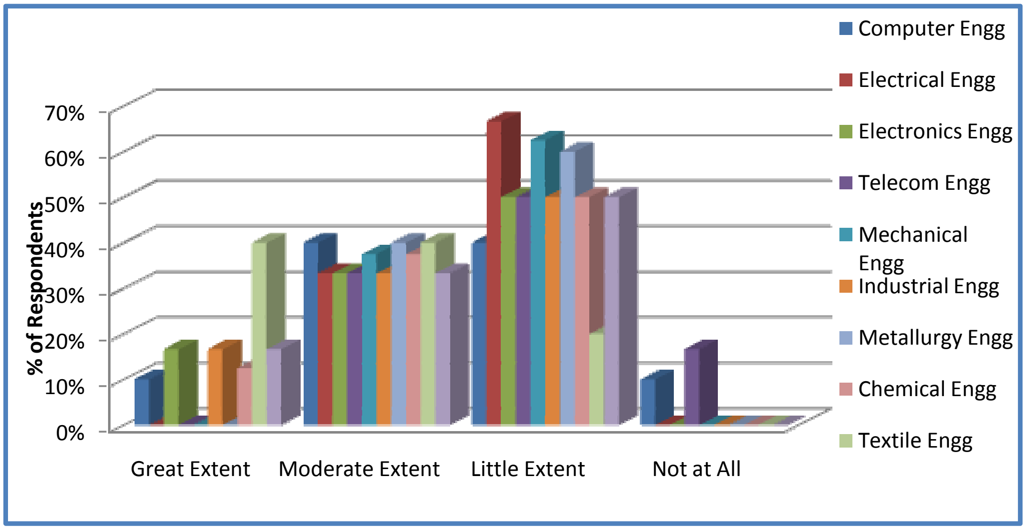

Figure 5. 22: University Infrastructure and Needs of Industrial Collaboration

Results and analysis of respondent's views is as under:

a. Only 10% respondents opined that to great extent university infrastructure is adapted to the needs of industrial collaboration. These respondents belong to NUST main campus Islamabad. This shows that NUST is trend setter university which is fully geared up to collaborate with industry.

b. Thirty six percent (36%) respondents opined that to moderate extent university infrastructure is adapted to the needs of industrial collaboration. I order to collaborate with industry this percentage needs to be improved significantly.

c. A high number of 51% respondents opined that to little extent university infrastructure is adapted to the needs of industrial collaboration. This is the area which merits immediate attention of all stake holders. Work on war footing is required to reverse this poor situation.

d. Only 2% respondents, belonging to UET Kohat, opined that their university infrastructure is not tailored to the requirements of industrial collaboration at all. Reasons are very much understandable; lack of resources, in process of its birth and an under developed geographical location.

5.3.3 Suggestions for Improving University-Industry Collaboration

A number of suggestions were identified for improving university-industry linkages and respondents were asked to indicate effectiveness of each suggestion on four point Liker scale varying from very effective to not effective.

5.3.3.1 Inclusion of industrial internship in the curricula

To provide hand on experience to the students of engineering disciplines, industrial internships are very vital. In industrialized countries these internships are common phenomena for university students being part of their curricula. However, in Pakistan this aspect has not been given due importance. Few years back there was no concept of industrial internship in our universities. Now industrial internships are planned and conducted but in a very casual manner. Respondent's opinion was invited on "Inclusion of industrial internship in the curricula". Result of respondents views are shown in figure .As high as 69% respondents opined that inclusion of industrial internship in the curricula is very effective, 29% opined that it is effective and 4% views as slightly effective. So inclusion of industrial internship in the curricula is most important suggestion as almost 70% respondents feel it very effective mean of establishing university industry collaboration.

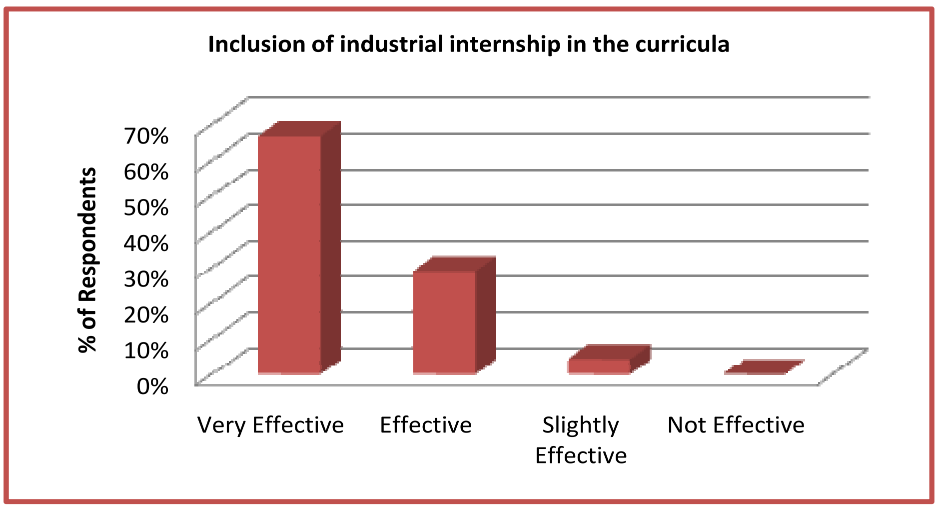

Figure 5. 23: Effectiveness of inclusion of industrial internship in the curricula

5.3.3.2 Encouragement of industrial visits by students

Industrial visits are helpful to familiarize students with industrial functions and processes where they can see practical demonstration of their theoretical knowledge. Students get the opportunity to share their ideas and views with industry people. These visits are equally useful for industry people, where they can identify and engage prospect students for their future assignments. Respondents opinion was invited on "encouragement of industrial visits by students" .Results of respondents view are shown in figure 5.24. Forty six percent respondents opined that industrial visit by students are very effective, 36% view this measure as effective while remaining consider it as slightly effective.

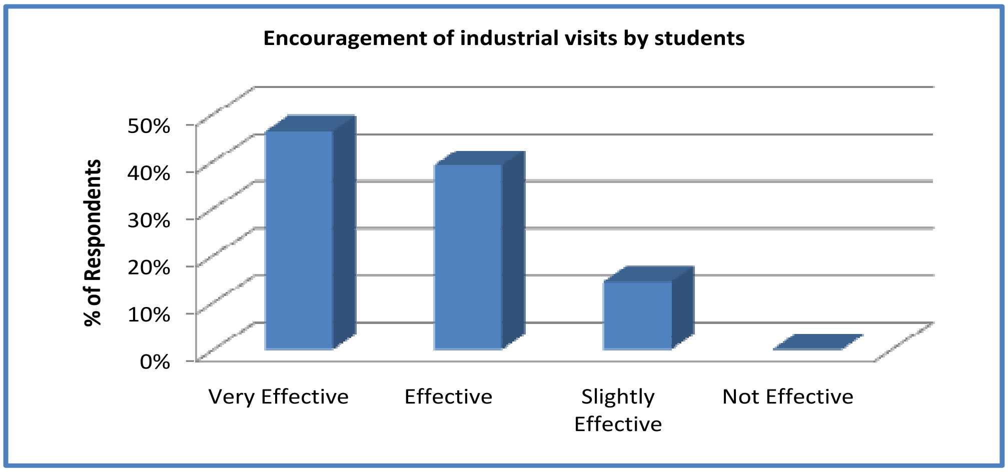

Figure 5. 24: Effectiveness of encouraging industrial visits by students

5.3.3.3 Encourage visits of faculty to industry

Respondent's opinion on "effectiveness of industrial visits by academics" was solicited. Results of respondent's views are shown in figure 5.25. Fifty two percent (52%) respondents opined that step is very effective, 36% viewed it as effective while remaining 12% opined that it is slightly effective. Interaction of academics with industrial people through visits can be very useful in number of ways:

- **a.** Academics can appreciate problems faced by industry.
- **b.** They can render advice to industry.
- **c.** They come to know about the performance of their students.
- **d.** They can arrange training programmes for industry people.
- **e.** They can inform industry about the research capabilities of university.
- **f.** Internships of students can be planned.
- **g.** Contents of curricula can be discussed with industry people.
- **h.** Consultancy and research assignments can obtain from industry.
- **i.** Student projects relevant to industry can be identified.
- **j.** Utilization of industry facilities can be coordinated.
- **k.** Funds can be attracted from industry.

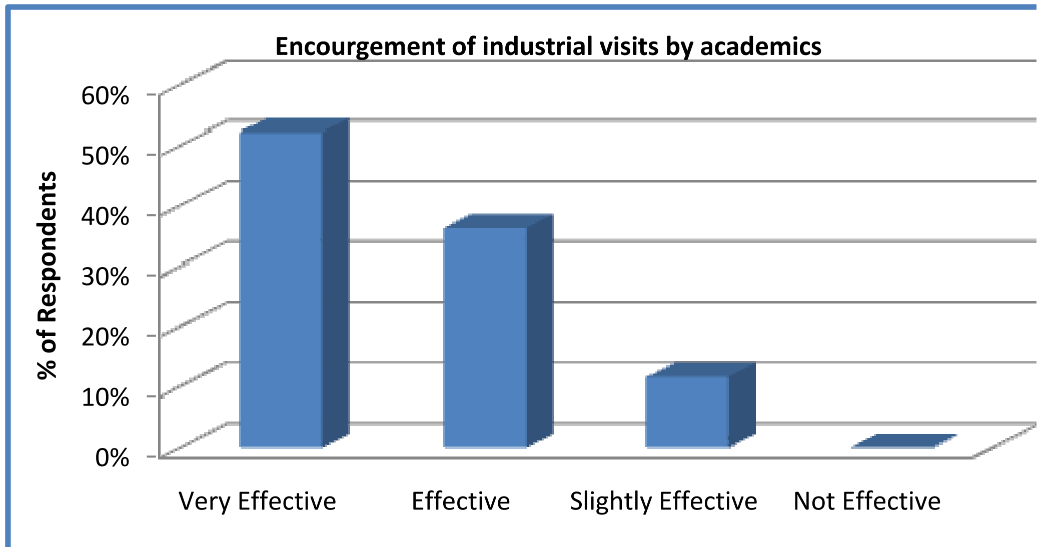

Figure 5. 25: Effectiveness of industrial visits by academics

5.3.3.4 Improvement of laboratory facilities

In order to conduct applied search which have relevance to our industry, good lab facilities are essential. Respondents opinion was solicited how effective could be improvement of lab facilities for effective university industry collaboration. Results of respondent's views are shown in figure 5.26. Fifty one percent (51%) respondents opined that improvement of lab facilities will be very effective for industrial collaboration; while 17% opined that it will have slight effect on industrial collaboration. Improved lab facilities will have positive impact on university industry collaboration and following advantages are anticipated.

- Academics will feel more confident to undertake industry related research.
- Research abilities of students will be polished.
- University lab facilities can be extended to industry people.
- Use of lab facilities by industry people will generate funds for university
- Development of prototypes for industrial use.

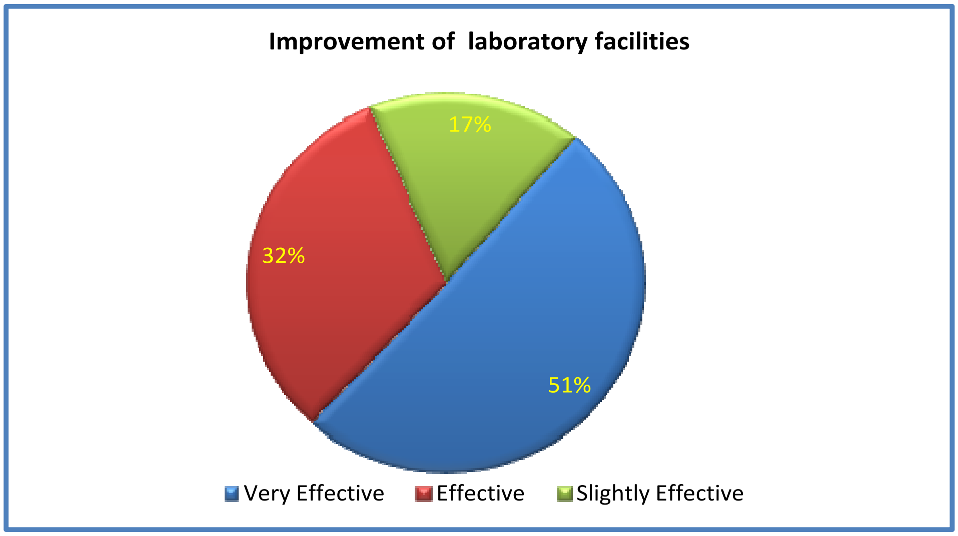

Figure 5. 26: Effectiveness of improvement in laboratory facilities

5.3.3.5 Involvement of staff from industry in teaching programmes

There are certain high tech industries where highly qualified and experienced staff is employed. These people can be engaged with university as visiting faculty for teaching purpose. Respondents were asked to express their opinion regarding involvement of industry staff in teaching programmes. Results are shown in figure 5.27. Only 14 % respondents opined that it will be very effective for fostering university industry collaboration, while 12% opined it will not be effective at all. Involvement of staff from industry can have both advantages and disadvantages.

a. Advantages

- Both theoretical and practical aspect of teaching can be covered more effectively.
- Student will remain abreast with latest developments taking place in industry.
- Industrial visits and internships can be planned and coordinated more efficiently.
- Employment of university graduates can be facilitated.
- Easy access to R&D facilities of industry.

b. Disadvantages

- Conflict of interest may arise between regular and visiting faculty.
- Teachers from industry may not be able to give due time to the students.

- They may not be regular in taking lectures due to their other engagements.
- They may lack theoretical aspect of teaching.

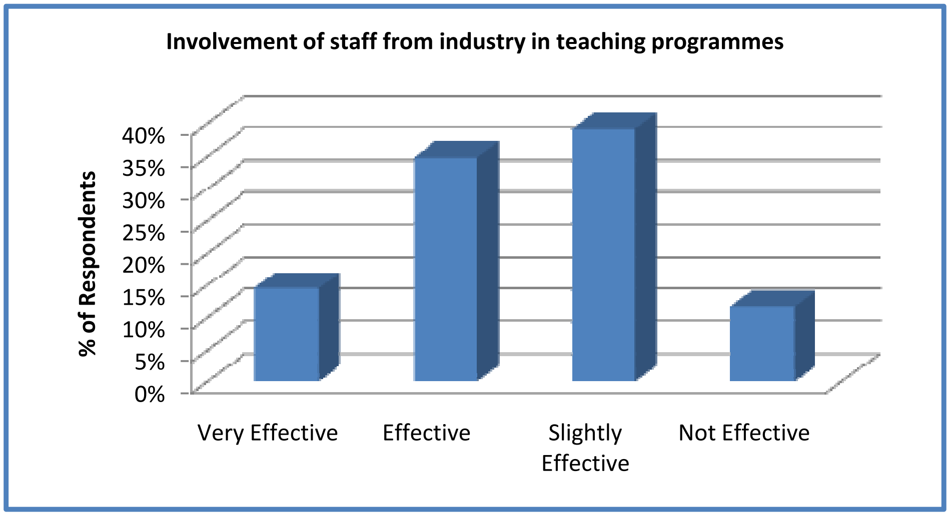

Figure 5. 27: Effectiveness of involvement of staff from industry in teaching programmes

5.3.3.6 Setting up of U-I liaison offices in universities

Setting up of university industry interaction cell is a planned and formal mechanism for coordinating industrial collaboration. This type of unit can help in bridging gap between university and industry, thereby making both to benefit from each other. Result of respondent opinion is shown in figure 5.28. 51% respondents opined that setting up of U-I interaction cell will be very effective. While 14% opined that this arrangement will be slightly effective. Enormous advantages can be achieved through these units.

a. University and industry representative's formal meetings can take place in these units.

b. University research can be commercialized through these units.

c. Academics can have easy access to different channels of funding.

d. Intellectual property rights and patents can be managed more effectively.

e. It can help in generating finds for university.

f. It can help in providing solutions to industry.

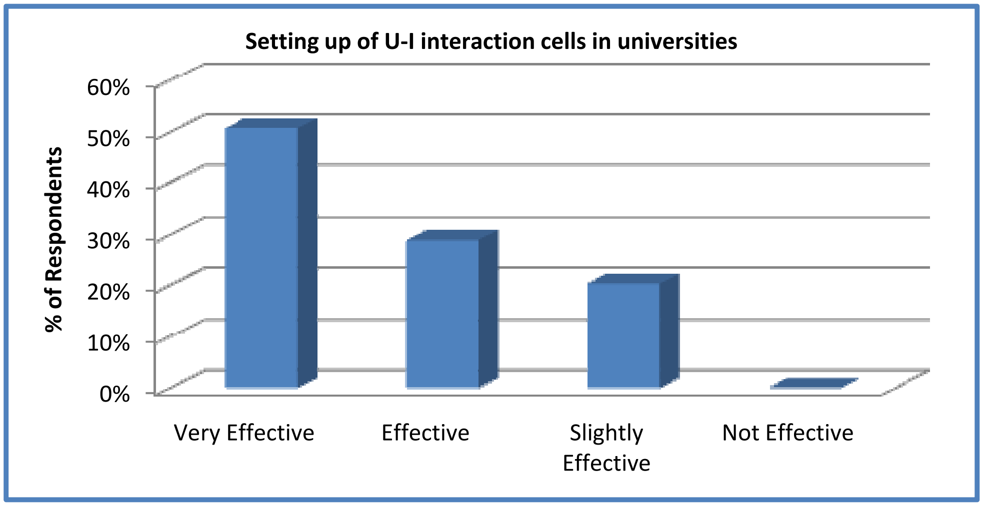

Figure 5. 28: Effectiveness of setting up of U-I interaction cells in universities

5.3.3.7 Publicizing university research to industries and their representative bodies

If university is not aware of university potential then there are very dim chances of U-I collaboration. Contrary to this if university activities are publicized, chances of U-I collaboration will be increased. All possible means of publicity should be utilized to promote university activities relevant to industry. Results of respondents view on this important aspect are shown in figure 5.29. A high percentage (57%) respondents opined that this activity can be very effective for promotion of university industry linkages, while it will have slight effect on U-I collaboration. Following benefits can be obtained by publicizing university activities relevant to industry.

- **a.** It will help in fostering U-I collaboration.
- **b.** Eventually this activity will bring more funds to university.
- **c.** Industry will be better informed about university services.
- **d.** University enterprise rile will be enhanced.
- **e.** Commercialization of university research will be facilitated.

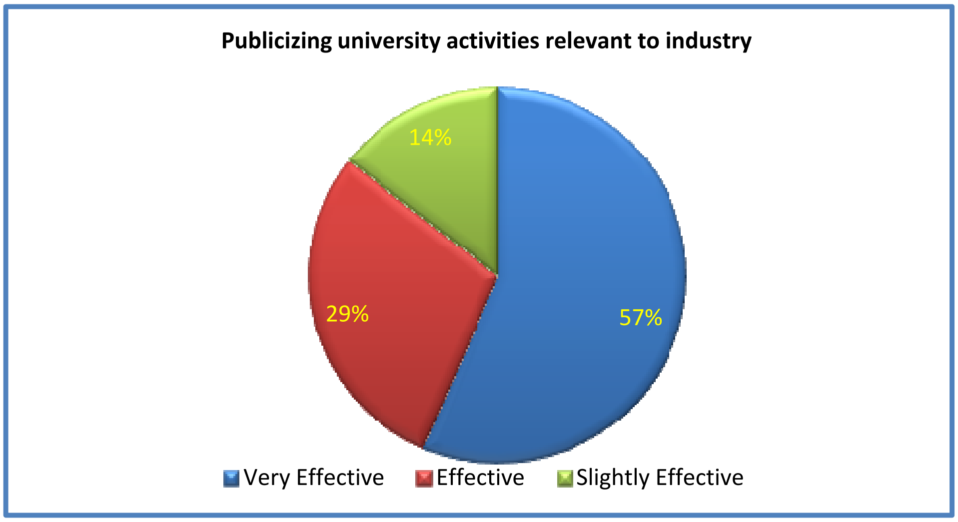

Figure 5. 29: Effectiveness of publicizing university activities relevant to industry

5.3.3.8 Conducting seminars, workshops for industry professionals

Conducting seminars and work shops for industry people provides a forum of interaction between academics ad industry people. Here, people from both sides can share their experiences, ideas and concerns. This mode of interaction with industry can lead to formal collaboration agreement on consulting services, contact research and licensing of patents. Results of respondent's views are shown in figure 5.30. Fifty four percent (54%) respondents opined that this activity is very effective for U-I collaboration, while 14 % opined that it is slightly effective.

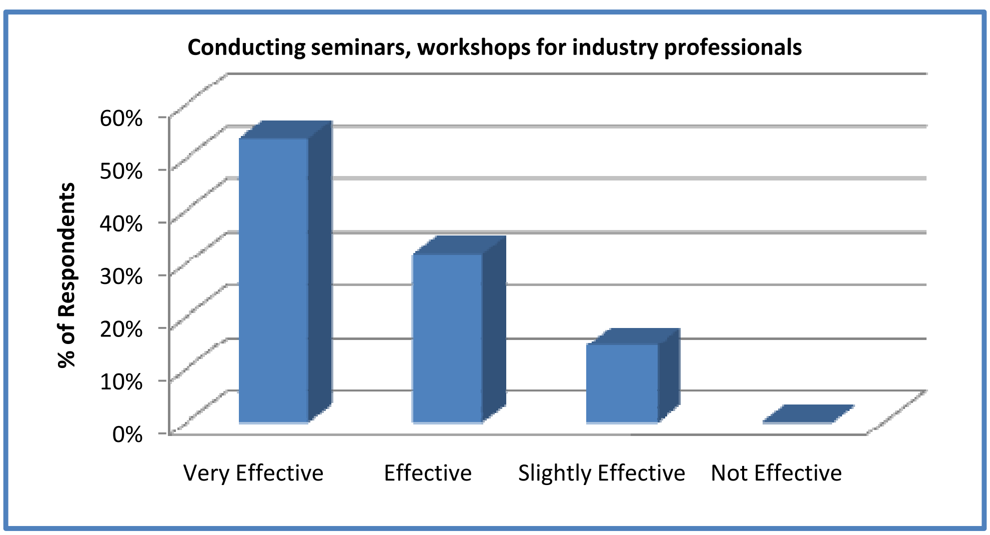

Figure 5. 30: Effectiveness of conducting seminars, workshops for industry professionals

5.3.3.9 Reduced taxation for those industries which engage in collaborative activities with universities

Industry is considered as engine of economic growth. Any step taken to grow industry will lead to growth of national economy. Industry people always focus on making more profit and they always look towards governments for seeking tax concessions .Results of the respondents on this aspect are shown in figure 5.31 .Sixty one percent (61%) respondents opined that this step will be very effective for improving collaboration. Some of its benefits are given below:

- **a.** Industry will be encouraged to collaborate with university.
- **b.** University research activities will be charged up.
- **c.** Industrial processes will be improved and productivity will be enhanced.
- **d.** Company spin offs and new startup activity will take place.
- **e.** Funds from industry will start pouring in

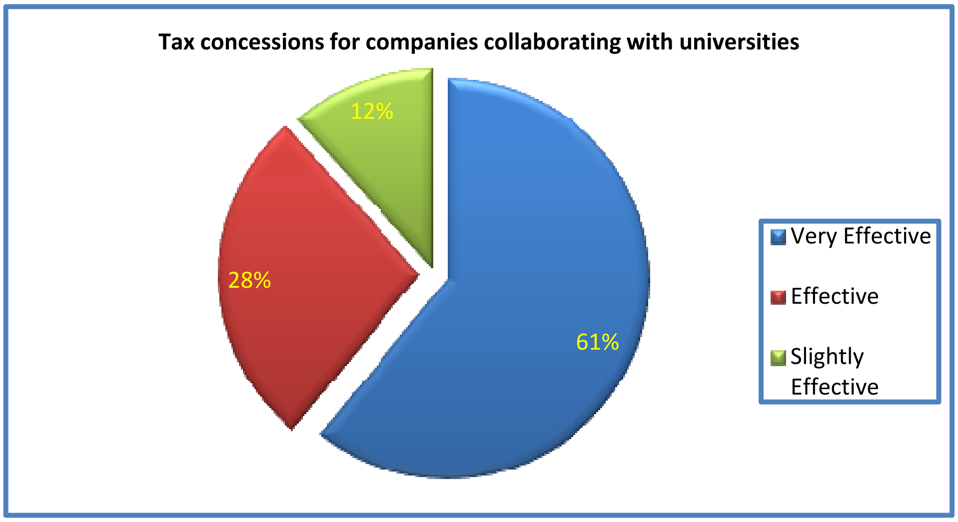

Figure 5. 31: Effectiveness of tax concessions for companies collaborating with universities

5.3.3.10 Making it mandatory for faculty to carry out some kind of collaborative work with industrial sector

By enlarge our academics are not geared up to collaborate with industry. They are restricted to teaching activities only .They must be pushed to collaborate with industry so that our industry becomes innovative and competitive. Results of respondent's views are shown in figure 5.32. Overall 45%respondents opined that it will be very effective step to improve U-I collaboration, while 14% opined that it will have slight effect .Following benefits are anticipated through this step.

- **a.** Intellectual input will start flowing from university to industry.
- **b.** Industrial related research will be encouraged in the university.
- **c.** Prototypes and new products will be designed for the industry.
- **d.** Industrial processes will be improved.
- **e.** University research will have more chances of commercialization.

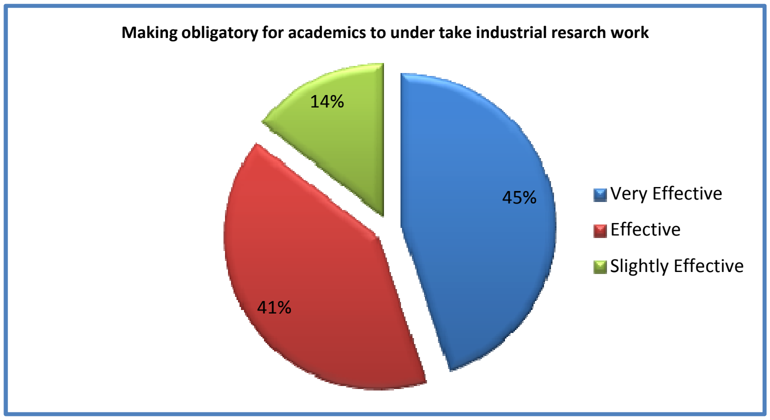

Figure 5. 32: Faculty to carry out some kind of collaborative work with industrial sector

5.3.3.11 providing consultancy/collaboration linked increments and promotions

Policy of stick and carrot always work s well. This means that rewards are linked with performance. Once respondents were asked to give their opinion on "providing consultancy/collaboration linked increments and promotions". The results were very astonishing. Detail of results is shown in figure5.33. Overall 29% opined that it will very effective impact on improving U-I collaboration, while 36% opine that it will have slight effect and 4% respondents opined that it will have no effect in improving U-I collaboration. Its positive effects are as under.

- **a.** It will force the academics to collaborate and work with industry.
- **b.** Research culture will have multiplier effect.
- **c.** University's enterprise role will be dominated.

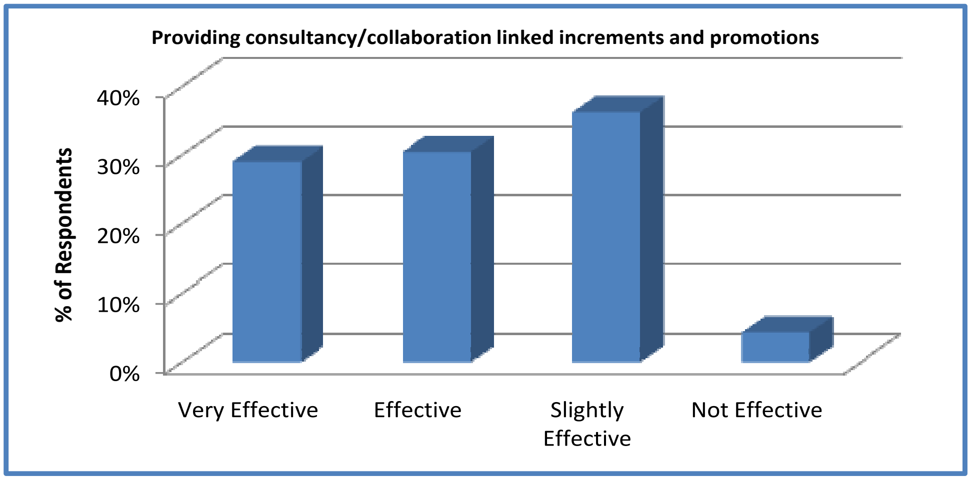

Figure 5. 33: Effectiveness of providing consultancy/collaboration linked increments and promotions

CHAPTER 6

MEASURES FOR IMPROVEMENT OF UNIVERSITY-INDUSTRY LINKAGES

6.1 Basic University-Industry-Government Interaction Model

We, in Pakistan, must get away with the "laissez-faire triple helix" model of university-industry-government relations, where institutions act competitively rather than cooperatively in their relations with each other. We must follow a model based on the principle of triple helix model of innovation. Basic interaction model is shown in figure 6.1.

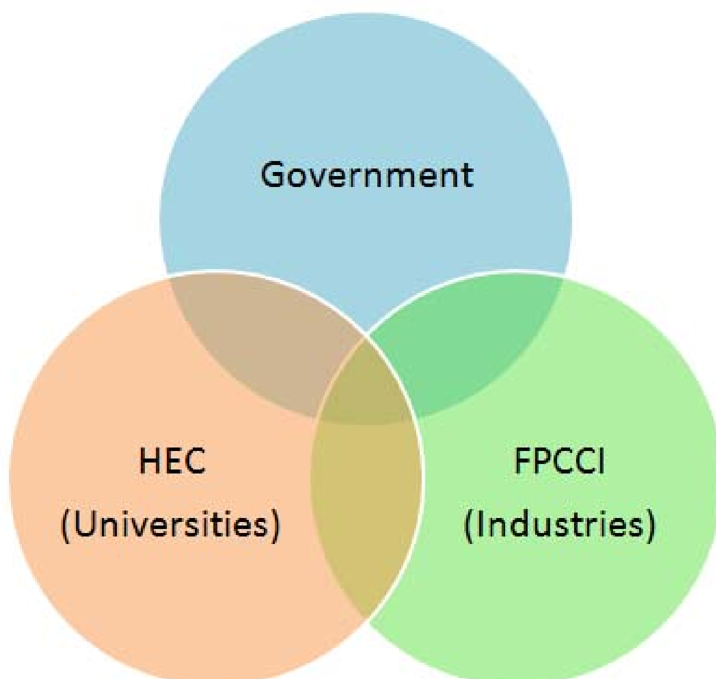

Figure 6. 1**:Basic University-Industry-Government Interaction Model**

Role of three key players, Government of Pakistan, Higher Education Commission and the Federation of Pakistan chamber of Commerce and Industries, is very important and crucial to initiate, grow and strengthen university-industry. All of them must work cooperatively rather than separately to achieve the desired results of university-industry collaboration. Detail of their roles and responsibilities is given in d

6.2 University-Industry-Government Interaction Model

A detail university-industry-government interaction models is shown in figure 6.2.

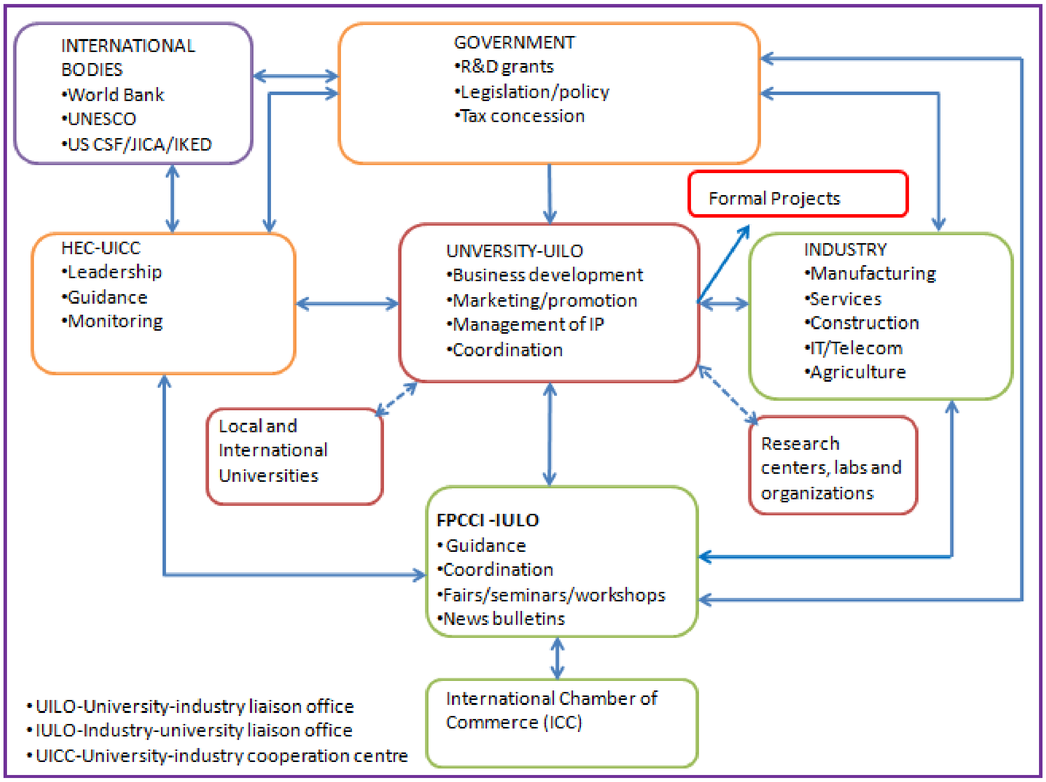

Figure 6. 2: University-Industry-Government Interaction Model

At the top government should make two way interactions with HEC, FPCCI, international bodies and resort to necessary legislation to initiate and strength university-industry linkages. Role of government is to facilitate and remove impediments confronted by all the stake holders. Description of suggested model is as under:-

6.2.1 Government

Government has a vital role to play in terms of doing legislation and making policies which should encourage and promote university-industry linkages. Grants and tax concession by the government to universities and industries will stimulate the process of university-industry linkages. Government should provide incentives and encourage industries to participate in collaborative activities. Government ministries should formulate policies in consultation with stake holders of industries and universities.

6.2.2 Federation of Pakistan Chamber of Commerce and Industries

FPCCI should play an active role in highlighting the benefits of university-industry collaboration to industrialists by conducting special exhibitions, seminars and workshops. It should motivate its member bodies to visit universities for making necessary coordination and liaison. FPCCI should furnish proposals and suggestions to government with regard to taxation, industrial investment, custom laws and income tax laws. It should engage with HEC for making roles and regulations to initiate and monitor university-industry linkages. It should also interact with foreign chambers of commerce to shares common interest and enhance Pakistan's exports.

6.2.3 Higher Education Commission of Pakistan

Higher Education Commission of Pakistan being regulatory body of higher education in the country must take lead role in fostering university-industry linkages. It is also one of the strategic aim of HEC to link our higher education with economic growth of the country.HEC must provide regulatory frame work in consultation with university researchers prominent industrialists and their representative bodies to initiate the process of sustainable university-industry linkages. Necessary guidance and advice be provided to both universities and industries and en effective mechanism of monitoring be emplaced. The whole process must be periodically reviewed to overcome any shortcomings.

6.2.4 International Bodies

Government and HEC must engage constructively with international bodies like World Bank, UNESCO, JIKA, IKED and US CSF etc for seeking funds and training of professionals. Funds so obtained must be used on operational functional rather than administrative functions. University researchers and industrialist must be facilitated to visit these bodies more frequently. These international bodies encourage university-industry linkages for the socio-economic growth of nations.

6.2.5 HEC University-Industry Collaboration Centre (UICC)

At HEC level UICC should be established to provide policy frame work followed by effective guidance and monitoring. UICC should consist of renowned professors of universities, members of business community and representative of MoIP. Its meeting should be held once in every quarter and also on as and when required basis.

6.2.6 University-Industry Liaison Office (UILO)

University-Industry Liaison Offices (UILO) at universities should perform functions of business development, marketing/promotion management of IP and coordination with industry. It should make liaison and necessary coordination with industries and their representative bodies and also with other universities and research organizations.

6.2.7 Industry - University Liaison Office (IULO)

Establishing of Industry-University Liaison Offices (IULO) at chambers of commerce and industry association level could be very effective for fostering these linkages. These offices should interact with industry, university and HEC and conduct seminars, workshops and fair

6.3 University-Industry Collaboration Working Model

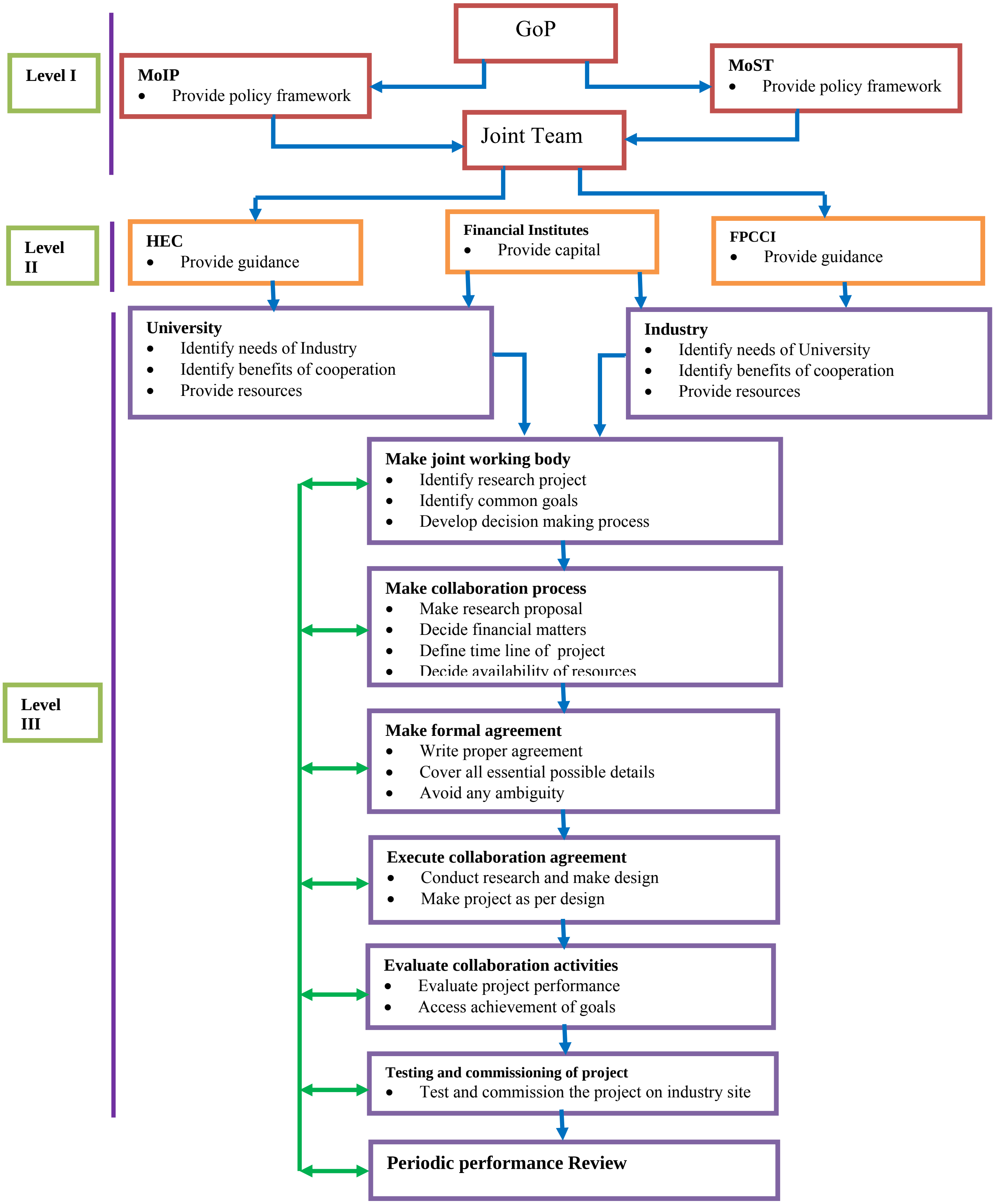

Figure 6. 3: University-Industry Collaboration Working Model

Functioning of University-Industry-Government collaboration working model takes place at three levels, detail description of the same is as under:-

6.3.1 Level I

a. At level I, Government of Pakistan needs to pass necessary legislation to effectively start and boost up university-industry collaboration.

b. Government should provide duty exemptions on import of hi-tech equipment to industries and universities.

c. Government should provide tax concession to those industries which engage themselves in meaningful university-industry collaboration.

d. Ministry of industries and production and ministry of science and technology must formulate their policies in the light of legislation passed by GoP.

e. MoIP must focus on concept of industrial cluster formation, where universities research centers and amenities are also placed.

f. MoST must revise its two decade old S&T policy to meet challenge of 21st century and take the country on path of progress and development.

g. Both the ministries need to form a joint working team which should interact with HEC and FPCCI to oversee and monitor the goals set in policies for fostering university-industry linkages.

6.3.2 Level II

a. .At level II, HEC and FPCCI has an important role to play with regard to formulations of regulations based on the policies provided by MoST and MoIP.

b. HEC shoud formulate its regulations, which establish, encourage and strengthen university-industry collaboration, in consultation with universities and joint working team of both the ministries

c. FPCCI should also formulate its regulation, which establish, encourage and strengthen university-industry collaboration, in consultation with industries and joint working team of both the ministries.

d. HEC should guide the universities for implementation of rules and regulation on university-industry linkages. HEC should ensure monitoring of universities

e. Similarly, FPCCI should provide necessary guideline to industries for implementation of roles and regulations on university-industry linkages. FPCCI should monitor the progress made by industries.

6.3.3 Level III.

a. Both university and industry identify their needs for entering in to collaborative activity. At this stage they also weigh the benefits of this collaborative activity. Availability of required resources is also checked.

b. If both the parties consider that collaborative activity can serve their interests, then they will move to next stage of making a joint working body. Tasks of this body are to identify research project, common goals and develop decision making process.

c. In next stage this body will initiate collaboration process. Following steps will be taken at this stage:-

- Make research proposal
- Decide financial matters
- Define time line of project
- Decide availability of resources

d. After finalizing collaboration process, formal agreement is made. This stage includes writing proper agreement, covering all essential possible details, avoiding any ambiguity and removing irritants.

e. Then the execution stage comes where design is made and product/process is produced.

f. In third last stage collaborative activities are evaluated. Here project performance is checked and achievement of goals is determined.

g. In second last stage, testing and commissioning of the project is undertaken at industry site.

h. Finally, periodic performance review of whole working model must be carried out to make necessary changes and adjustments.

6.4 Measures to Improve University-Industry Linkages

a. Universities must establish effective university industrial liaison offices (UILO) equipped with highly qualified and trained work force with following goals:

(1) **Management of Technology.** All aspects relevant to management of technology like, creation of Intellectual Property (IP) its disclosure, assessment, valuation and protection for faculty involved in research.

(2) **Commercialization.** In order to commercialize Intellectual Property (IP) in the form of licensing, start-ups or spin-off companies so that researcher, university and industry get due financial benefits. **Mentoring.** In order to launch programs which offer openings for researching faculty, staff, students and others people to connect in entrepreneurial activity and develop necessary skills that will help them to setup new industry in the country.

(3) **Collaboration.** In order to collaborate and manage relationships with industry effective liaison and coordination must be made with industry associations and chambers of commerce. Links with other R&D organizations and universities should also be established.

(4) **Information.** To publicize and communicate outcome of university research activities regarding products and processes and technology transfer to industry, government, R&D organizations and universities.

b. Academics should be motivated and encouraged to display high degree of entrepreneur spirit by undertaking research having relevance to industry. Following measures are likely to produce admirable results.

(1) Increase in pay package of those academics how are actively involved in producing research having commercial value.

(2) Accelerated promotion for academics proactively involved in entrepreneur activities.

(3) Providing sufficient capital to academics for entrepreneur activities like, spinning off companies and new start ups.

(4) Fifty percent of income, generated through of commercialization of research, is given to concerned researcher.

c. Ample time is given to academics to take part in activities having direct relevance to industrial collaboration. Over burdening of academics be avoided by following measures.

(1) Better planning of teaching schedule in consultation with concerned academics.

(2) Dedicated staff be appointed to deal with student administration, procurements and infrastructure development.

(3) Better time management by carrying out advance planning and avoiding overlapping of events.

(4) Maintain proper teacher to student ratio by increasing faculty strength in accordance with international standards.

d. Academics should be made aware of all possible channels and accessing of those channels for seeking sponsored research and consultancy assignments. Following measures are suggested.

(1) Industrial liaison office should arrange short training courses to educate academics.

(2) An updated data bank of all potential industries, organization, agencies and departments be maintained.

(3) Information with regard to various channels of funding be uploaded on university web site.

e. University must publicize its activities having relevance to industry. University must take initiative and make access to industry for changing its mindset by rendering advice, expertise and services at nominal cost. Following means be adopted to publicize university activities.

(1) Use of electronic media.

(2) Use of internet

(3) Making broachers and sending to industry, chambers of commerce and other potential user of university services.

(4) Use of news letters and news bulletins.

f. University laboratory facilities must be upgraded in accordance with research needs. For this purpose all possible resources must be mobilized. Additionally following measures can be taken to over come this constraint:

(1) Pooling up of lab facilities amongst schools and departments of the university.

(2) Developing a common facility of labs in collaboration with industry and government.

(3) MNCs like IBM, Motorola and Seaman's must be contacted and convinced to establish their lab facilities in our universities by offering them free research.

g. University policies and procedures must be revised in accordance with requirements of industrial collaboration in full consultation with all stake holders. These policies and procedures must facilitate and encourage academics to collaborate with industry rather than imposing strict conditions and checks. Recognition and rewards criteria for faculty members with regard to commercial research activities must be well defined in the University's reward system.

h. Curriculum of all programmes, especially under graduate level must be revised in consultation with industry professionals. Specials customized short courses should be conducted for industry professionals in accordance with their needs.

i. UILO must educate academics about intellectual property rights, funding opportunities and commercialization procedures so that they are not confronted with any unpleasant situation.

j. Inclusion of industrial internship in the curricula. Industrial internship must be treated as a subject of some credit hours weight age. Students must take their final year projects based on this internship and these projects be implemented in the industry free of cost as a confidence building measure.

k. Encouragement of industrial visits by students. It will provide the student with an opportunity to understand industrial systems, processes and their requirements. It can also help students in their placements in the industry.

l. Encourage regular industrial visits by staff. Interaction with industry at academics level will certainly help to understand industry problems and gaining each others confidence.

m. Incorporating the University Researcher as advisors to industries for technology up gradation and procurement of hi-tech equipment.

n. Conducting seminars, workshops for industry professionals. Such events provide a forum of sharing ideas, experiences and concerns and identification of opportunities and activities for collaboration these events can lead to formal collaborations with the industry.

o. Making it mandatory for faculty to undertake a certain amount of work with industry. This measure will kick start the collaboration activity leading to create a culture of industrial collaboration.

CHAPTER 7

RECOMMENDATIONS AND CONCLUSION

7.1 Recommendations for Government

a. Government should provide the essential fund and assistance to universities in order to encourage industry related research for overall benefit of all stake holders.

b. Government should make and apply framework, policies and regulations that are helpful for industrial collaboration.

c. Government should provide conducive atmosphere for the universities and the industry to effectively engage in university-industry linkages.

d. Government should provide tax exemption for certain imports of educational support materials and equipment.

e. Government should provide a standard quality assurance and accreditation centre.

f. Government should provide tax concession to those industries which collaborate with university.

g. Government should provide financial support to industries to collaborate with universities for their consultancy and research assignments.

h. Government should ask financial institutions to provide soft loans for start-up and spin off companies.

i. Government should make obligatory that new universities be established close to industrial zones.

j. Government should take necessary measures for provision of uninterrupted and cheap supply of electricity and natural gas to make industry competitive.

k. Government should give special incentive to those industries which are engaged in active collaboration with universities.

l. Government should announce special awards and prizes for those university researchers who display high standards of entrepreneurship.

m. Government should revise 25 year old science and technology policy to meet the challenges of 21st century.

7.2 Recommendations for measures for Industry

a. Industry should take part in designing of curricula having practical relevance to the needs of industrial sector.

b. Industry should concentrate on the provision and growth of skilled workforce by providing necessary help and assistance to related universities.

c. Industry should arrange the advance training of their technical workforce and management by seeking support of university experts in their respective area of specialization.

d. Industry should provide sponsorships to the university students and researcher to speed up the collaborative activities.

e. Industry should interact with the government regulatory bodies/agencies for providing incentives for the growth of industrial sector.

f. Industry should make use of internet along with physical visits to universities in order to seek solutions to their problems.

g. Industry should encourage internships of university students and their subsequent employment.

7.3 Recommendations for University

a. University should realize its important role in overall socio-economic development of the country and must make efforts to meet this challenge.

b. Universities should make appropriate policies and regulations to encourage faculty to undertake research having direct relevance to our national needs in general and industry in particular.

c. Universities must make their legal, operational and financial functions transparent to gain the confidence of researchers and industry partners.

d. Researchers engaged in active collaboration with industry should be given sufficient time by reducing their administrative and teaching work load.

e. Universities should setup industrial liaison offices in premises of industrial clusters and zones.

f. University should design its curricula in consultation with industry partners and the same must be reviewed periodically.

g. University must run tailored made courses to meet requirement of industry.

h. Universities must set up technology and business incubation centers close to industrial zones for new start-up companies and spin off firms.

i. University must conduct seminars and workshops to have meaningful interaction with corporate sector partners.

j. University should welcome professionals from industry to deliver lectures to students. It will help to foster university-industry linkages.

k. Universities must upgrade their libratory facilities and render its services to industry.

l. University infrastructure in terms of communication, transport, books and buildings must be upgraded.

m. University should publicize its activities having relevance to industry. University must take initiative and make access to industry for changing its mindset by rendering advice, expertise and services at nominal cost.

n. Universities should make internships mandatory for graduating students and encourage their thesis/ research work based on solving industry problems.

7.4 Recommendations for Department(Future Research)

a. Another research should be taken up to get the perspective of industry for identifying barriers and establishing strong university-industry linkages.

b. Both the research works should be combined to have a clear picture of barriers affecting university-industry linkages and suggesting a more comprehensive model for effective collaboration.

7.3 Conclusion

Pakistan has a great potential for strengthening science and technology links between higher education institutions and industry. In triple helix model of innovation, university, industry and government must engage in constructive and meaningful interaction for socio-economic uplift of the country. In many developing countries an increasing number of companies are spinning off from universities, a process that happens when researchers are encouraged to look for commercial applications of their work. In fact, the very nature of the knowledge revolution, and the intimate links between, academia and industry, has helped shape a different set of cultural values around such.

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